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An assessment of the current municipal solid waste management system in Lahore, Pakistan

Maryam Masood[1], Claire Y Barlow[1] and David C Wilson[2]

Abstract

The current status of solid waste management in Lahore, a metropolitan city of Pakistan, is reviewed in this article using an existing approach, the UN-Habitat city profile. This involves a systematic quantitative and qualitative assessment of physical components and governance features of the current waste management system. A material flow diagram (MFD) is developed, which allows visualisation of the current waste management system with all related inputs and outputs. This study shows that in the current system, waste collection and transportation is the main focus, however the collection coverage is only about 68%. There is no controlled or even semi-controlled waste disposal facility in Lahore. There is no official recycling system in the city. It is estimated that currently ~27% of waste by weight is being recycled through the informal sector. Making use of the organic content of the waste, a composting facility is operative in the city, producing 47,230 tonnes year^{-1} of organic compost. Lahore does not perform very well in governance features. Inclusivity of users and providers of the waste management system is low in the city, as not all stakeholders are consulted in the decision making processes. Waste management costs US$20 per tonne of waste, where the main focus is only on waste collection, and the current user fees are much lower than the actual costs. This study recommends that recycling should be promoted by increasing public awareness and integrating the informal sector to make the current system sustainable and financially viable.

Keywords

Solid waste management, Lahore, material flow analysis, landfill, recycling, integrated solid waste management

Introduction

Increasing population levels, growing economies, rapid urbanisation and industrialisation, technical and economic development, and improved living standards all contribute to steady increases in the volume of municipal solid waste (MSW) produced around the world. The rapidly growing cities in developing countries are major contributors to this. In common with other developing countries, Pakistan also faces serious challenges in terms of MSW management. Waste generation in Pakistan is likely to be as high as 71,000 tonnes day^{-1} by the end of 2014 (JICA and Pak-EPA, 2005). This continuous increase in the absence of a proper waste management plan poses enormous challenges for public health, environmental protection and sustainable development in Pakistan.

One of the problems in dealing with solid waste management (SWM) issues is a dearth of global MSW data; even when the data is available, it is in varied formats and is often not comparable (Hoornweg and Bhada-Tata, 2012; Wilson et al., 2012). The absence of reliable solid waste data is also an issue in Pakistan. This article presents a baseline assessment of SWM in Lahore, developed using the UN-Habitat methodology (Scheinberg et al., 2010b; Wilson et al., 2012). Lahore has particularly been chosen for this study because it is the provincial capital of Punjab and major investments have been made in the last five years to restructure its SWM system. It makes an interesting case to assess whether or not the waste management in the city has improved with these interventions.

This article presents the characteristics of the SWM system in Lahore in a format that can be compared with the data from other cities in developing countries. Previous studies of the SWM in Lahore (Batool et al., 2008; Ernst Basler + Partner ICEPAK, 2007; JICA and Pak-EPA, 2005; Masood and Barlow, 2012) are mostly focused on the physical components of the system rather than providing a comprehensive analysis including the governance aspects as well. Also, each study has a different basic methodology that makes it hard to compare the system in Lahore with other cities of the world. In the present study, background information is provided about the city of Lahore and each component in the waste

[1]Institute for Manufacturing, University of Cambridge, Cambridge, UK
[2]Department of Civil and Environmental Engineering, Imperial College London, London, UK

Corresponding author:
Maryam Masood, Institute for Manufacturing, Department of Engineering, University of Cambridge, 17 Charles Babbage Road, Cambridge CB3 0BU, UK.
Email: marymasood@gmail.com

management system is then evaluated to assess the current situation. The policies and regulations developed over the years and the role of municipal authorities are also examined. The physical components and the governance aspects of the city are then scored against seven benchmarking indicators. Recommendations for improvement in the current system are proposed.

Methodology

The data collection and presentation for this article follows the city profiling methodology developed for UN-Habitat (Al Sabbagh et al., 2012; Scheinberg et al. 2010b; Sim et al., 2013; Wilson et al., 2012). It is based on the concept of integrated sustainable SWM (van de Klundert and Anschütz, 2001) and is divided into three physical components and three governance features (Scheinberg et al., 2010b). The physical components considered are: (i) public health, (ii) environment and (iii) resource management; while the governance features are: (iv) inclusivity, (v) financial sustainability and (vi) institutional coherence (Wilson et al., 2012). We have calculated and report here the quantitative indicators for the physical components and the qualitative indicators for the governance features, and use those to provide an overview of waste management in Lahore. Another important aspect of the UN-Habitat methodology is the construction of a MFD, which helps to provide quick visualisation of the current system (Brunner and Rechberger, 2004). A Sankey style MFD has been produced for the waste flow in Lahore, developed using the software STAN2.5 (Cencic and Rechberger, 2008; Institute for Water Quality Resources and Waste Management TU-Wien, 2012).

To collect the required data, a desktop study was initially conducted with the available official reports, legal documents and scientific literature related to the SWM trends in Lahore over the last number of years. The next phase was data collection in the field to assess the current scenario (2012), including interviews with the waste management personnel at Lahore Waste Management Company (LWMC) operating in the city District of Lahore, on behalf of City District Government Lahore (CDGL). Observational data was also collected at official and unofficial dumpsites and communal waste container sites. Interviews were conducted with waste pickers, itinerant waste buyers and junk shop owners to understand the informal waste recycling system in the city. This information was used to update and validate the data obtained in the desktop study. The data collected for quantification of the informal sector was used to estimate the waste flows using established protocols and best judgements. The estimated data has been cross-referenced with sources available for other developing countries.

A public survey was also conducted with a sample of 60 people to understand the general public awareness regarding waste management, recycling and its environmental and health impacts. The survey participants were randomly selected at the office of a government organisation to get a good mix of people belonging to different parts of the city. As the survey was conducted at an office, only 35% of the respondents were female and the rest were male. The respondents were within the age range of 20–40 years. The sample size is small as this was a pilot exercise prior to a full survey, which is currently being undertaken as part of the overall project on the role of the informal waste sector (IFWS) in SWM.

