COMPARATIVE ANALYSIS OF SOLID WASTE MANAGEMENT IN CITIES AROUND THE WORLD

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SUMMARY : This paper uses the new data set compiled on 20 cities in six continents for the UN Habitat flagship publication 'Solid Waste Management in the World's Cities'. The comparative analysis looks first at waste generation rates and waste composition data. A process flow diagram is prepared for each city, as a powerful tool for representing the solid waste system as a whole in a comprehensive but concise way. Benchmark indicators are presented and compared for three key drivers / physical components of an integrated and sustainable waste management (ISWM) system – public health / collection, environment / disposal and resource recovery – and for three governance strategies required to deliver a well functioning ISWM system – inclusivity, financial sustainability and sound institutions / pro-active policies. Key insights include the importance of the informal recycling sector in many developing country cities; they not only deliver recycling rates comparable to modern Western systems, but also save the city authorities millions of dollars in avoided waste collection and disposal costs.

1. INTRODUCTION

1.1 The UN Habitat book

UN Habitat's Third Global Report on Water and Sanitation in the World Cities – '*Solid Waste Management in the World's Cities*' was recently launched at the *5th World Urban Forum* in Rio on 23 March 2010, the first time in more than 10 years that the UN system has focused on solid wastes. The request to WASTE, Advisers on Urban Environment and Development to prepare the book, created an opportunity for a global community of practice to work together to fill a gap in the literature and in the knowledge base about solid waste management in low-, middle- and high-income countries. Produced in two expert meetings and eight months of intensive research and writing, the result provides a fresh perspective and new data, based on the framework of Integrated Sustainable Waste Management (ISWM). The work goes beyond traditional solid waste engineering, and indeed beyond strategic planning, to explore the intersection between waste management and recycling, and far-reaching concepts of sustainability and inclusive good practice.

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The study brings out common elements and develops a lens for "viewing" a solid waste management system, while at the same time encouraging every city to develop its own individual system, appropriate both to its specific history, economy, demography and culture and to its institutional, environmental and financial resources. A central tenet is that there is no one right answer that can be applied to all cities and all situations. In this the work challenges the notion that all that a developing country city needs to do is to copy a system that works in a particular developed country city.

1.2 Reliable and consistent data

A major constraint in comparing solid waste management systems in different cities is that there are few consistent solid waste and recycling benchmarks anywhere in the world - not even the most common indicator, cost per ton, is available for most cities. The most basic kinds of information are collected in very different ways in each city, if indeed they are collected and recorded at all. The 20 real cities presented in the book were chosen from six continents. They provide up-to-date and comparable data which are used to inform issues of waste policy, good and bad practice, management, governance, financing, etc. The focus is on processes and interactions among stakeholders as much as it is on technologies deployed.

This paper uses the fresh and exciting city data collected to compare and contrast solid waste management systems in cities around the world, in order to get to a broad understanding of what solid waste management is, and what it can mean for cities, whether they are located in low-, middle- or high-income countries. Three aspects of the data collection methodology are worth highlighting:

- using a process flow approach to understanding the entire waste and recycling system through the construction of a process flow diagram;
- developing and requesting unusual data points and indicators as a way of extending the boundaries of what can be understood and compared; and
- designating a person who has worked in the city and knows it well as the 'city profiler'. This person worked with the city authorities, and provided a critical view on the information obtained.

1.3 Analytical framework

The analytical framework is built around the concept of integrated and sustainable (solid) waste management, known as ISWM (Scheinberg, 2001; Ijgosse et al., 2004). The global team responsible for the work have divided an ISWM system for convenience into two 'triangles', the physical elements and the governance features. The first triangle focuses on three key drivers for waste management (Wilson, 2007), corresponding to the three key physical elements which *all* need to be addressed for an ISWM system to work well work sustainably over the long term:

- public health: maintaining healthy conditions in cities, particularly through a good waste collection service;
- environment: protection of the environment throughout the waste chain, especially during treatment and disposal; and
- resource management: 'closing the loop' and returning both materials and nutrients to beneficial use, through preventing waste and striving for high rates of reuse, materials recycling and organics recovery.

The second triangle focuses on ISWM 'software': the governance strategies to deliver a well functioning system. When solid waste systems fail, our observation is that they often do so not for technical reasons, but because of politics, economics, or institutions. So we have identified three inter-related requirements for delivering ISWM under the framework of 'good waste governance'. There is a need for the system as a whole to:

- *be inclusive*, providing transparent spaces for stakeholders to contribute as users, providers and enablers;
- be financially sustainable, which means cost-effective and affordable; and
- rest on a base of sound institutions and pro-active policies.

Using this ISWM framework has produced some rather surprising insights and results, which challenge conventional wisdom about e.g. waste quantities, costs and governance systems.

