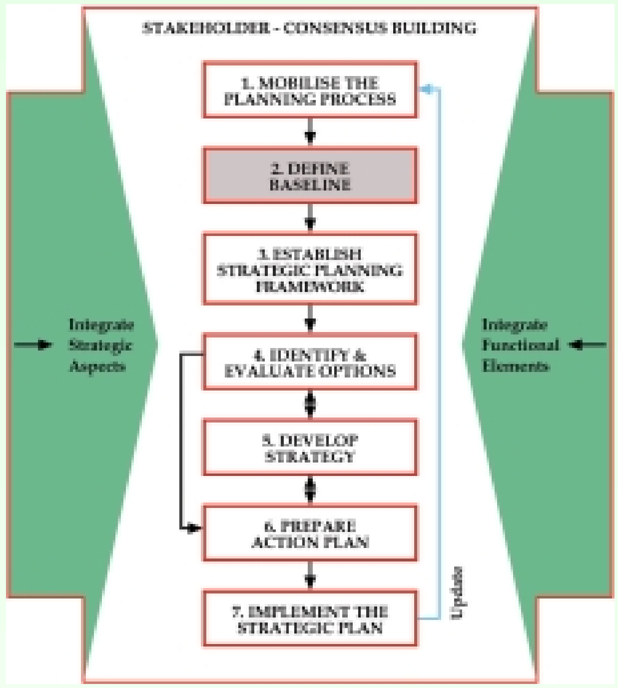
CONTENTS

2 *STEP 2 - DEFINING THE BASELINE*

2.1 *USER GUIDE TO THIS STEP*



Having completed setting up the foundation for the Strategic MSWM plan in [Step 1](#) work on the substance of the plan may now begin.

The purpose of *Step 2* is to help you characterise the present situation in your city, and also to use this knowledge in predicting the future requirements of your MSWM system.

Guidelines and practices for collecting and analysing data are presented, focusing on what is useful and valuable for the MSWM plan. In most metropolitan regions, it is likely that much of the essential data will already be available, and what will be required will be to verify and build on these existing data. *Step 2* of the Planning Guide will therefore help to ensure that these data are comprehensive enough to enable effective decision-making. In doing so *Step 2* will include work in four specific areas:

Task 2.1 Determining Waste Quantities and Composition		*Task 2.2* Reviewing Waste Management Operations		*Task 2.3* Predicting Future Capacity Requirement

Understanding Shortfalls and Constraints

Completion of each of these tasks will provide an essential understanding of both the baseline situation, and what is required in the Strategic MSWM Plan.

Box 2.1 *How to Use Step 2*

Determining Waste Quantities and Composition involves identifying and collecting currently available data. Data will also need to be verified, and sometimes built on through hands-on survey and measurement. Where no data already exists, then measurement will be required. This task should be led by a suitable expert(s) from the Working Group, or if necessary, by an external consultant. Measurement will involve a team of municipal workers, and should be undertaken initially over a two to four week period, and subsequently at seasonal intervals throughout the strategic planning process, to take account of variations in waste quantities and characteristics.

Reviewing Waste Management Operations will establish a benchmark of current operations, and provide the basis for ongoing monitoring and performance measurements. The task should be undertaken by members of the Working Group (or consultants on their behalf) in partnership with municipal waste management staff. Reviewing operations can be a fairly extensive process, and it is important to plan the work carefully and build on existing data. Depending on the scale of the operation and the availability of data, this benchmarking exercise may take anywhere from three to twelve weeks.

Predicting Future Capacity Requirements is designed to understand future demand for services. The task should be led by an appropriate member of the Working Group (or consultant) in consultation with local waste managers and statistics offices. This is a discrete task that will need to be carried out following determination of the current baseline.

An **Understanding** of **Shortfalls and Constraints** will emerge from the previous tasks. These shortfalls and constraints form the basis of an initial understanding of some of the key issues requiring attention during the strategic planning process.

How long will it take to complete Step 2?

Depending on the availability of existing information and the complexity of the existing system/study area, the Baseline study can take anything from one to three months. Data will need to continue to be collected at regular intervals over a period of 6-9 months to account for seasonal variations.

Who should use this Step?