Background information on SWM in Lahore

Lahore is the capital of Punjab covering an area of 1772 km^2. It has a population of 8.16 million (Bureau of Statistics, Government of Punjab, 2012), of which 83% is urban and 17% is rural. The rate of population increase in Lahore is 3.1%, which is higher than the 1.55% average population increase in Pakistan (estimated figures from CIA-World Fact Book, 2013); this uplift can be attributed to the high rate of urbanisation in the country. Lahore has been administratively divided into nine towns, which are further divided into 150 union councils. The nine towns of Lahore, with their population, area and estimated waste generation, are listed in Table 1.

Currently, SWM in Lahore is the responsibility of LWMC. This company started operations in 2011 and is responsible for waste collection, transportation and disposal, together with street sweeping. LWMC has 58 officials and 10,000 field workers for waste collection and disposal (LWMC, personal communication, 2011). LWMC has now contracted out part of the waste collection and transportation to disposal sites to two private Turkish companies, M/s Albayrak and M/s OzPak, in March 2012. These companies are taking over the waste management responsibilities in the city in phases.

Physical components of waste management

Waste generation and composition

The amount of waste generated in Lahore has increased over the years mainly owing to population increase and expansion of the city. Estimates of waste generation per capita range from 0.5–0.65 kg day^{-1} (JICA and Pak-EPA, 2005); LWMC have used a per capita figure of 0.65 kg day^{-1} to estimate the total amount of waste in the city at 5300 tonnes day^{-1}. This figure is used here; however, it must be emphasised that it is only an estimate, because there are no procedures in place to measure the actual amount of waste generated or collected in the city (LWMC, 2012a). The waste delivered at the composting plant and one of the disposal sites is weighed, but for two unofficial disposal sites there is no record for the amount of waste entering the site. Waste generation rates depend on household income, time of year and cultural or religious activities. According to LWMC, 'municipal solid waste (MSW) is predominantly household waste (domestic waste) with sometimes the addition of commercial wastes, construction and demolition debris, sanitation residue, and waste from streets collected by a municipality within a given area'.

Table 1. Towns of Lahore with population, area and waste generation rates.

Town Name	Population (million)	Area (km^2)	Approximately waste quantity[a] (tonnes day^{-1})
Allama Iqbal Town	0.80	513	520
Aziz Bhatti Town	0.59	68	383
DGB Town	1.01	30	656
Gulberg Town	0.81	43	526
Nishter Town	1.04	494	676
Ravi Town	1.65	31	1072
Samnabad Town	1.03	37	669
Shalimar Town	0.55	24	357
Wahga Town	0.68	442	442
Cantonment Area[b]	–	97	–
Grand total	8.16	1780	5301

[a]The quantity of waste generated in each town is calculated based on population and average waste generation rate per capita of 0.65 kg/capita/day (JICA and Pak-EPA, 2005).
[b]Cantonment areas are residential areas for army officials and are managed by the army. This area is not a responsibility of CDGL.

Table 2. Composition of waste by weight in Lahore in the year 2012 (data rounded to one significant figure) (ISTAC, 2012).

Waste type	Households (%)	Commercial (%)	Institutional (%)	Overall (%)
Biodegradable	67.0	67.5	45.6	64.8
Combustibles	3.2	2.3	1.5	2.1
E-waste	0.1	0.6	0.10	0.3
Glass	0.7	0.6	1.8	0.8
Hazardous waste	0.8	0.6	13.6	1.5
Metals	0.1	0.02	0.30	0.10
Other	7.6	4.0	7.3	5.3
Paper–cardboard	2.8	1.9	6.1	2.4
Plastics	0.8	0.4	1.3	0.9
Plastic bags	9.00	13.7	11.7	11.7
Tetra pak	1.0	1.0	2.6	1.0
Textile	6.9	7.4	8.1	9.1
TOTAL	100.0	100.0	100.0	100.0

The waste composition in Lahore is presented in Table 2, as characterised in a recent study (ISTAC, 2012). This study is based on waste samples collected from communal waste containers. According to the report, the characterisation process took into account the socio-economic structure of the city by collecting waste samples from low, middle and high income areas, as well as the commercial zones and institutes in the city. The characterisation study found that approximately, 65 wt% of the generated waste in Lahore is organic, while paper and plastic appear to constitute only about 15 wt% of the total generated waste. The interesting fact here is that these sampling tests were carried out on waste collected from communal containers, so the expectation is that most of the recyclable materials, such as paper, plastic, glass and metal, had already been retrieved from the waste by the waste pickers. Of the 16 wt% apparently recyclable fraction left in the 'residual' waste that is collected, nearly three-quarters (12 wt%) is plastic shopping bags; which is a very high percentage considering the low density of these bags. About 1.5 wt% of the waste is hazardous waste and it can be seen that most of this derives from institutional waste; the most likely reason for this high percentage is that the institutional waste sampled here came from the waste collected from hospitals.

Waste collection

The public health driver in the integrated solid waste management (ISWM) approach of UN-Habitat (Scheinberg et al., 2010b; Wilson et al., 2012) is assessed based on a quantitative indicator of the waste collection coverage in the city. This refers to the proportion of population served by a reliable waste collection service. Waste collection in Lahore is carried out in two steps, termed primary and secondary collection. Primary collection is door-to-door collection of waste from households by either the private companies or the informal waste collectors. Secondary collection is collection of waste from the communal waste containers placed at various locations in the city. In the current system, the dominant method of waste collection is secondary collection. The two private companies are, according to their contract with LWMC, operating in 17 out of 150 union councils, collecting 292 tonnes of waste every day by door-to-door

Table 3. Details about the communal waste containers and their capacity.

Company that owns the containers	No. of union councils served	Total No. of containers	Total capacity of containers (tonnes)	Total amount of waste generated in the area (tonnes)
LWMC	133	975	1319	4700
OZPak	8	757	115.10	293
Al-Bayrak	9	852	136.30	307

LWMC: Lahore Waste Management Company.

Figure 1. Communal waste containers used by LWMC (10 m^3), OZPAK (0.76 m^3) and Al-Bayrak (0.8 m^3).
The LWMC containers are the old system that is currently being replaced in phases by the new containers by OZPAK and Al-Bayrak. The figures show there is not much improvement in terms of cleanliness of the container sites owing to change in containers.

collection procedures. Waste is collected by the waste workers at a fixed time from each household in the plastic bags provided by the companies, and is then taken to the nearest communal container site. The other 133 union councils are still being covered by LWMC and there is no door-to-door collection provision in those areas.