2. COMPARING WASTES, FLOWS AND BENCHMARK INDICATORS

2.1 The reference cities

This paper presents and compares the results for the 20 reference cities. Table 1 identifies the 20 reference cities and their populations. The selection criteria were aimed to give a good mix of cities, which would demonstrate a range of urban solid waste and recycling systems across the six inhabited continents and illustrate how solid waste management works in practice in tropical and temperate climate zones, in small and large cities, in rich and poor countries, and at a variety of sizes and scales. Among the 20 cities selected, there are three cities with a population over 5 million, and three with less than 100,000. Some criteria were pragmatic – cities needed to be willing to participate and to share both good and not-so-good practices.

Table 1: Population, income levels, municipal solid waste generation and composition in the reference cities (Scheinberg et al., 2010)

City & Country	Population	GDP (US$) per capita, country	Kg Per Capita/ year	Kg Per Capita/ day	Paper	Glass	Metal	Plastic	Organic	Other	Total
Rotterdam, Netherlands	582,949	46,750	528	1.4	27%	8%	3%	17%	26%	19%	100%
San Francisco, USA	835,364	45,592	609	1.7	24%	3%	4%	11%	34%	21%	100%
Tompkins County, USA	101,136	45,592	577	1.6	36%	6%	8%	11%	29%	11%	100%
Adelaide, Australia	1,089,728	39,066	490	1.3	7%	5%	5%	5%	26%	52%	100%
Belo Horizonte, Brazil	2,452,617	6,855	529	1.4	10%	3%	2%	11%	66%	9%	100%
Curepipe, Mauritius	83,750	5,383	284	0.8	23%	2%	4%	16%	48%	7%	100%
Varna, Bulgaria	313,983	5,163	435	1.2	13%	15%	10%	15%	24%	24%	100%
Canete, Peru	48,892	3,846	246	0.7	6%	2%	2%	9%	70%	11%	100%
Sousse, Tunisia	173,047	3,425	394	1.1	9%	3%	2%	9%	65%	13%	100%
Kumming, China	3,500,000	2,432	286	0.8	4%	2%	1%	7%	58%	26%	98%
Quezon City, Philippines	2,861,091	1,639	257	0.7	13%	4%	4%	16%	50%	12%	100%
Bengaluru, India	7,800,000	1,046	236	0.6	8%	2%	0%	7%	72%	10%	100%
Delhi, India	13,850,507	1,046	184	0.5	7%	1%	0%	10%	81%	0%	100%
Managua, Nicaragua	1,002,882	1,022	420	1.1	9%	1%	1%	8%	74%	6%	100%
Lusaka, Zambia	1,500,000	953	201	0.6	3%	2%	1%	7%	39%	48%	100%
Nairobi, Kenya	4,000,000	645	219	0.6	6%	2%	1%	12%	65%	15%	100%
Bamako, Mali	1,809,106	556	256	0.7	4%	1%	4%	2%	21%	52%	83%
Dhaka, Bangladesh	7,000,000	431	167	0.5	9%	0%	0%	4%	74%	13%	99%
Moshi, Tanzania	183,520	400	338	0.9	9%	3%	2%	9%	65%	12%	100%
Ghorahi, Nepal	59,156	367	167	0.5	6%	2%	0%	5%	79%	7%	99%
Average	**2,462,386**		**343**	**0.9**	**12%**	**3%**	**3%**	**10%**	**53%**	**18%**	
Median	**1,046,305**		**285**	**0.8**	**9%**	**2%**	**2%**	**9%**	**61%**	**12%**	

2.2 Waste generation

The initial comparison is between the quantities of waste generated in the 20 cities. Even this apparently simple comparison posed considerable challenges – definitions of ‘municipal solid waste’ vary widely between countries, with some including little more than household waste while others include varying proportions of their commercial, industrial and construction and demolition (C&D) wastes. The figures in Table 1 have in some cases been corrected to remove some of the more obvious discrepancies – e.g. the reported data for Adelaide and Belo Horizonte appeared to include a much larger proportion of C&D wastes than in other city definitions.

The per capita data in Table 1 shows less difference than usually assumed between cities of widely differing location and income level. The cities in the lowest-income countries generally show waste generation in the range 150-250 kg/capita/year, those in middle income countries 250-450 and those in high income countries 450-650 kg/capita/year. Belo Horizonte in Brazil and Managua in Nicaragua have a relatively higher than expected generation rates, which may be a general characteristic of Latin America.

2.3 Waste composition

Table 1 also provides comparative data on waste composition. These data come with at least two ‘health warnings’. First, cities differ widely as to how and where in the system composition is measured. For example, the measurements apply to: (i) the whole waste stream generated; (ii) the wastes collected from households; or (iii) the wastes arriving at the disposal site. When an active informal sector is removing waste for recycling at different points of the system, the result is that waste composition figures may be measured after some recycling has already happened, so comparisons can be misleading. Cities are often unaware of these nuances and, for the researcher, guessing which is which is not always so obvious. Second, what wastes are included also affects composition – e.g. Adelaide’s high value for ‘other’ again reflects the large fraction of C&D wastes.

