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Solid Wastes, Poverty and the Environment in Developing Country Cities

Challenges and Opportunities

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Abstract

Many cities in Africa, Asia, and Latin America face serious problems managing their wastes. Two of the major problems are the insufficient collection and inappropriate final disposal of wastes. Despite spending increasing resources, many cities – particularly in Africa and Asia – collect less than half of the waste generated. Most wastes are disposed of in open dumps, deposited on vacant land, or burned by residents in their backyards. Insufficient collection and inadequate disposal generate significant pollution problems and risks to human health and the environment. Over one billion people living in low-income communities and slums lack appropriate waste management services. Given the rapid population growth and urbanization in many cities, the management of wastes tends to further deteriorate. This paper examines the challenges and opportunities.../

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that exist in improving the management of waste in Africa, Asia, and Latin America. It is argued that, despite a worsening trend, there are opportunities for reducing pollution, alleviating poverty, improving the urban environment, and lowering greenhouse gas emissions in developing countries by implementing low-cost, low-tech, labour-intensive methods that promote community participation and involve informal refuse collectors and waste-pickers. Evidence from several cities in Africa, Asia, and Latin America is discussed.

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1 Introduction

Cities in the developing world have undergone a rapid urbanization during the past 50 years. The number of urban dwellers is expected to double between 1987 and 2015. Nearly 90 per cent of this increase will take place in the developing world, where growth rates exceed 3 per cent a year, three times that of the developed countries (UN-HABITAT 2003).

Urbanization in the developing world implies the expansion of existing slum areas and the creation of new ones. In the 1990s, the urban population in low-income countries increased by one third. According to a UN-HABITAT report published in 2003, nearly one billion people worldwide live in slums, or about one third of the world's city dwellers. If present trends continue, two billion people could be living in slums by the year 2030 (UN-HABITAT 2003). Future need for waste collection in slums, therefore, is likely to put additional strain on municipalities already unable to provide the service to their current residents. Population growth intensifies the pressure on urban infrastructure in many cities already overburdened with the provision of urban services. Many developing world cities lack the resources to meet the demand for services such as water, sanitation, and solid waste management. Many cities in Africa and India collect less than half of the waste they generate. Worldwide, over two thirds of human waste are released into the environment with little or no treatment, resulting in a deterioration of the urban environment in the form of air, water, and land pollution that pose risks to human health and the environment (Suez Lyonnaise des Eaux 1998).

Solid waste management in developing countries has received less attention from policymakers and academics than that paid to other urban environmental problems, such as air pollution and wastewater treatment. Nevertheless, the improper handling and disposal of solid waste constitutes a serious problem: it contributes to the high morbidity and mortality rates in many cities. This paper examines the challenges and opportunities that exist in improving the management of waste in Africa, Asia, and Latin America.

2 Municipal solid waste management in developing-country cities

2.1 Definition of municipal solid waste

Municipal solid waste (MSW). refers to the materials discarded in the urban areas for which municipalities are usually held responsible for collection, transport, and final disposal. MSW encompasses household refuse, institutional wastes, street sweepings, and commercial waste, as well as construction and demolition debris. In developing countries, MSW also contains varying amounts of industrial waste from small industries, as well as dead animals and faecal matter (Cointreau 1982).

2.2 Current problems

Collecting, transporting, and disposing of MSW represents a large expenditure for developing country cities: waste management usually accounts for 30–50 per cent of municipal operational budgets. Despite these high expenses, cities collect only 50–80

per cent of the refuse generated. In India, for instance, about 50 per cent of the refuse generated is collected, 33 per cent in Karachi, 40 per cent in Yangon, and 50 per cent in Cairo. Disposal receives less attention: as much as 90 per cent of the MSW collected in Asian cities ends up in open dumps (Cointreau 2008; Medina 1997a).