As LWMC does not provide door-to-door collection in the 133 union councils it serves, informal waste pickers/collectors provide primary collection, using either donkey carts or wheel barrows. They collect the waste and sort it for recyclables. They are usually paid by the households every month for their service, either in cash or in barter for items such as food and clothing. These informal collectors then transport the collected and sorted waste to the nearby container sites for secondary collection by LWMC. It is important to note that LWMC is not responsible for waste collection from cantonment (areas of residence for military personnel and their families) and private housing societies, as these areas are responsible for their own waste collection and transportation. The waste from these towns, however, is dumped in the city either in the designated dumpsites or on vacant plots.

LWMC has supplied 975 containers of 10 m^3 and 5 m^3, while the private companies have installed 1609 new containers of 0.8 m^3 each in the areas they have taken over (see Table 3 and Figure 1). These new containers are equipped with lids and wheels for smooth transfer of waste to compactors. It had been expected by LWMC that these containers would improve the cleanliness of the city. However, it has been observed that in the communal areas, such as markets or shopping centres, waste becomes scattered around the bins before the secondary collection takes place owing to the small size of the containers. Although there is a large number of a small containers, people tend to throw waste only in the closest available bin, even if it is already full. The problem could be alleviated by strategic positioning of bins according to waste generation rates.

Overall in Lahore, it has been estimated that approximately 68% of the waste generated is collected by informal and formal waste collection systems. LWMC claims that, together with its partnering private companies, it collects 73% of the waste generated, however, we observe that this figure relates only to the waste generated in the urban union councils (83% of the population) of the city.

The number of waste collectors employed for any town in Lahore is not based on the total area or population of the town. The areas that have more political backing because of their central location, businesses and regular visits from politicians have more resources directed towards them, while some towns with larger areas are completely neglected (Masood and Barlow, 2012). In Lahore, following an outbreak of Dengue virus in the year 2011, the government has placed particular emphasis on improved waste collection from the city. Since then, every year LWMC launches a number of campaigns to clear empty plots of land used as garbage dumping sites in order to control the breeding of dengue mosquito larvae in them. However, in the areas where collection is infrequent, waste bags are still seen dumped outside houses, resulting in flies and bad odour. Heaps of wastes were observed during the field study outside public parks, close to/inside water drainage channels and in vacant plots. Along with illegal disposal on land, uncollected waste also causes a serious threat of blocked drains and flooding (Wilson et al., 2013b). There is a high percentage of plastic bags in the waste stream of

Lahore (see Table 2), which are responsible for blocking drains in the city causing problems almost every monsoon.

LWMC has a fleet of about 500 vehicles for waste transportation to the disposal sites. It also operates a workshop to maintain these vehicles. Most of the fleet is old and obsolete and requires continuous repair (LWMC, 2012). According to a World Bank report, on average 15%–18% of all mechanical vehicles are down for repair or maintenance on any given day (KOICA–WorldBank, 2007). The private companies have imported modern vehicles, including compaction garbage trucks and mini dumpers. These vehicles will become LWMC's property after the end of the seven year contract with the private companies. It is expected by LWMC that these new vehicles will solve the issues of odour and littering of waste during transportation: these are major drawbacks of the open-top collection vehicles currently in use by LWMC. However, the potential benefits are somewhat questionable for two main reasons. The older parts of the city have narrow streets and it is not clear how these larger modern vehicles can be deployed effectively in these areas. Further, the waste stream of Lahore already has a high density as a result of its high organic content, so use of compaction trucks may not provide any benefits in terms of improving collection capacity. There is a possibility that they may only become an additional burden on the overall costs of transportation.

The collection points are supposed to be visited once per day in the early morning, but in many areas there is no specific secondary collection schedule that is followed. It was also noted during the observational study that there is no proper system of planning and monitoring the efficiency of the collection routes. There is no attempt to minimise fuel consumption by optimising the routes followed by the transport trucks, and no fuel usage records are kept (Mehmood et al., 2010).

Disposal

In common with most developing countries, waste disposal is a weakness in the SWM system of Lahore (Batool and Chaudhary, 2009; Wilson et al., 2013b). The amount of waste treated or disposed in a controlled facility is the UN-Habitat methodology indicator for environmental control. There is no landfill in the city of Lahore. A proposal was presented as part of the master plan Lahore-2021 (NESPAK, 2004) for three new landfill sites, but only one of these sites, Mehmood Booti, is currently in operational mode. Two more sites are also being unofficially used by LWMC to dispose of waste, namely Saagian dumpsite and Bagrian/Tiba dumpsite. The only difference between the official and unofficial sites is the ownership of land and the provision of a weighbridge. On the unofficial sites, the waste is dumped on the wish of the land owners wanting to fill depressions in their land with the waste.

A weighbridge is installed on Mehmood Booti and is used to measure the amount of waste brought to the site every day. This site has been in use since 1997 and is in the flood plain of the river Ravi, which flows almost 5 km away; it has never been upgraded to a landfill as proposed. The level of waste dumped at each of the disposal sites was observed to be about 8 ft higher than the ground level; there are no leachate management facilities. The absence of daily covers increases the odour, presence of vermin and pests, animal scavenging and the risk of uncontrolled fire. There are no barriers around any of the disposal sites to prevent public entrance.

It has been observed that waste is also sometimes dumped at the water bodies or vacant plots nearest to the collection point (Batool and Chaudhary, 2009; Mehmood et al., 2010). Since LWMC has taken charge of the city, such practices have visibly reduced but they still exist. Instances are also observed of waste being burnt, illegally, both by scavengers to retrieve metals, but also by the SWM authorities themselves. This is done to reduce the volume of waste because of insufficient space. Only about 40% of the waste generated ends up in the disposal sites, while 8% of the total waste is converted to compost (see Figure 3, detailed later). The details of the composting plant are given in the next section. In essence, Lahore performs rather poorly on the environmental indicator as there is no controlled or semi-controlled landfill site in the city. The waste treatment facility, i.e. composting plant, is however run as a controlled facility, so the score of Lahore on this indicator is thus 8%.

Resource recovery

The indicator for reduce, reuse and recycle (3Rs) is quantitative and is calculated based on the recycling rates in the city. In Lahore, a composting plant operates as a public private partnership project. The CDGL awarded a concession to a private company Lahore Compost (Private) Limited (LCL) for set-up and operation of the plant to process the organic content of MSW arriving at Mahmood Booti dumpsite. The composting plant is located in the vicinity of the dumpsite and uses a windrow-type composting method to produce 47,230 tonnes year^{-1} of compost of what is expected to be sold as 100% organic fertiliser (although sales are presently low, perhaps because of poor marketing but also because of the quality of the compost). The project has been set-up on a Build–Operate–Transfer basis for a period of 25 years.