- Paper percentages appear relatively low, with 14 cities reporting 3-10% and only 4 reporting more than 15% (in Mauritius, Netherlands and the USA).
- Plastic levels seem more evenly spread; just two cities report less than 5%, 10 cities are in the range 5-10% and eight are between 11-17%. Rotterdam reports the highest figures, but those for Curepipe, Mauritius, Quezon City, Philippines, and Nairobi, Kenya, are unexpectedly higher than for both the US cities.
- Organic levels generally follow expectations, with 10 of the ‘southern’ countries reporting 50-80%, and the five cities in Europe, North America and Australia reporting less than 35%. However, there are exceptions, which point to the importance of local conditions and practices: Bamako in Mali and Lusaka in Zambia collect around 50% of ‘other’ components, which are identified as sand, grit and probably soil, which reduces the relative organic levels.

2.4 Process flow diagrams

The core of the data collection method used a process flow diagram (PFD) to represent a city’s solid waste and recycling system – including both formal and informal elements and operations. A PFD turns out to be a relatively powerful way of presenting the system as a whole in a comprehensive but concise way. A combination of process flow and materials balance was first used in a 2007 study for GTZ and the Collaborative Working Group on Solid Waste Management in Low- and Middle- Income Countries (CWG) (Scheinberg et al, 2007).

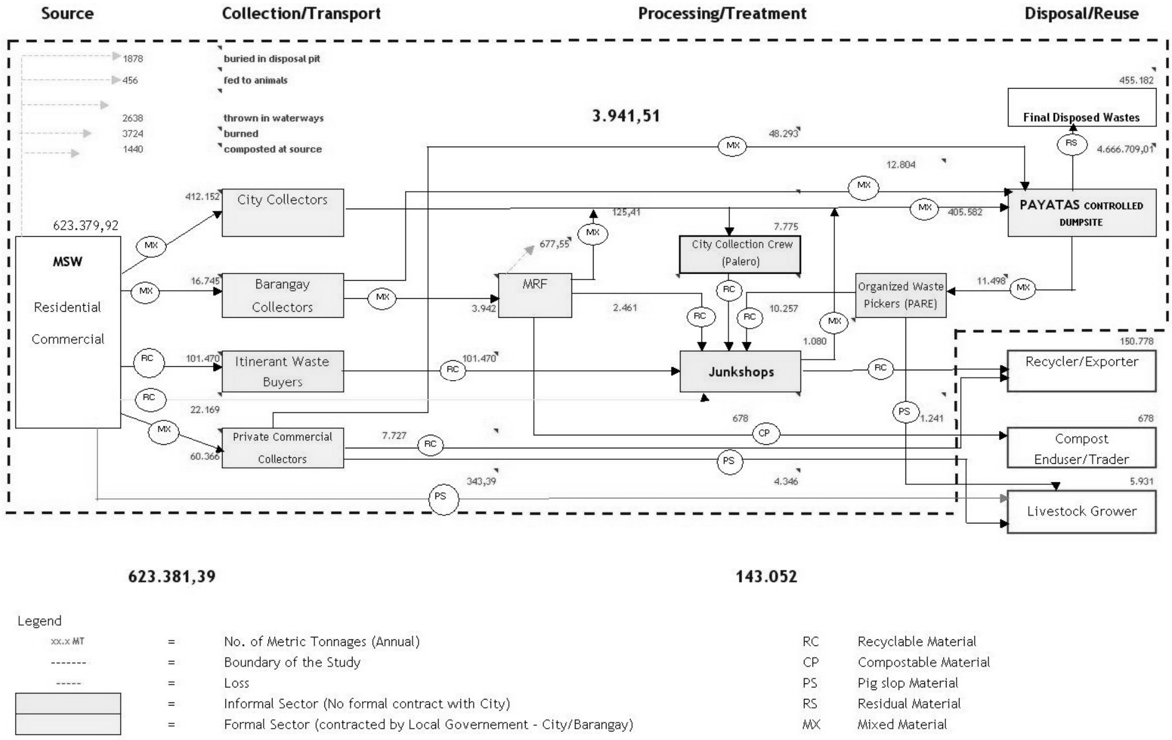

Figure 1: Process Flow Diagram – Quezon City, the Philippines (Source: Solid Waste Association of the Philippines (SWAPP), as shown in Scheinberg et al., 2007)

Process flow diagramming creates a way of making clear where the system boundaries are, of understanding linkages between different types of actors and institutions and of cross-checking numbers that are provided. The process flow for Quezon City, in Figure 1, for example, shows the differences between formal and informal systems, but also how they have become partially integrated in the modernisation process.

2.5 Benchmark indicators

One of the aims of the work was to produce a series of benchmark indicators that can be applied to cities in low-, middle- and high-income countries, and can be used both to allow comparison between cities and to support an understanding of processes and drivers that affect them all. Table 2 compares seven benchmark indicators for the 20 cities, including at least one indicator for each of the three drivers / physical elements and the three governance elements. Four of the benchmarks are quantitative, while three, on inclusivity and institutional coherence, are necessarily qualitative. These indicators are discussed in the sections which follow.