In areas that lack refuse collection – usually low-income communities – residents tend either to dump their garbage at the nearest vacant lot, public space, creek, or river, or simply burn it in their backyards. Uncollected waste can accumulate on the streets and clog drains when it rains, which might cause flooding. Waste can also be carried away by run-off water to rivers, lakes, and seas, affecting those ecosystems. Alternatively, waste can end up in open dumps, legal and illegal: the most common disposal method in the developing world.

Open dumping of solid waste generates various environmental and health hazards. The decomposition of organic materials produces methane, which can cause fire and explosions, and contributes to global warming. The biological and chemical processes that occur in open dumps produce strong leachates, which pollute surface- and groundwater. Fires periodically break out in open dumps, generating smoke and contributing to air pollution. In the Mexican city of Tampico, on the Gulf of Mexico coast, for instance, a fire burned for over six months at the local open dump. Fires at open dumps often start spontaneously, caused by the methane and heat generated by biological decomposition. Dump managers in some cities deliberately periodically set fires at the dumps in order to reduce the volume of the waste, which allows more waste to be disposed there and thus extends the life of the dumps. Human scavengers might also cause intentional fires, since metals are easier to spot and recover among the ashes after the fires than among piles of mixed wastes. Food leftovers and kitchen waste attract birds, rats, flies, and other animals to the dumps. Animals feeding at the dumps can transmit diseases to humans living in the vicinity. Biodegradation of organic materials could take decades, which might limit the future use of the land on which open dumps are located.

2.3 Globalization, generation of waste, and the impact on human health and the environment

A positive correlation tends to exist between a community's income and the amount of solid waste generated. Wealthier individuals, who consume more than people on a lower income, generate a higher rate of waste. The processes of accelerated population growth and urbanization translate into a greater volume of waste generated (Medina1997b). Globalization can promote economic growth, a desirable outcome. However, this economic growth – in addition to population increase and urbanization – will seriously strain municipal resources in order to deal with a booming amount of waste. See Table 1.

Higher incomes and economic growth also tend to have an impact on the composition of waste. Wealthier individuals consume more packaged products, which results in a higher percentage of inorganic materials – metals, plastics, glass, textiles, and so on – in the waste stream. Higher volumes of waste and a changing composition have a profound impact on waste management practices. This situation also points out the policy changes that developing countries need to make.

More waste being generated, and with a higher content of inorganic materials, could have a significant impact on human health and the environment. If the additional waste resulting from population and economic growth is not collected, treated, and disposed of properly, health and environment in third world cities will further deteriorate.

2.4 Conventional waste management systems and their shortcomings

In order to extend refuse collection, upgrade disposal facilities, and diminish the risks to human health and the environment associated with inadequate waste management, various measures have been implemented. The solutions that are commonly proposed to the problems in municipal solid waste management (MSWM) in the developing world often have the following features:

- Centralized and undiversified – solutions that do not distinguish between the different needs and heterogeneity of neighbourhoods within each city, and between cities;
- Bureaucratic – top-down solutions, usually reached without (or with little) community participation;
- Capital-intensive approaches – involving advanced technology and equipment, frequently imported from industrialized countries; and
- Formal – conventional solutions only consider the formal sector, neglecting the existence and possible contributions of the informal sector that has developed around waste collection and recycling in many cities (Medina 2007).

In this paper, I argue that cities in the developing world require a fundamentally different approach to the solutions that are currently proposed.

3 Differences between developed and developing country cities that affect MSWM

Profound differences exist between industrialized and developing countries in terms of income, standard of living, consumption patterns, institutional capacity, and capital available for urban investment. Conventional solutions usually do not take into account these differences, resulting in less than optimum outcomes. Table 1 summarizes the waste generation per capita as well as total waste generation in countries of different income levels.

Residents of low-income countries tend to generate less garbage than people in wealthier areas. But they are catching up fast. China, with its billion-plus population, growing economy and improving standard of living, surpassed the US as the world's largest generator of solid wastes in 2005. If current trends continue, India will also generate more total wastes than the US in the year 2025 (Medina 2008a, b).