- The MSWM department (or equivalent)
- Working Group Members
- Facilitators/Consultants

Outputs of this Step

A baseline study synthesising key data and information on the existing system, predicting future waste quantities and presenting an audit of MSWM services and summary of shortfalls and constraints.

The baseline study should be carried out early on in the planning process, and preferably be prepared in time for a summary to be presented at the first participatory workshop in *Step 3*. Where more detailed surveys are required to fill data gaps, results should be integrated into later strategic planning outputs.

2.2 KEY MESSAGES OF THIS STEP

'Key Messages'

The effectiveness of a future waste management system will depend upon the quality of data used in planning.

Measuring waste quantities and characteristics is aimed at ensuring adequate capacity for waste collection, recycling and disposal.

Do not duplicate work, it is extremely likely that a high proportion of required information is already available. Select representative areas for sample surveys and focus data collection on key data that have a critical effect on decisions.

An understanding of key shortfalls and constraints needs to be gained during Step 2. This initial analysis should be developed into a set of agreed key issues at the participatory workshop held during Step 3.

The SWM service must cope with all situations, so measure daily and seasonal variation, not just average quantities and composition.

Estimation of future quantities and characteristics needs to reflect increasing wealth and consumption, demographics, as well as materials likely to be recovered from the waste stream for recycling.

Quantities of waste requiring treatment and disposal will be determined by the performance and coverage of waste collection services.

2.3 GENERAL GUIDANCE ON DATA COLLECTION

2.3.1 *Why is Data Collected?*

The effectiveness of a future waste management system will be heavily influenced by the quality of data used in planning.

The baseline study will need to evaluate the range of institutional, technical, financial and promotional aspects of MSWM. *Box 2.2* below provides a checklist of issues to address in collecting data.

The focus of the baseline study should be to collect the data and information required to understand key shortfalls and constraints and prepare a basis for the Strategic MSWM Plan. Following the baseline study additional surveys should be carried out to fill data gaps.

This exercise has considerable value beyond the baseline study itself. Both the data themselves, and the systems used to collect the data, can provide a basis for the long-term improvement of MSWM services. The original data forms a benchmark for future comparison, and when collected on an ongoing, repeatable basis, provides valuable management information (see *Step 7*).

Box 2.2 ***Data Collection Checklist***

The preparation of a Strategic MSWM Plan requires a great deal of information. Generally we need information to assist us in answering questions we are facing in planning the MSWM system.

- What questions about the MSWM system are you seeking to answer?
- What sources of information are immediately available, both internally and in related organisations?
- How much detail is required?
- What are we going to use the data for?
- How accurate do the answers need to be?
- Can reliability be checked, if so how?
- What format should be used for data collection and storage?
- Are we seeking quantitative information, qualitative information or both?
- Does qualitative data need to be structured, in terms of opinions, views, or judgements?

Source: Adapted from ERM (1990). Solid Waste Disposal, Seven Towns Project in Uganda. For GTZ/World Bank

2.3.2 *How to Collect Data?*

In the subsequent sections we look at alternative methodologies for collecting specific data.

Building on Existing Data

It is extremely likely that a high proportion of data required are already available, although maybe not in one source. Data may be obtained from, for example, the examination of existing departmental records or the examination of official statistics at the municipal and/or national level. It is important to build on previous studies, making maximum use of previous studies in order to avoid unnecessary duplication of effort. Existing regional or city development plans should be used as sources for information on socio-economic development. Another useful source of data and information may be (available from) NGOs.

Alternative Methods for Collecting Data

There are a number of alternative methods available for collecting data. These include observation studies, consultation with other departments and bodies, and the use of interview checklists or surveys.

Where checklists are used (eg, for willingness-to-pay surveys, etc) they should be filled in by interviewers and field surveyors, rather than simply distributed for postal return (ie, questionnaire type surveys). This is because of the difficulty of obtaining responses and ensuring that all respondents complete the checklist in the same way, so that the results are meaningful.

It is also necessary to consider the technical and human resources required to carry out the survey and collate and interpret the results. A pilot test of the survey will be useful to allow for an analysis of the results before using it on a large scale. If external specialists are used to do the work, the terms of reference for the work should be carefully defined.