3 DRIVERS/ PHYSICAL ELEMENTS OF THE SYSTEM

3.1 Public health - collection coverage in the cities

Data on the coverage of waste collection and street sweeping in each city – i.e. the percentage of population that has access to waste collection services – is collated as the first indicator in Table 2. These figures matter, as there is strong evidence linking uncollected household wastes to public health, both directly to higher incidence of diarrhoea and acute respiratory infections in children, and indirectly to flooding and the spread of water-borne diseases via blocked drains.

Table 2: Benchmark indicators in the reference cities (Scheinberg et al., 2010)

	Drivers for solid waste management			**Governance**			
	Public health	**Environmental control**	**Resource recovery**	**Inclusivity**		**Financial sustainability**	**Institutional coherence**
	1	**2**	**3**	**4A**	**4B**	**5**	**6**
CITY	**Percent collection / sweeping coverage**	**Percent controlled disposal / incinerated of total disposed / incinerated**	**Percent materials prevented or recovered**	**Degree of user-inclusivity**	**Degree of provider-inclusivity**	**Population using and paying for collection as percent of total population**	**Degree of institutional coherence**
Adelaide	100%	100%	54%	HIGH	HIGH	100%	HIGH
Bamako	*57%*	0%	*85%*	MEDIUM	MEDIUM	95%	LOW
Bengaluru	70%	*78%*	25%	MEDIUM	MEDIUM	40%	MEDIUM
Belo Horizonte	95%	100%	*1%*	HIGH	HIGH	*85%*	HIGH
Canete	73%	*81%*	12%	MEDIUM	HIGH	40%	HIGH
Curepipe	100%	100%	NA	LOW	LOW	0%	HIGH
Delhi	90%	100%	33%	HIGH	MEDIUM	0%	LOW
Dhaka	55%	*90%*	18%	MEDIUM	MEDIUM	80%	HIGH
Ghorahi	46%	100%	11%	MEDIUM	LOW	0%	MEDIUM
Kunming	100%	100%	NA	MEDIUM	MEDIUM	50%	HIGH
Lusaka	45%	100%	6%	MEDIUM	MEDIUM	100%	MEDIUM
Managua	82%	100%	19%	MEDIUM	LOW	10%	MEDIUM
Moshi	61%	78%	18%	MEDIUM	LOW	35%	MEDIUM
Nairobi	65%	65%	24%	MEDIUM	HIGH	45%	LOW
Quezon City	99%	100%	39%	MEDIUM	MEDIUM	20%	HIGH
Rotterdam	100%	100%	30%	HIGH	LOW	100%	HIGH
San Francisco	100%	100%	72%	HIGH	LOW	100%	HIGH
Sousse	99%	100%	6%	LOW	LOW	*50%*	MEDIUM
Tompkins County	100%	100%	61%	HIGH	MEDIUM	95%	HIGH
Varna	100%	100%	*27%*	LOW	LOW	100%	HIGH
Average	82%	90%	30%			57%	
Median	93%	100%	25%			50%	

The data show higher collection coverage than might have been expected. Almost half of our cities, including a number in developing countries, report coverage of 99-100%. Rates as low as 10% had previously been reported as opposed to 45% we found. The lowest four in our group of cities are in the range 45-60%, with another four between 60 and 80%. Some of the coverage rates do hide considerable variation between poorly served slums and well served city centres and richer residential areas within cities, and also between urban and more rural settlements within the administrative city boundaries.

3.2 Environmental control - waste disposal methods and standards

Column 2 in Table 2 shows the percentage of total waste destined for disposal that is deposited in an environmental landfill or controlled disposal site, or any other formal treatment system, including incineration. Here, the shift was to consider both engineered sanitary landfills and controlled disposal sites as “improved disposal”, supporting the gradual process of upgrading open dumps (Rushbrook and Pugh, 1999). Table 3 splits the total tonnages between ‘state-of-the-art’ and ‘controlled disposal’ – the latter term indicates a disposal site with a minimum degree of management, including gate control, fencing and waste placement, which reduces the potential of water, soil and air pollution, and is widely advocated as a first step as a system modernises towards sound environmental control. With the exception of Bamako, all the cities are controlling a minimum of 65% of waste going to their formal disposal sites, with 14 out of 20 controlling 100%. Five of the 20 cities – Delhi, Nairobi, Managua, Canete and Moshi – currently rely entirely on controlled disposal. Many of the cities have attracted international investment to assist with developing state-of-the-art facilities – e.g. Bengaluru and Delhi in India, Kunming in

China and Sousse in Tunisia – while others have donor support to upgrade their former dumpsites – e.g. Dhaka in Bangladesh, Lusaka in Zambia and Managua in Nicaragua. Rotterdam and Kunming are the only examples from the 20 cities that rely heavily on incineration.

Ghorahi in Nepal is interesting as an example of a small municipality in a developing country with very limited institutional and financial resources, which has nevertheless managed to conduct scientific studies, identify a very suitable site that is accepted by the general public, and develop a well-managed state-of-the-art facility. This includes systems for waste sorting and recycling, sanitary landfilling, leachate collection and treatment, and a buffer zone with forests, gardens and a bee farm that shields the site from the surrounding area. Key success factors included a clear vision and strong determination, which enabled them to use a small initial investment from the municipality budget to mobilise national financial support and to bring the site into operation within five years; and a strong landfill management committee involving local people and key stakeholders to ensure that the site is properly managed and monitored.