Table 1: Waste generation per capita and total waste generation

	Waste generation rate (lbs./person/day)	Total waste generation (million tons/year)
Low-income countries	1.3	569
Middle-income countries	1.8	986
High-income countries	3.1	566

Source: Cointreau (2008).

The following represent the major differences between developed and developing countries that are relevant to the design of MSWM solutions in the latter:

- Developed countries enjoy a relative abundance of capital and have high labour costs, while developing countries have a relative scarcity of capital and an abundance of unskilled and inexpensive labour. It makes sense for the former to devise waste management systems intensive in capital and that save in labour costs, but it often does not make sense for the latter to follow the same approach.
- Developing countries need low-cost, labour-intensive solutions that reduce poverty, particularly among the most underprivileged sections of society. Socially desirable MSWM solutions in developing countries are those that create income opportunities for unskilled workers, particularly the poor.
- The physical characteristics of cities in developing and developed countries differ markedly. Cities in the developing world have extensive areas with substandard conditions – slums – with narrow, hilly, and unpaved streets. Many immigrants cannot afford to purchase land on which to build their homes. As a result, some migrants occupy vacant land and become squatters. Most of the areas that lack refuse collection services are slum and squatter settlements. Some local authorities decline to provide refuse collection to squatters because they do not pay taxes. This refusal to provide waste collection has a deleterious effect on the urban environment.
- An important difference between developed and developing countries refers to the dissimilar amount and characteristics of waste generated. The waste generated tends to go up as income increases. Further, in addition to low-income communities generating less refuse, the composition of the waste also tends to be different. Waste generated in developing countries contains a large percentage of organic materials, usually three times higher than that of developed countries. The waste is also more dense and humid, due to the prevalent consumption of fresh fruits and vegetables, as well as unpackaged food. First-world residents consume more processed food and food packaged in cans, bottles, jars, and plastic containers than in the developing world. As a result, waste generated in the former contains more packaging materials than in that of the latter.
- Many cities in the developing world have a dynamic informal sector that has evolved around waste, which provides income opportunities for recent migrants, unemployed, children, women, elderly, and handicapped individuals. The most

common occupations are informal refuse collection and scavenging. Due to their importance, section 3.3 below presents a more detailed discussion of these occupations.

3.1 Urban versus rural waste management

There are also profound differences between waste management in urban and rural areas. If per capita incomes are higher in the cities than in rural areas – as it is often the case in developing countries – urban residents tend to generate more residential wastes per person. The composition of urban wastes tends to be highly diverse due to the wide variety of production activities and all the various material inputs used in them. Productive activities also generate wastes in their processes and consumers discard products and packaging materials after consumption. Thus, urban wastes are highly diverse and urban residents tend to generate more wastes than their rural counterparts.

Rural areas, however, can generate large amounts of wastes, depending on the type of existing economic activity, but these tend to be less diverse than urban wastes. Agriculture and mining, for example, can generate staggering amounts of wastes. It has been estimated that up to 26 kg of agricultural wastes are generated for every kg of crops produced. Disposing of these wastes can have significant environmental impact. Agricultural burns to dispose of residual organic matter – common throughout the developing world – constitute a source of pollution that can pose risks to human health and the environment. Mining wastes are often dumped on vacant land, sometimes destroying valuable habitats and can also pollute surface and groundwater (Cointreau 2008).

Due to their dispersion, the cost of collecting wastes from rural residents can be much higher than in urban areas. Not surprisingly, many rural areas in developing countries lack waste collection service. Rural residents who lack refuse collection often dump their wastes on vacant land, bodies of water, or simply burn them.

3.2 Financing and management models

Traditionally, municipalities have been responsible for managing the wastes generated by their residents. The most common waste management model involved the use of city vehicles to do the collection, transport, and to take the garbage to its final disposal site. Cities would also invest public funds to build and operate the final disposal sites. This system was financed by the city's general budget. The cost of providing waste management services was supposed to be covered by the taxes paid by residents. This model, however, does not work in developing countries. A significant percentage of the urban population in Africa, Asia, and Latin America lives in slums. Many slum residents do not pay property or income taxes. Therefore, cities lack the money to provide waste management and other services.