The pilot phase of the project started operation in March 2006 to initially process up to 300 tonnes day^{-1} of MSW. The project was registered as a clean development mechanism (CDM) project by the Board of the United Nations Framework Convention on Climate Change (UNFCCC) in April 2010. According to LCL, the composting plant is now being run at its full capacity and receives approximately 1000 tonnes day^{-1} of mixed waste collected from the city (UNFCCC, 2013). The compost production ratio for this facility is 17%, as the plant receives waste on 275 days of the year (UNFCCC, 2013). The mixed waste is sorted both manually and mechanically. About 65% of the total waste received is organic waste that goes to the composting plant, the remaining 35% is a combination of recyclable waste and rejects (UNFCCC, 2013). The percentage of recyclables in the rejects is

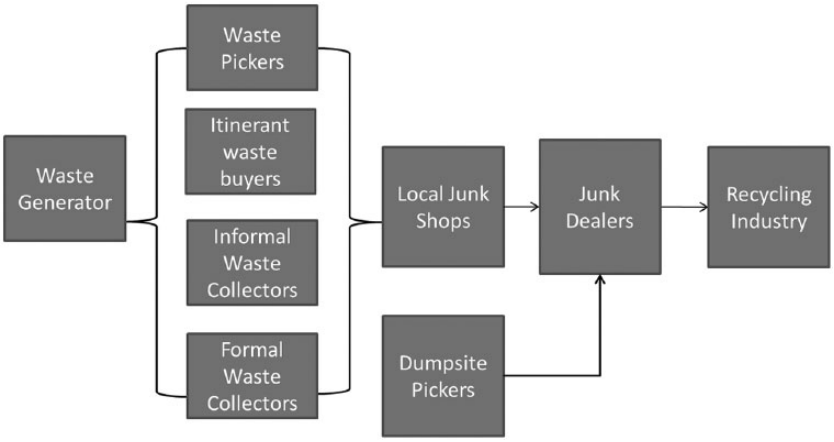

Figure 2. A generic diagram representing the flow of recyclables in the city of Lahore.

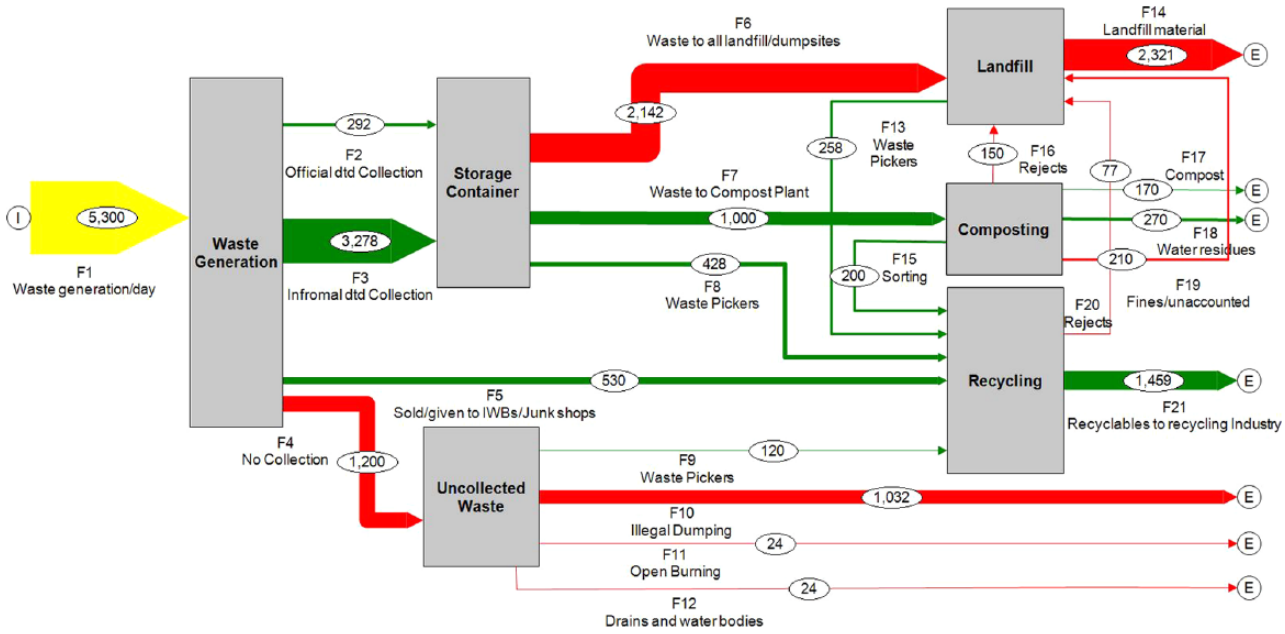

Figure 3. MFD for waste flow in Lahore (detailed assumptions, estimations and sources of data are listed in Table 5).

reported as 60% (of 35%), and the rest is inert waste that also goes to the dumpsite (Aly et al., 2010). The recyclables are taken by the waste pickers operating on the dump site. As the fines and remains from the composting plant are also dumped in the Mehmood Booti dumpsite, the total amount of waste converted to compost is 8% of the total generated waste in the city.

Along with the high organic content, the waste stream of Lahore also includes such potential dry recyclables as plastic bottles, newspaper, cardboard and metals. There is no formal recycling system in place in the city, although segregation of waste starts at the source in many cases, a trend common in many developing countries (Sembiring and Nitivattananon, 2010). A strong informal network including waste pickers on streets, communal waste container sites and dumpsites, itinerant waste buyers, formal waste collectors and even domestic servants primarily capture all the recyclables in municipal waste. As Figure 2 shows, the formal waste collectors (the waste workers employed by LWMC) also separate the recyclables from the waste collected from communal container. The recyclables collected are either reused by the collector or passed on through a network of local junk shops to the major junk dealers in the city. Sorting of all waste is done manually and no protective clothing is used.