Table 3 also shows quantities lost or illegally dumped. This data point is created by mapping and accumulating losses from a range of steps in the process flow diagram. The losses identified in the reference cities include: deliberate, such as illegal dumping or traditional backyard burning; accidental, such as losses from blowing litter in transit; physical, such as loss of mass from piles of organic waste by evaporation and biodegradation; or related to informal or undocumented recovery, for example by grazing animals on the disposal sites or tolerating “skimming” of recyclable materials by truck crews. Again, it is encouraging that as many as half the cities report zero losses, while the highest figure is less than half the total waste generated.

Table 3 Waste disposal in the reference cities (Scheinberg et al., 2010)

City	GDP (US$) per capita, country (DP, 2007; HDR, 2009)	Disposed at state-of-the-art landfills in tonnes per year	Disposed at simple controlled disposal sites in tonnes per year	Percent of controlled disposal (including incineration) of total generated	Lost or illegally dumped in tonnes per year
Rotterdam	46,750	245	0	70%	0
San Francisco	45,592	142,330	0	28%	0
Tompkins County	45,592	22,507	0	39%	0
Adelaide	39,066	341,691	0	46%	0
Belo Horizonte	6,855	1,136,246	0	88%	1,405
Curepipe	5,383	23,764	0	100%	0
Varna	5,163	*74,378*	0	54%	*610*
Canete	3,846	0	8,490	0%	2,040
Sousse	3,425	64,000	0	94%	0
Kunming	2,432	615,000	0	62%	0
Quezon City	1,639	450,020	0	61%	9,221
Bengaluru	1,046	1,364,188	*350,000*	65%	209,875
Delhi	1,046	0	1,810,035	71%	611,317
Managua	1,022	0	376,878	90%	10,950
Lusaka	953	77,298	0	26%	112,918
Nairobi	645	0	*307,000*	*35%*	*262,800*
Bamako	556	0	0	0%	198,757
Dhaka	431	511,000	0	44%	509,248
Moshi	400	0	46,538	0%	6,205
Ghorahi	367	2,200	0	67%	394
Average				52%	
Median				58%	

Notes: Figures in italics are estimates. Adelaide: Waste data is that for the entire South Australia, of which Adelaide comprises 78% of the population (2006). Kunming: incinerates some 37% of the waste disposed and landfills 63%. Rotterdam: incinerates almost all of the waste disposed; only the residue (of less than 1%) is landfilled. Quezon City: Payatas disposal site has been very significantly upgraded, but cannot strictly be qualified as a state-of-the-art landfill.

Column 4 of Table 3 reports the percent of generated waste going to controlled disposal. This indicator tends to start low prior to modernisation, then increase as dump sites are replaced, first with controlled disposal and then with engineered sanitary landfill, and has recently been declining again in developed countries as wastes have been diverted from landfill back to e.g. recycling.

3.3 Resource recovery

Table 4 shows a selection from the extensive data in the book on resource recovery. The average rate of resource recovery across the 20 cities is 30%, which is relatively high and by coincidence also the figure achieved by Rotterdam, the only representative from Western Europe. Other developed country cities in the USA and Australia have higher recovery rates (54, 61 and 72%), but so also do three developing country cities – Bamako in Mali at 85%, Quezon City in the Philippines at 39% and Delhi in India at 33%.

Table 4 also helps to put some detail on these bare statistics, by splitting the recovery rate for each city between the formal and informal sectors, and also between materials recycling (glass, metals, paper, plastics,...) and organics recovery to the agricultural value chain.

Recovery in the developed country cities is reported to be entirely carried out by the ‘formal’ sector, although on further scrutiny one encounters individuals in Rotterdam and “mosquito fleet” of informal vehicles in San Francisco that precede the collection early in the morning, focusing on recyclable materials, furniture and household appliances. In Tompkins County and Adelaide there are a range of only partially formalised reuse activities that result in diversion of waste materials from disposal. In the developing country cities, there is much more recovery than is usually thought or reported, probably because these activities are largely informal.

High recovery rates generally require a combination of both materials and organics recycling. In practice however we see that cities may focus on one or the other, or even on individual waste streams: Adelaide’s materials recycling is predominantly for C&D wastes; Tomkins County’s high rate is entirely materials recycling, mostly metals. Quezon City also relies for its high rate (39%) on materials recycling – in this case, 24% is clean, source-separated materials, which are bought by itinerant waste buyers (IWBs), who in the Philippines are employed by local informal sector junk-shops, who in turn are organised by a local NGO, Metro Manila Linis-Ganda. Other data shows that in three of the cities where recovery is predominantly carried out by the informal sector (Quezon, Canete and Ghorahi), the operation recovering the most is the IWBs, while in two more (Bengaluru and Delhi), it is shown as jointly the IWBs and waste pickers who generally sort from mixed wastes, operating either at the *dhalaos*, the central waste collection points, or at the disposal sites.