Focus on Representative Sample Areas

Often it may be almost impossible to carry out a detailed assessment of the present situation in the entire planning area.

Therefore it is common practice to undertake analysis in one or more sample areas which are areas significantly smaller than the whole planning area, but which are representative in some way of the larger area. However, even in a small city there are many types of areas with different characteristics, and it is therefore vital that the chosen sampling areas reflect the whole system of study.

It is likely that operating systems will have evolved to meet local conditions, and sampling must therefore be undertaken for each type of area, bearing in mind that any planned changes in the system should take its historical context into account. However, the number and size of the sampling areas should be decided based upon the availability of study resources, ie, a balance will need to be arrived at between the need for representative samples, and the extent of your project budget.

Box 2.3 provides an example classification of common waste generation sampling areas. Another common system of classification may be based upon collection vehicles in use, eg, hand carts, small vehicles, large vehicles etc.

Box 2.3 *Example Classification of Sampling Areas*

- Ordinary Residential Area (high income area)
- Ordinary Residential Area (middle income area)
- Ordinary Residential Area (low income area)
- Marginal Settlements, eg, peri-urban squatter settlements
- Commercial Area
- Rural Town and Village
- Large Waste Generators (markets, hotels, shopping complexes, flats, etc)
- Industrial Areas

2.3.3 What Data to Collect?

Data will need to be collected covering a wide range of topics. As noted, most of the general background data will hopefully already exist and will simply need to be located and compiled. An example of the range of general background data useful for the Strategic MSWM Plan is provided in *Box 2.4* below.

Box 2.4 *Overview of Required Background Data and Information*

Geographic Boundaries of the Plan Area (see *Step 3*)
- Key MSWM geographic data

Socio-economic Background
- Population size and trends
- Demographic statistics (migration rates, density, geographic distribution, etc)
- Income profile
- Urban employment by sector
- Economic development
- Customs and culture

Housing
- Dwelling ownership
- Dwelling unit profile (occupants, size, facilities, access to facilities, etc)
- Low-income dwelling unit profile (growth rate, density, access to facilities, etc)

Health
- Basic statistics
- Principal diseases and rate
- Geographic and social indicators

Natural Environment
- Ecosystem(s) description (include region, not just metropolitan area, also any areas of particular sensitivity)
- Climate (rainfall, temperature, dispersion conditions)
- Water table and resource supply (inputs and outputs)
- Topography
- Environmental hazards (eg, monsoon, landslides, seismic and volcanic activity)
- Environmental issues (eg, traffic, air quality and water quality)

Land Use
- Urban land use by category
- Land ownership and registration
- Land use regulation
- Land use by suitability

Political Profile
- Administrative system
- Key authority designation
- Key planning initiatives (national, regional, local)
- Key city objectives

Source: Adapted from J. Leitmann (1995) . Rapid Urban Environmental Assessment - Lessons from Cities in the Developing World, Volume 2: Tools and Outputs. UMP Technical Paper No. 15, The World Bank, Washington. ISBN 0-8213-2791-7.

Other data sets may, however, require measurement. This is most likely to be the case in the determination of waste quantities and composition, as even if these data have been the subject of previous studies, they will generally require expansion and verification. Guidance on the measurement of waste quantities and characteristics is provided in Task 2.1.

Be careful not to `grab a number'. Big decisions require local data, eg, on waste quantities and composition. Literature or data extrapolated from other cities should be used for scoping only.

2.4 MEASURING WASTE QUANTITIES AND COMPOSITION

2.4.1 *Objectives and Outputs*

Key objectives and outputs for measuring waste quantities and composition are presented below.

Objectives

- Determine the capacity required for on-site storage, transportation, transfer facilities and disposal of solid waste;
- Identify the recycling and resource recovery potential of solid waste; and
- Determine the likely future capacity requirements of the waste management system.

Outputs

- Generation rates of MSW in kg/person/day;
- Bulk density of solid waste generated in kg/m^3; and,
- Composition of waste generated as proportions of the total.

Why Measure?

- Quantification is required to estimate future demand on services.
- Where data are not available special surveys may be required.