In an annual progress report LWMC claims that about 10% of the uncollected waste is removed from the city by the waste pickers (LWMC, 2012).However, from on-going research on the quantification of the role of the informal sector, through surveying households and junk shops in the city, we have estimated that about 27% of the waste generated in the city is recycled informally. Another interesting finding of the research is that 10% of the generated waste is already separated at source for reuse or recycling, giving a useful reduction in the weight of solid waste that is collected and disposed of by LWMC; this observation matches the estimates in a previous study (Batool and Chaudhary, 2009). Table 4 presents information about the survey that was conducted in one

Table 4. Details of survey participants and interviewees.

Actors	Number of survey participants	Number of interviewees
Informal waste collectors (IWC)	–	30
Waste pickers (container sites) (WP)	61	30
Dumpsite pickers (DP)	–	–
Itinerant waste buyers (IWB)	–	30
Formal waste collectors (FWC)	–	5
Junkshops	110	30

of the nine towns of Lahore to estimate the amount waste that is recycled in the city. The overall estimate is an extrapolation of the data collected for one town, i.e. Gulberg Town.

Recycling activities in Lahore not only reduce the environmental burden of solid waste, but also enhance economic opportunities (Batool et al., 2008; Scheinberg et al., 2010a). Owing to the presence of the informal sector and their activities in the recycling sector, LWMC has to deal with about 27% less waste for collection and disposal. These figures are similar to those observed in cities such as Delhi in other developing countries (Handayani et al., 2010; Scheinberg, 2001, 2011). This is an established system in developing countries and to improve the recycling rates it is important to integrate the work of the informal sector with the formal sector (Masood and Barlow, 2013; Velis et al., 2012; Wilson et al., 2013b).

The authorities, however, are not usually supportive of the role of what they regard as scavengers, and indeed are attempting to remove them from the city by reducing the size of storage containers making sorting of waste more difficult for them (LWMC, personal communication, 2011). Such a mind-set exists because local politics has so much influence on the urban development issues; the informal sector workers, especially those at the base of the chain, are either migrants from other countries (particularly Afghanistan) or from rural areas, and do not necessarily have a local vote, so their welfare is not a prime concern for politicians. Additionally, most of the waste pickers work on their own and are not a part of any co-operative or union; this makes it more difficult for them to protest against any changes made to the system that affect their livelihood.

The response of the general public towards the informal sector and the task they fulfil was observed to be mixed. People are often unaware of the presence of waste pickers at the communal waste container sites or even on the streets, but nevertheless their role as waste collectors is regarded as beneficial. They are paid for their services on a monthly basis and are also sometimes provided with food, old clothes or other usable items by the households. In some cases, it was also observed that the households tend to separate recyclables, such as plastic bottles, aluminium cans and paper, at the source for the informal collectors. The source-segregated waste is less contaminated and can be sold at better prices.

The best estimate we have for an overall recycling rate in Lahore is 35%, where 27% of the waste is recycled by the informal sector and 8% is composted. The estimate is based on a combination of our observations and published data as shown in Figure 3.

MFD

The MFD presented in Figure 3 represents all major flows of waste in Lahore, including both formal and informal activities and processes. The quantities in this diagram were estimated and in some cases extrapolated based on data available from LWMC and published reports (Ernst Basler + Partner ICEPAK, 2007; JICA and Pak-EPA, 2005; KOICA–WorldBank, 2007; LWMC, 2012b; UNFCCC, 2013). No official data exists on the recycling rates in the city, so these figures are estimated based on the data collected as part of the current project. The results are in line with the data available in the literature for other lower-middle income countries (Scheinberg et al., 2010b; Wilson et al., 2009, 2012). Details about the sources of data are given in the methodology section. The sources and methods used for each estimation in the MFD are presented in Table 5.

Governance factors

Inclusivity

Inclusivity in the context of the current study refers to the role and responsibilities of all stakeholders in the waste management system. The UN-Habitat methodology discusses inclusivity in two dimensions: (i) user inclusivity and (ii) provider inclusivity. This is a qualitative indicator and is assessed on the degree to which users (waste generators) and providers (private and informal sector) of the solid waste services are included in the decision-making process for waste management.

As suggested by many waste management specialists, SWM solutions for any community have to be tailored to local circumstances (Scheinberg et al., 2010b; Wilson et al., 2012). In Pakistan there are no specific laws that ensures people are made a part of the decision-making process through consultation. The level of public awareness and attitudes towards waste impacts not only the quantity and nature of waste generated, but also its final destination. The results from the sample public survey suggests that almost 80% of the people are concerned about the impacts of waste on the environment, however, only 30% were ready to separate their waste for recycling purposes. Only 20%

Table 5. Details of the flows of the MFD (Figure 3).

Waste flows	Description	Method of estimation	Information source
F1	The overall quantity of waste generated in Lahore every day.	Calculated as the estimated waste generation rate (0.65 kg capita^{-1}) multiplied by the population.	Waste generation rate: JICA and Pak-EPA (2005). Population: Bureau of Statistics, Government of Punjab (2012).
F2	Waste collected from door-to-door by contractors on behalf of LWMC. Currently covers only 17 out of 150 union councils.	Figure from LWMC data.	LWMC, 2012a.
F3	Collection by informal sector workers who collect waste from door-to-door and then take it to the communal storage containers. They also pick recyclables from the waste, which is depicted in the separate flow 'waste pickers'.	Calculated by the authors. F3 = F1 – (F2 + F4 + F5)	Estimate by authors.
F4	This includes recyclables separated at source and given away to domestic servants or sold directly to itinerant waste buyers/junkshops.	Estimate based on observations, interviews and data collected on informal sector in Lahore.	Estimate by authors.
F5	Waste that is left on the streets or open places and is never collected.	Figure reported by LWMC. Validated by the authors using field observation and data collection.	LWMC, 2012b.
F6	Total amount of waste dumped in all 3 disposal sites of the city.	Figure reported by LWMC	LWMC, 2012b.
F7	Mixed waste that is delivered by LWMC to the composting plant	Figure reported by LWMC and UNFCCC.	Aly et al., 2010; LWMC, 2012b; UNFCCC, 2013.
F15	Recyclable material, both manually and mechanically sorted, from the mixed waste at the composting plant is picked up by the informal sector.	Figure reported by Aly et al. and UNFCCC report	Aly et al., 2010; UNFCCC, 2013.
F16	Inorganic waste not suitable for recycling goes to the landfill.	Figure reported by Aly et al. and UNFCCC report	Aly et al., 2010; UNFCCC, 2013.
F17	Compost ready for sale.	Reported in UNFCCC monitoring report	UNFCCC, 2013.
F18	Moisture loss from the waste material during composting	Calculated by the author based on figures reported in literature. The actual figures vary in each plant and these figures are only indicative	Andersen et al., 2010.