Bamako is something of an ‘outlier’, with 85% recovery, no controlled disposal and a large percentage reported as illegally dumped. The largest recovery operation is the local traditional practice of *terreautage*, whereby unprocessed waste is sold to crop farmers *(céréaliculteurs),* and waste that has already partially decomposed in the collection sites (*fumure*) is sold to the *maraîchers*, the vegetable farmers in the floodplain of the Niger River.

During the past 10–20 years, high-income countries have been rediscovering the benefits and advantages of recycling as an integral part of their waste (and resource) management systems, and have invested heavily in both physical infrastructure and communication strategies to increase recycling rates.

Table 4 Resource recovery in the cities (Scheinberg et al., 2010)

City	Tonnes recovered, all sectors	Percent materials prevented or recovered	Percent recovered by formal sector	Percent recovered by informal sector	Total percent recycled as materials	Total percent to agricultural value chain
Adelaide	2,611,214	54%	54%	0%	28%	26%
Bamako	392,893	*85%*	0%	85%	25%	31%
Bengaluru	524,688	25%	10%	15%	15%	10%
Belo Horizonte	145,134	7%	0.1%	6.9%	6.9%	0.1%
Canete	1,412	12%	1%	11%	12%	0%
Curepipe	NA	NA	NA	NA	NA	NA
Delhi	841,070	33%	7%	27%	27%	7%
Dhaka	210,240	18%	0%	18%	16%	2%
Ghorahi	365	11%	2%	9%	*11%*	NA
Kunming	600,000	38%	38%	NA	38%	0.05%
Lusaka	17,446	6%	4%	2%	*6%*	NA
Managua	78,840	19%	3%	15%	17%	2%
Moshi	11,169	18%	0%	18%	NA	18%
Nairobi	*210,240*	*24%*	*NA*	*NA*	*20%*	*4%*
Quezon City	287,972	39%	8%	31%	37%	2%
Rotterdam	90,897	30%	30%	0%	28%	1%
San Francisco	366,762	72%	72%	0%	46%	26%
Sousse	4,168	6%	0%	6%	*2%*	4%
Tompkins County	36,495	61%	61%	0%	61%	NA
Varna	37,414	*27%*	2%	26%	27%	NA
Average		30%	16%	15%	23%	9%
Median		25%	4%	11%	22%	4%

NOTES: Figures in italic are estimates. Adelaide: Waste data is that for the entire South Australia, of which Adelaide comprises 78% of the population (2006).The data includes municipal solid waste, commercial and industrial waste, and construction and demolition (C&D) waste. Belo Horizonte: The data includes C&D waste. In addition to recycling and agricultural applications, 0.2% waste is prevented due to a food programme. Kunming: Tonnes recovered include only formal sector and mostly comprise industrial scrap metal. Tompkins County: includes tonnes prevented and reused.

Their motivation is not primarily the commodity value of the recovered materials, but rather a competitive ‘sink’ that the recycling market offers as an alternative to increasingly expensive landfilling, incineration or other treatment options. Many developing and transitional country cities still have an active informal sector and micro-enterprise recycling, reuse and repair systems which, as the data here shows, often achieve recycling and recovery rates comparable to those in the West. Moreover, by handling such large quantities of waste, which would otherwise have to be collected and disposed of by the city, the informal recycling sector has been shown to save the city 20 per cent or more of its waste management budget (Scheinberg et al, 2007). There is a major opportunity for the formal and informal sectors to work together for the benefit of both - building recycling rates, protecting and developing people’s livelihoods, and reducing costs to the city of managing the residual wastes. Good examples include New Delhi, India, Belo Horizonte, Brazil, Canete, Peru, and others. The recycling systems are organised similarly to that in New Delhi, where the city has joined forces with NGOs to recognise and legitimise the informal primary collectors, who deliver their waste after recycling to the *dhalaos*, from which the city’s formal private sector contractors collect the waste for transport to disposal sites.

4. COMPARING GOVERNANCE ASPECTS

An important contribution of the UN Habitat book is the emphasis on the importance of good governance, alongside the more technological and physical elements of the system.

4.1 Inclusivity

A key aspect of good waste governance is inclusivity and fairness, with a dual focus on users and service providers. Looking back at Table 2, one sees in columns 4A and 4B a qualitative assessment of inclusivity for each category. The assessment is based on a composite score from a set of qualitative indicators allowing a yes for present and a no for absent feature in the system.

For *user* inclusivity, the indicator represents the degree to which users of the solid waste services are included in policy formation, planning and siting of facilities, as well as in evaluation of these services. Criteria include, for example, functioning citizens' committees with a mandate and scope to address waste management issues; formal procedures to measure customer satisfaction with waste management services at municipal or sub-municipal level; and effective feedback mechanisms between service providers and service users that are used as the basis for making changes or improvements. For *provider* inclusivity, the indicator represents the degree to which both formal and informal private/ community-based service providers and waste recyclers are included in the planning and implementation process of waste management services and activities.