Two emerging models attempt to provide a solution: privatization and informal sector involvement. Under the privatization model, the private sector invests its own money in purchasing equipment and building facilities for collecting, transporting, treating, recycling, and final disposal of wastes. The World Bank has actively advocated this model in the developing world. The private sector can provide one component of the waste management system, for example, waste collection, or a combination of two or

more components: waste collection, operation of transfer stations, recycling, incineration, and final disposal. Bogotá, Colombia, for instance, divided the city into five different zones where private companies can bid to provide waste collection and street sweeping. Residents pay for this service through their electric bills. Private sector participation can improve efficiency and lower operating costs throughout the waste management system. Privatization, however, can have significant social costs by displacing the informal sector. Worldwide, more than 15 million people make a living in the informal collection, recycling, and handling of wastes. If these informal sector workers lose their livelihoods, the end result can be greater inequality and more poverty in the cities. The rest of the paper explains in greater detail the benefits of promoting greater informal sector involvement in the waste management system of low and middle-income cities.

3.3 Informal refuse collection and scavenging

Informal refuse collectors

Most cities in the developing world do not collect the entirety of waste generated by their residents, which has a negative impact on human health and the environment. In some areas not served by the municipalities, local entrepreneurs provide waste collection for a fee. In many Latin American cities, informal refuse collectors using pushcarts, tricycles, donkey carts, horse carts, and pick-up trucks serve the poor and retrieve the recyclables contained in the garbage, before disposing of the remainder of the waste. In Santa Cruz, Bolivia, for example, informal refuse collectors serve about 37 per cent of the population. In the low-income areas of Ciudad Nezahualcoyotl, Chalco, and Iztapaluca, near Mexico City, hundreds of informal collectors with pick-up trucks, pushcarts, and horse carts provide service in areas not served by municipal authorities. In many Indian communities, residents pay a small fee to local sweepers for cleaning the street in front of their homes (Medina 1997c).

Informal refuse collection can be a profitable activity: the informal refuse collectors of Cairo, popularly known as *zabbaleen*, earn three times the city's minimum wage. Another study found that informal refuse collectors operating in the Mexican city of Nuevo Laredo, on the Texas border, earn five times the minimum wage, putting them in the top 3 per cent of income earners in that city (Meyer 1987; Medina 1998).

Scavenging

Scavenging is a ubiquitous occurrence throughout the developing world. The World Bank has estimated that up to 1 per cent of the population in African, Asian, and Latin American cities survives by recovering materials from waste. Scavengers salvage materials to sell for recycling, as well as reparable and re-usable items that they can sell or use themselves (Bartone 1988; Cointreau 1982).

The recovery of materials from waste by scavengers in developing countries takes place in a wide variety of settings, from plastics bags placed on the kerbside for collection, waste bins on the streets, and at dumps and landfills.

Economic and environmental impact of scavenging

Scavenging renders economic and environmental benefits, such as providing an income to unemployed individuals; supplying inexpensive raw materials to industry; reducing the demand for collection, transport, and disposal equipment and facilities. Further, the recycling of materials has a lower environmental impact compared with the use of virgin resources (Vogler 1984; Medina 2007).

Despite the lack of reliable data at the national level, various studies have highlighted the economic importance of scavenging activities. In Bangkok, Jakarta, Kanpur, Karachi, and Manila, scavenging saves each city at least US\$23 million a year in lower costs for imports and reduces the need for collection, transport and disposal equipment, personnel, and facilities. According to some estimates, Indonesian scavengers reduce the amount of waste that need final disposal by one third, which has significant environmental and economic benefits. In the city of Nuevo Laredo, on the Texas–Mexico border, the economic impact of scavenging activities has been estimated at nearly half a million dollars a month (Furedy 1991; Lohani and Baldisimo 1990; Medina 1997a).