(Continued)

Table 5. (Continued)

Waste flows	Description	Method of estimation	Information source
F19	Fines/unaccounted material that end up in landfill	Calculated by the author based on figures reported in literature. The actual figures vary in each plant and these figures are only indicative	Andersen et al., 2010.
Waste pickers	Waste pickers collect recyclable items from storage containers, open dumps, streets and disposal sites.	Estimate based on observations, interviews with waste pickers and data collected on amount of recyclables gathered by them.	Estimate by authors.
F8			
F9		Figure reported by LWMC	LWMC, 2012b.
F13		This figure is estimated based on literature, observations, interviews and field work for a study on informal sector in Lahore.	Estimate by authors.
F11	Uncollected waste that is burnt locally to reduce its quantity or to get rid of the odour. Also, informal sector burns the waste to retrieve metals.	This figure is estimated by the author with observation of waste container sites, illegal dumpsites and official disposal site.	LWMC, 2012a.
F12	Waste dumped at drains or water bodies in the city.	Reported by LWMC.	LWMC, 2012b.
F10	Waste not removed by waste pickers or authorities remains either on the streets or open spaces.	Reported by LWMC.	LWMC, 2012b.
F20	Rejected material from recyclable stuff.	This figure is estimated based on literature, observations, interviews and field work for a study on informal sector in Lahore. There is, however, a possibility that part of this waste is dumped illegally, but no proof for that was found during the study.	Estimate by authors
E	End point.	This refers to the end point of a waste stream	

of people said that they were aware of the waste management policies in the city, even though LWMC claims to frequently promote waste management targets and goals in the city. There is no permanent scheme of public education through schools or colleges. Campaigns and outreach activities for waste prevention and proper disposal of waste are held only occasionally. A complaint cell was established by LWMC in December 2011, where complaints can be registered by phone or by the LWMC website, but our sample survey indicates that only 5% people know that such a service exists.

Provider inclusivity represents the degree to which non-municipal waste service providers are involved in the planning and implementation of SWM systems in a city (Wilson et al., 2012). In Lahore, the private sector participates in the provision of the waste services, but it has been observed that most decisions taken about selection of private contractors are political. In 2011, three private companies were contracted by LWMC to conduct door-to-door waste collection from six union councils designated as model areas. However, despite a reasonably good performance of the companies, their contracts were terminated to award new contracts to Turkish companies. Such decisions are discouraging for the local private companies and create an uncertain business environment for them. Despite their contributions in the system, the IFWS is completely ignored. Neither the authorities nor the public appreciate their economic contribution in SWM and to the economy. This can be clearly seen from the fact that the city has effectively brought in two private contractors at the expense of existing informal service providers who appear to be deliberately excluded. Lahore thus performs relatively poorly on the inclusivity indicator, with a 'low' assessment against the criteria for both user and provider inclusivity.

Financial sustainability

The indicator for financial sustainability is the percentage of the population using and paying for waste collection services. The total budget for SWM in Lahore was Rs. 2.9 billion (US$30 million year^{-1}) for the year 2009–2010; a breakdown of the budget is shown in Table 3 (Aly et al., 2010). The budget was raised to Rs. 6.0 billion year^{-1} (US$65 million year^{-1}) for the year 2011–2012 to accommodate the high costs of waste management by the private companies. Overall, the waste management cost has risen from about US$13 tonne^{-1} to US$20 tonne^{-1}, with waste collection and transportation remaining the only focus. Waste collection is a cost intensive activity involving collection, transportation to container sites, transportation to disposal sites, salaries of staff and other incidental charges. LWMC receives its budget from two sources; first from CDGL for regular operations and second from the provincial finance department for carrying out special initiatives such as outsourcing of services.

The user fees for waste management services are collected by the Water and Sanitation Agency (WASA) along with the water bills. The waste management charge is 21.45% of the water bills of households, of which WASA retains 15% as a service charge and the remaining 85% goes to CDGL. Industrial and commercial units pay a fixed fee directly to CDGL, while the residential charges depend on the property size. From the survey, it was observed that most people were unaware of the exact fees paid for their waste management service, because the billing procedures are difficult to understand. LWMC provides collection services to 68% of the population (based on the average collection rate) and the charges are collected from households with water bills. So the UN-Habitat indicator for financial sustainability is estimated to be 68% for Lahore, as 68% of the population is both using and paying for the service. Lahore scores high on this indicator because the indicator is based only on one criterion and does not take into account other factors, such as accounting systems, the coverage of overall budget, the percentage of revenue generated from user charges in the overall budget and the affordability of user charges and access to capital for investment.

LWMC proposes to implement a robust and viable revenue generation plan. The waste management user fee was set quite a few years ago and was directly related to costs at that time. With the increased costs, the proportion of the cost covered by the user fee is now very low. The proposed plan for improved revenue generation is based on zoning according to rich and poor areas. The proposed increase in charges ranges from increasing residential charges from 0.11–0.55 (US$/month/households) to 1.00–6.00 (US$/month/household), which is a substantial increase. To put these figures into context, the average monthly household income in Lahore is generally in the range of US$60–$300, so the new charges could amount to 1.6%–2% of household income – a commonly used test of affordability of user charges for SWM is that it should not exceed 1% (Wilson et al., 2012). LWMC understands that approval of the new user fees will be dependent on political decisions, and may well not be granted. Even with these increased user charges, it is expected that LWMC will raise enough to cover only 50% of its expenditure in the year 2013–2014 (LWMC, 2012b). The important question to be asked here is whether users will be prepared for such a sharp increase in the charges. Because of the lack of door-to-door service in the current system, many users are already paying charges twice (to the formal sector and to informal collectors), so the increased charges will only put extra financial burden on them.