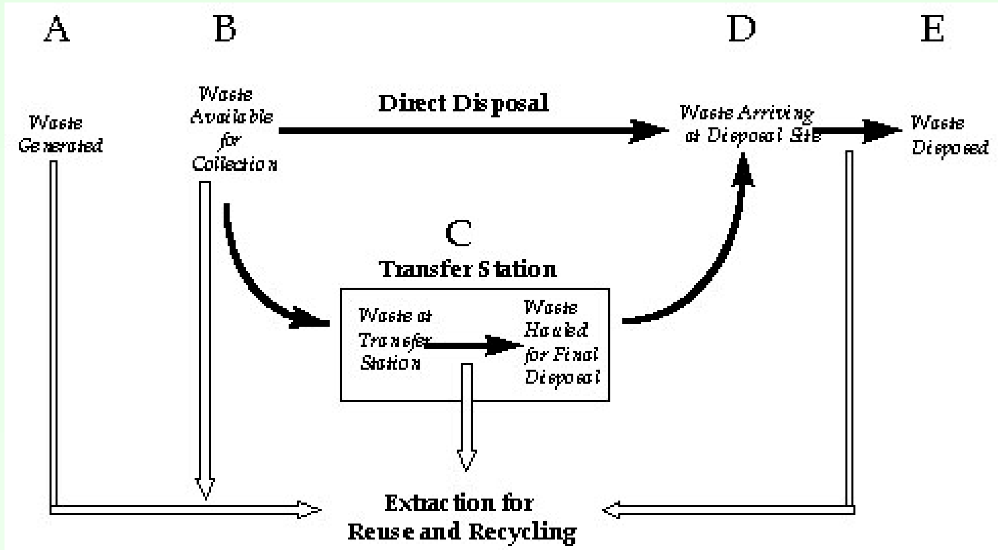
Many waste systems are currently sub-optimal as a result of a lack of good data and information to support management decisions.

2.4.2 *Measuring Waste Quantities*

What to Measure

Waste quantities may be measured at a number of different points along its route from generation to disposal. *Figure 2.1* depicts the route, or chain, in the waste management system.

Figure 2.1 ***Points in the Waste Management System*** (*Source: ERM*)



Measurement of waste quantities at points A-E shown in *Figure 2.1* will indicate varying quantities of waste along the same chain, from source to disposal. The relationship between these points and their 'measurability' will differ according to the nature of the system in operation. However, typically waste generated (point A), and waste arriving for either transfer or disposal (points C and D - which may also be termed waste collected) are the most readily measurable quantities.

Waste quantities (outside of or between these points) will vary according to infrastructure, and quantities of secondary raw materials extracted for recycling purposes.

Measuring waste quantities and characteristics is aimed at ensuring adequate capacity for waste collection, recycling and disposal. The waste service must be able to cope with daily and seasonal fluctuations, so measurement of variability is important. Maximum and minimum values are of interest, not just average values.

How to Measure

Several methods are available for determining the quantity of wastes that require collection and disposal. However, perhaps the only means of arriving at an accurate figure is to weigh all waste in a given area by measuring the load on each vehicle as it arrives at point C or D. Weigh scales or weighbridges can be usefully installed at the entrance to each site, or use made of other weighbridges in your City.

If circumstances make this unfeasible, or information is required for other points in the system, then alternative options exist. These include measuring *samples* of waste generated and *samples* arriving for transfer and disposal. By reconciling point A measurements with those from points C and D, quantities of wastes being reused, or disposed elsewhere may be determined.

The remainder of this section describes the methodologies used in sampling quantities and characteristics of wastes. *Box 2.5* highlights some issues to be aware of when undertaking sampling programmes. Further information and examples are provided in *Annex 2.1* and *Annex 2.4*.

Box 2.5 How to Undertake a Waste Sampling Programme

1. When undertaking a sampling programme it is important to define carefully the nature of the study. Socio-economic groups of higher income generally produce more household waste than lower-income groups, and there is also variation in the waste composition. Understanding the socio-economic characteristics of a region is therefore of vital importance. For these reasons sampling programmes must reflect the diversity of the sampling area. This is true at all points of measurement - collection, transfer and disposal.