3.4 Solid waste policy: the need for an integrated waste management approach

In order to handle growing volumes of waste, the proper policies need to be enacted and implemented. In the developed world, the approach to waste management regarded as the most compatible with an environmentally sustainable development is called ‘integrated waste management’. This approach consists of a hierarchical and coordinated set of actions that reduces pollution, seeks to maximize recovery of re-usable and recyclable materials, and protects human health and the environment. Integrated waste management aims to be socially desirable, economically viable, and environmentally sound. The integrated waste management approach, however, should be adapted to the local conditions when implemented in third world cities.

Integrated waste management comprises: waste prevention, re-use, recycling, composting, incineration, and sanitary landfilling.

Waste prevention

Waste prevention is given the highest priority in integrated waste management. This is a preventive action that seeks to reduce the amount of waste that individuals, businesses, and other organizations generate. By not creating waste, fewer collection vehicles and fewer refuse collectors would be needed; fewer and smaller waste handling facilities would be required, and it would extend the life of the landfills. Society, as a whole, would benefit from a successful implementation of a waste prevention programme.

Re-use

Once the waste prevention programme has been implemented, the next priority in an integrated waste management approach is promoting the re-use of products and materials. Re-use consists of the recovery of items to be used again, perhaps after some cleaning and refurbishing. Re-using materials and products saves energy and water,

reduces pollution, and lessens society's consumption of natural resources compared with the use of single-application products and materials.

Recycling

After the re-use of materials and products, recycling comes next in the integrated waste management hierarchy. Recycling is the recovery of materials for melting them, repulping them, and reincorporating them as raw materials. It is technically feasible to recycle a large amount of materials, such as plastics, wood, metals, glass, textiles, paper, cardboard, rubber, ceramics, and leather. Besides technical feasibility and knowhow, demand determines the types and amounts of materials that are recycled in a particular region. Areas with a diversified economy and industrial base usually demand more different types of raw materials that can be recycled. In many African countries, artisans also constitute a significant source of demand for waste materials. African artisans and micro-entrepreneurs manufacture consumer products from waste materials, such as sandals, lamps, pots, and pans.

Recycling can render social, economic, and environmental benefits. Factories that consume recyclable materials can be built for a fraction of the cost of building plants that consume virgin materials. Recycling saves energy and water, and generates less pollution than obtaining virgin raw materials, which translates into lower operating costs. Recycling also reduces the amount of waste that needs to be collected, transported, and disposed of, and extends the life of disposal facilities, which saves money for the municipalities. Recycling can result in a more competitive economy and a cleaner environment, and can contribute to a more sustainable development.

In the developing world, municipalities usually lack recycling programmes. That does not mean, however, that recycling does not exist. Informal recycling is common throughout Africa, Asia, and Latin America. Scavengers carry out the bulk of recycling of municipal waste. Scavengers salvage recyclable materials on the streets, before collection crews arrive, at communal refuse dumpsters and illegal open dumps, as well as at municipal open dumps and landfills.

Scavenging provides an income to unemployed individuals, recent migrants who have been unable to find employment in the formal sector, women, children, and elderly individuals. Many scavengers can be considered as a vulnerable section of the population. Due to their daily contact with garbage and their often ragged appearance, scavengers are typically associated with dirt and squalor, and are considered as undesirables – and sometimes even as criminals. Public policy generally considers scavengers as a nuisance or a problem to be eliminated (Abad 1991; Chapin 1995; Fundación Social 1991; Furedy 1984; Kresse and Ringeltaube 1982; Ouano 1991).