Sound institutions and proactive policies

The indicator for sound institutions and proactive policies is a qualitative indicator and is assessed on the following criteria: (i) policies, (ii) the degree of municipal control, (iii) control over waste management budget and (iv) management control of the responsible waste management department. The SWM system in the city district of Lahore was formalised under the Lahore Urban Project in 1978. In 1980, a mission of the World Bank first addressed the issues of SWM in Lahore. The Solid Waste Management Department of CDGL was made responsible for the collection and disposal of solid waste in the Lahore District in 2001. The CDGL operates under the Local Government and

Community Development Department through Punjab Local Government Ordinance, 2005. In March 2011, CDGL delegated to LWMC the task of waste management in the city. LWMC is responsible for collection, transportation and disposal of waste and part of the service delivery has been contracted to two private companies as explained earlier.

Decision making in SWM planning is done by CDGL, LWMC, Environmental Protection Agency (EPA) and other ministries if required. LWMC has become a reasonably competent municipal enterprise to deal with development and execution of waste management plans. The management, planning and supervisory staff are well educated, have clear job descriptions and are trained on a regular basis. Looking at the national picture, the SWM legislation and regulations in Pakistan are inadequate, outdated and not target oriented. A number of organisations are involved in different roles. Broadly categorised, the role of the federal government is advisory, the role of the provincial government is regulatory, and the role of the local government is statutory in management of solid waste and enforcement of related laws. Provinces take responsibility for enforcement of the environmental laws, and the task is further delegated to the districts, municipalities and union councils. The federal government appears to have been concerned with SWM since the 1990s with the formulation of the National Conservation Strategy.

The Pakistan Environmental Protection Act, 1997 (PEPA, 1997) laid out principles for protection of air, water and the environment in general. In the national environment policy, 2005 (Ministry of Environment, 2005), suggestions were provided to reduce the environmental risks caused by poor waste management. In Punjab, SWM byelaws were passed in 2005, in which city district governments were held responsible for the cleaning of streets and for protecting the health of people within their borders. Currently, no standardisation laws for solid waste collection and disposal processes exist. There is a dire need for legislation and policies that are target-oriented based on setting deadlines for achievement of the goals.

Poor enforcement of existing laws is also a major reason for the current state of waste management. For example, the Guidelines for Hospital Waste Management require the medical waste to be handled separately and incinerated. However, the legislation is not effective and the consequent presence of medical waste in the municipal waste stream poses a serious threat to health and safety of both formal and informal waste workers and the general public. Another major problem that exists is the unavailability of reliable data on waste generation rates, impacts of open dumping on the local environment, impact of illegal dumping on water bodies and amount of waste recycled or that can potentially be recycled.

The overall qualitative score of Lahore for this indicator is ‘medium’. LWMC has complete management control and accessibility to the SWM budget to use it according to its plans; however, it performs unsatisfactorily in terms of sustainable policies and implementation of existing regulations.

Discussion

Summary of current situation

The city of Lahore has been assessed on a set of indicators for this study. A summary of the indicators calculated for Lahore is presented in Table 6. Despite all the focus and attention of LWMC on waste collection and transportation, 100% collection rates have yet not been achieved. The inclusion of private companies for waste collection and transportation is expected to improve the collection rates, but it is too early to judge their performance. All three of the existing disposal sites in Lahore are no more than dumpsites. Only one of the sites has a weighbridge, but the methods of disposal are far from the requirements of a controlled landfill. Resource recovery still does not appear to be a major focus of the city government, although according to our estimate 27% of dry recyclables are being informally recycled in the city. A composting plant converting 8% of the waste into organic compost is in operation. Despite a major percentage of the SWM budget being spent on the physical components of the systems, i.e. collection and transportation, Lahore still has many areas that are unserved and face problems such as illegal dumping and burning of waste.

The performance of Lahore on the governance indicators is not very good. For a sustainable system to exist in the city, inclusion of all providers (formal, private and informal) as well as users in decision-making is essential. The composite indicator for inclusivity gets a ‘low’ score because of the uncertain conditions that prevail, both for the private sector companies and the informal sector. Public engagement is also only limited to biannual awareness campaigns. The financial sustainability indicator achieves a high score of 68%, but the important point in this case is that the amount collected as user fees is only a small percentage of the overall budget required for waste management. Also, the costs for waste management have risen sharply following the involvement of the private sector, but this has not been accompanied by a significant improvement in the service provision. The involvement of the private sector is generally expected to reduce the waste management cost, as it tends to be more efficient and can provide cheaper services than the public sector. In Lahore, however, we observe the opposite, mainly because the private companies have brought in new vehicles that will become LWMC’s property after the seven year contract period. The overall assessment for the sound institutions and proactive policies indicator is ‘medium’; however, in terms of clear policies for the future, Lahore scores a zero. To achieve a sustainable and integrated system, the municipality must take account of the financial and technical resources, manpower, knowledge available and expected waste quantities. Policies and legislation need to be examined and updated, but it is then crucial that such legislation is enforced.

Suggestions for future priorities

A number of suggestions are made here, aimed at the development of an integrated and sustainable system for SWM in Lahore. It has

Table 6. Summary of the performance of Lahore on UN-Habitat ISWM framework and definitions of the benchmark indicators (Scheinberg et al., 2010b; Wilson et al., 2012).

No	Driver	Category	Indicator	Score for Lahore	Description
	Physical components				
1	Public health	Collection	Waste collection coverage	68%	Quantitative percentage of population receiving reliable waste collection service.
2	Environmental	Disposal	Controlled disposal	8%	Quantitative percentage of the total waste disposed in either a controlled, engineered or state-of-the-art treatment or disposal site. For landfill definitions, see Hoornweg and Bhada-Tata (2012).
3	Resource management	3Rs – reduce, reuse, recycle	Recycling rate	35%	Quantitative percentage of total waste generated that is recycled (includes both dry material and organics recycling).
	Governance strategies				
4A		User inclusivity	Degree of user inclusivity	Low	Composite assessment on a set of five qualitative criteria, that is: • provision for user participation in the planning process (2); • policy formation; • feedback mechanism; • citizen committees.
4B		Provider inclusivity	Degree of provider inclusivity	Low	Composite assessment on a set of six qualitative criteria, that is: • policy formation; • platform for private sector; • informal sector involvement (2); • legal/institutional barriers and access (2).
5		Financial sustainability	Population using and paying for collection	68%	Quantitative percentage of total households both using and paying for waste collection services.
6		Sound institutions and proactive policies	Institutional coherence	Medium	Composite assessment on a set of six qualitative criteria, that is: • policy framework (2); • municipal control (2); • management controls within one department (2).

been observed that most of the budget is directed towards waste collection and transportation, with very little attention being paid to disposal and resource recovery. An efficient and sustainable system must be planned with a long term horizon using an integrated approach. For improving collection rates at a lower economic and environmental cost, it is suggested that the municipalities work with the existing informal collectors to provide a door-to-door collection and recycling service, with the non-recycled materials being delivered to communal containers from where they would be collected by the secondary collection vehicles (Masood and Barlow, 2013). A similar system has already been started in New Delhi (Scheinberg et al., 2010b); such a system has the potential to increase the level of collection service while minimising the collection cost, which is a major cost in the current system. This will reduce the burden on the waste management system and make the system financially more stable.