In Table 2, just two of the 20 cities score high on both of the inclusivity measures, Adelaide and Belo Horizonte. Belo Horizonte is an early adopter city in Brazil – a country which is notable for its programmes to recognize informal waste pickers as a profession and to integrate them into the waste management system and the national economy. Interestingly, both of these cities have a long history of high commitment to institutional development in the solid waste area.

Both measures of inclusivity include a focus on solid waste and recycling stakeholders outside of the formally recognised solid waste structures. It has often been quoted that up to 1% of urban populations in developing countries depend for their livelihoods on waste recycling. We wanted to check this assertion with real data. Table 5 presents the data from the 10 cities that could provide information. In these cities, the proportion of the total city population working in the informal waste sector is often in the range 0.3-0.5%; there are just two higher figures, 1.3% in Delhi and 1.7% in Dhaka. These 10 cities together have a total of 350,000 informal workers, who collect an average of 32 tonnes per person per year, or just under 3 tonnes per person per month. These figures reinforce the point made earlier, on purely financial terms, about the importance of working co-operatively with the informal sector; with such large number of the urban poor making their living from waste recycling, helping them to improve their livelihoods is a key component of working to meet the UN Millennium Development Goals.

Table 5 Profile of informal activities in solid waste (Scheinberg et al, 2010)

City	Workers, informal Sector	Tonnes collected per worker per year, informal	Informal sector workers as percentage of total population	Informal sector workers per km^2
Bengaluru	*40,000*	*6*	*0.5%*	*50*
Belo Horizonte	421	24	0.0%	1
Canete	176	7	0.4%	0
Delhi	173,832	5	1.3%	117
Dhaka	*120,000*	*2*	*1.7%*	*329*
Ghorahi	39	8	0.1%	1
Lusaka	480	205	0.0%	1
Managua	3,465	18	0.3%	12
Quezon City	14,028	17	0.5%	87
Sousse	*150*	*27*	*0.1%*	*3*
Total	352,591			
Average	35,259	32	0.5%	60
Median	1,973	12	0.4%	8

4.2 Financial sustainability

Good waste governance requires that the system be financially sustainable. A variety of benchmark indicators for the 20 cities is shown in Table 6. Compiling comparative – and comparable – data on costs has proved to be particularly difficult: accounting systems vary widely; cost and budgeting mechanisms are often fragmented and scattered over several departments; many cities are either unable or perhaps unwilling to share information on their costs; more information is generally available on budgets rather than on costs.

Table 6 shows that solid waste management comprises 0-15% of the municipal budget across the nine cities where we could calculate a figure, with most in the range 3-10%. This is lower than earlier reported figures of 20-50%, but, as noted above it is open to question because of differences in reporting and even in counting. The SWM budget per capita as a percentage of GDP per capita is another sought-after number: we could calculate this for 16 cities, showing a range of 0.03-0.4% for the four high-income cities, with the 12 low- and middle-income cities overlapping in the range 0.14% -1.22%.

The other columns in Table 6 refer to the collection of, and cost recovery from, SWM fees. All the high-income cities, as well as a number of others including Kunming, Moshi and Nairobi, use one bill, either a direct waste bill or through the utility company. Six of the cities, headed by Belo Horizonte and Bengaluru, complement the direct waste fee with revenues collected through property tax, municipal income tax or national transfers. As shown in column 5 in Table 2, Delhi, Quezon City, Curepipe and Ghorahi are the only reference cities where no general fee is charged to the citizens for waste collection services if they are provided by formal sector – in Quezon City fees are charged from businesses only; waste services in Curepipe, Mauritius, are financed by the Central government from income taxes. Similarly, Delhi finances its waste services from income taxes and other governmental sources. Ghorahi municipal authorities are in the process of introducing a fee.

Table 6 Benchmark indicators for sustainable financing (Scheinberg et al, 2010)

City	**SWM % of Municipal Budget**	**Population using and paying for collection as percent of total population obligated to pay**	**Percent of population that pays for collection**	**Reported cost recovery percentage collected via fees**	**Solid waste annual fee as percent of average annual household income**	**Solid waste budget per capita as pecent of GDP per capita**
Adelaide	10%	100%	100%	90%	0.21%	0.10%
Bamako	NR	95%	54%	NR	2.00%	0.14%
Bengaluru	NR	40%	28%	NR	0.15%	0.71%
Belo Horizonte	5%	85%	81%	36%	3.60%	0.69%
Canete	NR	40%	29%	30%	0.90%	0.14%
Curepipe	NR	0%	0%	0%	0.00%	0.33%
Delhi	3%	0%	0%	58%	0.00%	0.69%
Dhaka	NR	80%	44%	30%	2.00%	0.52%
Ghorahi	15%	0%	0%	0%	0.00%	0.31%
Kunming	NR	50%	50%	NR	1.00%	NR
Lusaka	3%	100%	45%	NR	NR	NR
Managua	NR	10%	8%	50%	0.14%	1.22%
Moshi	NR	35%	21%	20%	0.30%	NR
Nairobi	4%	45%	29%	38%	0.15%	NR
Quezon City	9%	20%	20%	0%	0.00%	0.45%
Rotterdam	NR	100%	100%	100%	0.00%	0.40%
San Francisco	0%	100%	100%	100%	1.43%	0.03%
Sousse	NR	50%	50%	0%	NR	0.40%
Tompkins County	NR	95%	95%	*35%*	0.11%	0.13%
Varna	5%	100%	100%	*76%*	0.90%	1.19%
Average	6%	57%	48%	41%	1%	0.47%
Median	5%	50%	45%	36%	0%	0.40%