Despite the stereotypical view of scavengers as being marginal and the poorest of the poor, a growing amount of evidence demonstrates that that is often not the case. Scavenging supplies raw materials to industry and, therefore, has strong linkages with the formal sector. In some cases, these linkages have existed for centuries, such as in the paper industry. Paper was invented by the Chinese and, up until the nineteenth century, it was made mainly of cotton and linen rags. Scavengers or 'rag pickers' recovered rags from residents and sold them to paper mills, which then recycled them. In the nineteenth century, the paper industry switched from rags to wood pulp as its main raw material. In developing countries today, scavengers still play an important role in supplying

wastepaper to the paper mills. Thus, the rag-pickers of the past and the wastepaper collectors of today have never been a marginal occupation. Scavenging can also save foreign currency by reducing imports of raw materials. Alternatively, if industrial demand is stronger in a neighbouring country, scavenging can become a source of foreign currency by exporting the materials recovered by scavengers (Medina 2007).

Scavengers are not always the poorest of the poor. In fact, scavengers sometimes earn more than factory workers. When scavengers organize themselves in micro-enterprises or scavenger cooperatives, or form public–private partnerships (PPPs) with municipalities, they can achieve a decent standard of living and improve their working conditions, resulting in grassroots development. In African, Asian, and Latin American cities, a growing number of successful micro-enterprises exists; scavenger cooperatives and PPPs that provide low-cost waste management services to municipalities (see Medina 1997c; Medina 2007; Cointreau and de Kadt 1991; Gonzalez *et al.* 1993; Guibbert 1988).

The structural causes of scavenging are underdevelopment, poverty, unemployment, and the lack of a safety net for the poor, as well as industrial demand for inexpensive raw materials. These factors are likely to continue to exist in many developing countries. Therefore, a public policy that supports scavenging activities would be humane, as well as make social, economic, and environmental sense.

Composting

Composting is the process of aerobic biological decomposition of organic materials under controlled conditions of temperature, humidity, and pH, so that the result is a soil conditioner that can be used in landscaping, agriculture, and horticultural projects. Considering the high proportion of organic matter in the waste generated in developing country cities (typically, over 50 per cent), composting can be an option to reduce the amount of waste that is currently disposed of as landfill, thus extending the lifespan of dumps. When composting is conducted under controlled conditions, it does not generate odours and does not attract flies or other animals. Composting recycles nutrients by returning them to the soil.

Incineration

In an integrated waste management approach, incineration occupies the next to last priority, after waste prevention, re-use, recycling, and composting have been undertaken. Incineration is the burning of waste under controlled conditions, usually carried out in an enclosed structure. Incineration could include energy recovery.

Waste generated in developing countries, however, usually does not allow energy recovery, due to the high level of moisture and high content of organic matter. Experience with incineration in developing countries has been mostly negative. Incinerators built in Africa, Asia, and Latin America did not function as promised. In Lagos, Nigeria, incinerators were built at a cost of US\$10 million. The moisture content of waste was so high that fuel had to be added to maintain combustion, which increased costs significantly. The incinerators never operated normally, one was abandoned and the other turned into a community centre. Similar experiences have been observed in

India, Mexico, the Philippines, Indonesia, and Turkey. Therefore, incineration of MSW is likely to fail in many low- and middle-income cities (Cointreau 2008).

Sanitary landfilling

Final disposal of wastes at sanitary landfills is given the lowest priority in an integrated waste management approach. A sanitary landfill is a facility designed specifically for the final disposal of waste in ways that minimize the risks to human health and the environment associated with solid waste. Sanitary landfills commonly include one, two, or three different liners at the bottom and sides of the disposal area in order to prevent leachates from polluting nearby surface waters or aquifers. Liners also prevent the underground movement of methane. Waste arriving at landfills is compacted and then covered with a layer of earth, usually every day. This prevents animals from having access to the organic matter to feed. Sanitary landfills can also include other pollution control measures, such as collection and treatment of leachate, and venting or flaring of methane. It is possible to produce electricity by burning the methane that landfills generate.

As Table 2 shows, high-income countries collect and properly dispose of all municipal wastes generated, while middle and low-income countries have serious deficiencies in the collection and proper disposal of wastes in sanitary landfills.