The poor performance of Lahore on the environmental protection indicator calls for action towards improvement of its disposal sites. As a first step, the landfill sites should be managed according to recognised standard procedures, including being covered daily with soil covers with additional intermediate soil covers in the monsoon season. In the longer term, new landfill sites should be planned as sanitary landfill sites, with proper facilities for leachate management and gas control (Rushbrook and Pugh, 1999). It will be important to phase in these vital improvements, so as to ensure the financial sustainability of the system.

The organic waste percentage in the waste stream of Lahore is high and there is already a composting facility in place. The maximum capacity of the composting plant should be utilised as a first step to diverting more waste from being landfilled. Currently, as shown in Figure 3, the plant receives mixed waste and processes only 650 tonnes day^{-1} out of the 1000 tonnes day^{-1} of waste received. However, before increasing the compost production it is very important to create a strong market for the sales of compost. Waste used in the composting plant is mixed waste from households, which substantially reduces the quality of the organic component of waste. Collection of source-separated organic waste directly from restaurants, and fruit and vegetable markets, could significantly improve the quality of the compost.

There is no formal recycling in Lahore, but estimating the recycling rate as the key indicator for resource recovery has helped in understanding and highlighting the current contribution of informal sector recycling to SWM in the city. We have estimated the current dry recycling rate as 27%; in the absence of informal sector recycling, it follows that waste quantities to be collected and disposed of would increase by nearly a quarter. The city's current (2011–2012) budget for waste collection and disposal of Rs. 6.0 billion year^{-1} ((US$65 million year^{-1}); it follows that the informal recycling sector is already saving the city around Rs. 1.5 billion year^{-1} (US$16 million year^{-1}) in avoided collection and disposal costs. We thus recommend that the city authorities should engage proactively with the informal recycling sector, with the aim of developing win–win solutions, which should further increase the recycling rates and the cost savings to the city, while at the same time improving livelihoods and working conditions of the recyclers (Masood and Barlow, 2013; Velis et al., 2012; Wilson et al., 2009).

Enhanced public awareness regarding waste management is essential to engage the public as the users of the system. The problem assessed in Lahore is that the city has not done enough to involve the users in the process. If behaviour change is needed, then that requires positive engagement with householders, involving them in the redesign of the services, as well as then providing instructions and information on the benefits of the new system, its working and the role of users. Workshops and public meetings need to be arranged at union council level to disseminate this knowledge at the local level. A good starting point may be schools, and teaching the teachers to spread the word is a very effective use of resources. It is observed that women generally take care of the waste at household level, so educating them and informing them of the hazards of poor waste management practices is essential (Masood and Barlow, 2012).

Despite major investment in improving the waste management system, the city is lacking in terms of governance strategies. The absence of target-based policies and proper planning does not allow the system to be sustainable on a long-term basis. The current political government is focused on the improvement on waste management and is spending more than the actual budget available. However, the system will face serious problems if the next political government is not willing to allocate a budget of this scale for waste management. The system needs to be more reliant on its local capacities, i.e. integration of the informal sector and efficient use of the formal employees.

Conclusion

The current waste management system in Lahore has some significant institutional and operational deficiencies. Like many developing countries, public health is still the major driver for waste management in Lahore (Wilson, 2007). Efforts are being made by the city towards improving SWM, but the improvements are not sufficiently comprehensive or far sighted. A lot of focus and money is still being directed towards waste collection and transportation, but the results are not impressive. Our calculations suggest that the collection capacity for communal containers is only 30% of the total generated waste. Such gaps in planning and physical infrastructure are major contributors to the poor state of waste management in the city. The waste disposal facilities are insufficient and of a very basic level.

A composting facility is in place providing an appropriate end-of-life route for organic waste; improving quality by sourcing well-controlled waste from commercial sectors, efficient operation of the facility and proper marketing of the product is required to enhance its benefits. The importance of the informal sector in recycling of waste should not be ignored: they can play a vital role in a fully integrated waste management system. The current user fee structure and sharp rise in the waste management budget of the city poses questions on the financial sustainability of the system on a long-term basis. It is concluded that, although there are weakness in the planning and institutional structure, the major weakness lies in the enforcement of regulations.

The methodology used for developing this city profile is generally very suitable for presenting an overall picture of waste management of a city. The six components encompass the wide array of aspects that are required for evaluation of the SWM system in a city. However, there are some weaknesses that exist in the original UN-Habitat framework as used here, more specifically, where quantitative indicators are involved. In developing countries, with the limited availability of data, it is difficult to justify the use of just one number while ignoring the associated issues. For example, the waste collection coverage indicator is based on the number of households that receive a waste collection service, but it does not account for the quality of service that is provided. Also, there is no mention of the frequency of the service provided, which varies for every city. So, even if theoretically 68% of households in Lahore receive a waste collection service, the service consists largely of no more than a secondary collection from communal containers. Also, the indicator for financial sustainability is based on the proportion of people who both use and pay for waste collection. As mentioned earlier, this indicator again only represents a single data point, whereas a composite indicator addressing a range of criteria would be more suitable to assess the situation. The methodology also does not provide much information about the socio-cultural aspects of the waste management system in the local context. Work is being undertaken to address such feedback and further improve the ISWM benchmark indicators (Wilson and Cowing, 2013; Wilson et al, 2013a).

Overall, it can be concluded from the current study that lack of planning, and of both public and political will, are key barriers to improving SWM services in the city. Significant investment in facilities is required, but opportunities exist to reduce both future investment and operating costs by increasing existing recycling rates through proactive co-operation with the informal sector. Engaging all the stakeholders in the system can be an important step towards improvement. Future developments should include focus on the areas of composting, recycling and sanitary landfills.

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The authors declare that there is no conflict of interest.

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