4.3 Sound institutions, proactive policies

A strong and transparent institutional framework is essential to good governance in solid waste. Without such a framework, the system will not work well over the long term. Indeed, it was suggested at the 2001 UN-Habitat World Urban Forum (Whiteman et al., 2001) that the cleanliness of a city and the effectiveness of its solid waste management system could be useful as a proxy indicator of good governance. The adequacy of services to lower-income communities also reflects on how successfully a city is addressing issues of urban poverty and equity. For waste management to work well, the city also needs to address underlying issues relating to management structures, contracting procedures, labour practices, accounting, cost recovery and corruption. Clear budgets and lines of accountability are essential.

Measuring institutional capacity is difficult. Column 6 in Table 2 shows one qualitative measure, 'institutional coherence': more than half the cities score 'high' against this indicator, with just three scoring 'low'. Among the parameters that contribute to this indicator are two relatively unusual data points relating to the organisational chart and the budget respectively. One data point asks how high in the organisational chart it is necessary to go to find a management position responsible for all solid waste and recycling functions. In terms of budget, we looked at the number of budgets that contribute to some aspect of solid waste management, and the percent of all budgeted costs which fall under the largest of these budget lines. The higher this percentage, the more coherent is the institutional system.

5. REFLECTIONS AND RECOMMENDATIONS

The decision to seek new data from 20 widely differing cities, and its analysis through the ISWM lens, has yielded some interesting insights and also some surprises which challenge conventional wisdom.

5.1 Data is power

It is a familiar saying that 'If you don't measure it, you can't manage it'. Without proper data collection and management systems, it is difficult to be accountable and transparent, or to make sound strategies and budget for them. If knowledge is power, then a city without knowledge of its solid waste system may lack the power to make positive changes. So, the quality of waste data in a city could be viewed as a proxy measure for the quality of its overall management system, of the degree of commitment of the city, or even of the city governance system.

If this is the case, then most of the reference cities perform quite poorly. Despite finding so many good things going on in the cities, we also found relatively little hard information that we can really point to in our analysis. The reasons for this may be manifold. For example, in highly industrialised and medium-income countries, record keeping is more likely to be designed to meet legal requirements on reporting rather than to facilitate analysis of the waste management system; in low-income countries, municipal authorities are more often involved in day-to-day 'fire-fighting' in providing services rather than systematic planning, implementation and monitoring of their activities. Still, we suggest that, if a city aspires to a 'modern' waste management system, then a good data collection and management system needs to be seen as a one of the key components. Having said that, the 20 reference cities reported here have provided a database which is probably unique, and which we believe offers a better basis for the quantitative comparison of solid waste management around the world than has been available before.

The project reported here has successfully tested and demonstrated a new methodology for compiling baseline information on SWM in a city, which goes beyond either solid waste engineering or social aspect alone to a broader, more balanced view. UN Habitat is now urging donor agencies and others involved in promoting improved SWM to adopt this methodology in their future work. We hope, within a few years, to be able to present comparative data for 50 cities.

5.2 Key messages

The stories from the 20 reference cities, rich and poor and in all parts of the world, show that it is possible to make progress in tackling solid waste management under all kinds of circumstances. There in no ‘one size fits all’: any successful solution must address all three physical elements of ISWM and all three features of good governance under the specific local conditions. The ISWM-based analytical framework suggests building on the existing good practice rather than pursuing some global ideal. In that, for example, developing a local controlled disposal site would be preferable to waiting for a regional sanitary landfill that might be developed in 20 years – and then, only if there are funds from the national government or international donor community. Similarly, seizing the opportunity to strengthen the existing informal recycling systems would be preferable to ignoring them and creating new ones from scratch.

In summary, a reliable approach is to be critical and creative; to start from the existing strengths of the city and to build upon them; to involve all the stakeholders to design your own models; and to ‘pick and mix’, adopt and adapt the solutions that will work in your particular situation.

If a city is at a relatively early stage of the journey of modernising its solid waste management system, then it is important to identify simple, appropriate and affordable solutions that can be implemented progressively, giving the inhabitants the best system they can afford. Early steps are likely to include extending collection to the whole city and phasing out open dumps, replacing them with controlled disposal sites. But that is not enough: an ISWM approach is to focus on building up existing recycling rates, and on taking measures to bring waste growth under control. This is particularly important, as every tonne of waste reduced, reused or recycled (the 3Rs) is a tonne of waste that the city does not have to pay to collect and dispose safely; there are win-win solutions, where the city authorities, citizens, businesses and the informal/ microenterprise sectors work together to progress the 3Rs and contribute to a sustainable resource management and sustainable development of the world community.

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