Table 2: Waste collection and disposal

	Waste collection	Proper disposal
Low-income countries	40 %	5 %
Middle-income countries	60 %	30 %
High-income countries	100 %	100 %

Source: Cointreau (2008).

4 Proposal for a decentralized MSWM system

A decentralized MSWM system is necessary in developing country cities to better respond to the needs of their residents. The proposed system recognizes the fact that low-income and middle-/ upper-income neighbourhoods have different physical and socioeconomic conditions, and that the waste generated tends to be dissimilar. Consequently, their needs diverge, and a decentralized system uses one approach for middle-/upper-income areas, and another for low-income neighbourhoods.

Middle-/upper-income residents' lifestyle and consumption patterns tend to follow those of the developed world. In these areas, the methods and equipment used for collection, transport, and disposal might resemble those of the developed countries. Middle-/upper-income neighbourhoods generally have wide, paved streets that allow conventional trucks to enter and collect the waste generated there. Private communities and apartment complexes commonly use dumpsters that require trucks equipped with a hydraulic mechanism for the loading of the waste into the collection vehicles. The 'not-in-my-backyard' (NIMBY) syndrome is likely to be stronger in middle-/upper-income

communities than in their low-income counterparts. This translates into strong opposition to the siting of any MSWM handling or disposal facility around their communities, necessitating a centralized approach. Wealthier communities are mostly concerned with having their waste picked up, removed from, and disposed of outside their neighbourhoods, preferably at a distant dump or landfill.

Low-income areas, however, require a different approach, almost the opposite to the conventional solutions. Slums require decentralized solutions that actively involve the community in the decision-making process, that are low-tech and affordable, and that consider the contribution that informal refuse collectors and scavengers can make in solving the problem of MSW in the developing world.

The first step towards improving the collection and disposal of MSW requires finding out what informal activities around waste already exist – the number and importance of informal refuse collectors and scavengers. A study employing a joint qualitative/quantitative methodology should be used. In order to identify and analyse the existing patterns in informal refuse collection and scavenging, observation and participant observation of these activities is important. In-depth interviews among scavengers, middlemen, and industry executives would then reveal the linkages between these informal activities and the formal sector. The quantitative part of the study would produce statistically significant data by means of a survey using a random sampling method.

The second step in the process involves an analysis of how informal refuse collection and scavenging could be improved, which involves setting minimum standards of service and incentives for achieving those standards. For example, some informal refuse collectors simply dump the waste they collected at their earliest convenience, either in vacant areas or by the side of the road. Incentives would be necessary to prevent illegal dumping. Informal collectors, scavengers, and the communities should be consulted on their perceptions of how MSWM could be improved in their communities, as well as the residents' willingness to pay for waste collection.

The third step in the process is the promotion and support of grassroots development efforts involving informal refuse collectors and scavengers. Each community would be responsible for collecting its own wastes. Informal refuse collectors would continue operating in the areas where they already work, and their activities would be monitored by the communities, the authorities, or NGOs. In areas that lack both refuse collection, either informal or municipal, small loans could be made to individual entrepreneurs or to groups of informal collectors organized as cooperatives to purchase locally made collection vehicles. Another possibility is the formation of PPPs between authorities and informal refuse collectors/scavengers so that, for example, collectors pick up the waste and take them to a transfer station, from which the municipality takes over for final disposal.

Scavenger cooperatives are increasingly common. Today, more than 1,000 cooperatives exist in South America alone. Many cooperatives are becoming more professional. Some countries – such as Argentina, Colombia, Brazil, and India – have formed national associations of cooperatives. In 2005, a Latin American network of scavengers was formed, and a global network is beginning to take shape (Medina 2008).

Organization and formalization of scavenging activities can render several benefits, such as job security, stability, higher incomes, and empowerment. Industry can also acquire inexpensive raw materials, and cities make savings in the collection and disposal of waste.

A great potential exists for the formation of PPPs for the provision of MSWM services. Indonesia's Kampung Improvement Programme (KIP) could serve as a model in this regard. Under KIP, communities are responsible for collecting their own waste and bringing it to transfer stations, where the local government picks it up and transports it to the final disposal sites. KIP creates income opportunities for informal refuse collectors, and formalizes and dignifies this activity. By assigning responsibility for waste collection to the communities, it minimizes the public investment needed to provide the service. It can also lower collection costs, because collectors tend to use affordable vehicles that are appropriate to the local conditions, and that do not require costly repairs or imported spare parts. The Indonesian government also supports the formation of scavenger cooperatives, and private banks make loans to the cooperatives.

The adoption of a decentralized and integrated MSWM system in third world cities would create jobs; reduce poverty; extend the collection and improve final disposal of waste; minimize public investment on personnel, equipment, and facilities; and reduce pollution and risks to human health and the environment.

4.1 Waste management and climate change

When organic waste – mostly food leftovers, kitchen waste, and garden waste – is sent to open dumps and landfills, it is buried under layers of waste or dirt. Eventually, all oxygen is consumed and organic matter decomposes in anaerobic conditions. Anaerobic decomposition generates methane, a greenhouse gas that is 20 times more potent than CO₂ in trapping the sun's heat. Garbage dumps and landfills generate about 11 per cent of anthropogenic emissions of greenhouse gases (Cointreau 2008).

Diverting organic waste from dumps and landfills can prevent the generation of methane and reduce greenhouse emissions. There are two ways to accomplish this: composting and pig farming. Composting is the biological decomposition of organic matter in aerobic conditions, which generates little or no methane. The resulting compost can be used in landscaping, horticulture, and as a soil conditioner in agriculture. Organic waste, such as food leftovers, can be recovered as used to feed pigs. Composting and pig farming can also create jobs and reduce poverty for the scavengers who recover those materials. In southern Bali, Indonesia, 50 pig farms generate enough demand for organic waste to provide income opportunities for hundreds of scavengers. This practice, however, requires additional research to make sure it does not pose risks to public health from consuming the meat from these farms (Medina 2009).

The recovery and recycling of inorganic materials by scavengers saves energy. Power generation is one of the largest sources of greenhouse gases. Assuming that everything else remains the same, recycling also reduces the emissions of greenhouse gases.

5 Conclusion

Waste management in the developing world is unsatisfactory. The improper management of solid waste represents a source of air, land, and water pollution, and poses risks to human health and the environment. Despite considerable expense, the situation will tend to deteriorate further due to the rapid growth of cities that is likely to occur over the next few decades. Globalization could increase the amount of waste that needs to be collected, transported, and disposed of, further straining cities in Africa, Asia, and Latin America.

Conventional solutions to waste management in the developing world often rely on high-tech, high-cost, bureaucratic, and centralized alternatives. Conventional solutions usually do not consider the profound differences between wealthy and low- and middle-income countries, resulting in less than optimum outcomes. Also, conventional solutions frequently involve the transfer of waste management technology from industrialized to developing countries. International development banks and bilateral development agencies tend to favour this transfer of technology. The experience on the use of advanced technology in developing countries, however, has been largely negative. An analysis of best practices and lessons learned in order to promote south-south transfer of technology and waste management methods should be conducted.

Conventional waste management solutions usually ignore the potential contribution of the informal sector. Scavengers and informal refuse collectors render clear economic and environmental benefits to society, and their activities should be improved and supported. Given the failures of conventional solutions, this paper argues that a different approach is necessary. Low-tech, low-cost, labour intensive and decentralized options are available today. A decentralized system would be more appropriate to the conditions prevalent in the developing world, while encouraging self-reliance and private investment in the communities. A great potential exists for the formation of PPPs between scavenger cooperatives/micro-enterprises and public agencies for the provision of waste management services at a low cost. Successful use of low-tech approaches, and the incorporation of informal refuse collectors and scavengers exist in various African, Asian, and Latin American cities. A decentralized system could help solve the seemingly intractable problem of waste management in developing country cities in an economically viable, socially desirable, and environmentally sound manner.

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