2. When sampling quantities of waste generated it is often necessary to involve a waste survey targeting members of the local community, together with an appropriate proportion of shops, hotels, and restaurants, usually consisting of at least 100 locations. By ensuring that the sampling programme and its rationale are fully explained to the participants, a high degree of cooperation can be reached, for example through the distribution of leaflets, or the assistance of a community representative. In addition, care should be taken in making sure that samples take proper account of the potential for seasonal variations etc., and the sampling study should be therefore be repeated at a later date with seasonal information fed back into the planning process.

3. Sampling wastes destined for transfer and disposal may require the inclusion of numerous collection vehicles so as to ensure that the load/loads are truly representative of each type of socio-economic group/city district etc. Again, in ensuring accuracy, sampling programmes should be repeated at a later date, allowing for seasonal variations to be understood.

2.4.3 *Quantifying Generation (point A)*

Waste generation will need to be quantified to determine the extent of waste storage needs, the required future capacity of a collection fleet, transfer station, facility and equipment, and the extent of/potential for current and future resource recovery. *Box 2.6* provides guidance on quantifying levels of waste generation.

Box 2.6 How to Quantify Waste Generation

You will need: sample containers (eg, plastic bags), weighing scales, buckets, plastic sheet, gloves, data sheets, marker pens.

1. In estimating waste generation quantities, it is necessary to multiply the per capita rate of waste generated by the number of individuals in the collection area. A typical survey would involve each participating location being provided with a container (maybe a plastic bag) in which to place their daily wastes for collection. However, any reference to exactly when the containers will be collected should be avoided as this could cause untypical behaviour. For such reasons it may be necessary to operate the plastic bag system for some time before measurements are made.
2. During collection, containers will need to be clearly labelled and subsequently weighed in a central location (usually the disposal site) each day. Weights and social information should be recorded (number of people in the household, social status, shop type, etc), in addition to waste composition (see *Section* 2.4.6, below). Reference should be made to the quantities of metal, glass, plastics, and textiles, as these materials are commonly sold for recycling, before waste is made available for collection.
3. It is important to collect samples for at least a ten-day period, remembering that samples on the first day will need to be discarded as they may contain wastes accumulated from two or more days before. Recorded data values may then be multiplied in accordance with the population figures for the collection area, to determine per capita 'generation' quantities.
4. Finally, remember to dispose of all the waste properly and to clean the equipment used.
5. For more information and a worked example, see *Annex 2.1*.

Industrial Waste

Industrial waste, particularly hazardous industrial waste, is collected separately in many countries. Sampling approaches may be applied in the estimation of industrial wastes quantities, through the survey of factories, institutions, and industrial establishments. However, detailed methodologies for industrial surveys can be very involved, and are outside of the scope of this Planning Guide. For further reference a comprehensive guide to the survey of industrial wastes is presented in steps six and seven of the UK Department of the Environment (1995). Waste Management Planning: Principles and Practices. A Guide on Best Practices for Waste Regulators". HMSO, London. ISBN 0 11 7532096.

2.4.4 Quantifying Waste Received for Transfer and/or Disposal (points C and D)

One method of quantifying waste arriving at transfer and disposal facilities is weighing all or randomly selected incoming vehicles at the selected location, i.e. the transfer station or the disposal site. To arrive at the total quantities, sample weights can be multiplied by the number of loads arriving per day (*Box 2.7*).

Box 2.7 How to Quantify Waste Transfer and Disposal

1. One approach involves the use of weighing scales or weighbridges designed to accommodate vehicles of all sizes that arrive at a site. The weight of the empty vehicle must also be recorded. Several types of fixed or portable weighbridges may be used.

2. An alternative (and less accurate method), for arriving at waste quantities involves measurement and calculation. By identifying the average density of waste samples, the number of loads collected per day, and the average volume per load (% utilisation of vehicle body), the total daily weight may be determined. This process can be undertaken for representative samples of each type of collection vehicle. For example, if the waste density is 300kg/m^3, vehicles are 75% full, the average waste volume is 4m^3, and the total number of loads per day is 100, then the total daily input to the disposal site will be 120 tonnes. Waste densities can be determined using the methodology in *Section 2.4.6* below.

2.4.5 *When to Measure*

To account for both daily and seasonal fluctuations, sampling measurements at points A, C, or D should be obtained for a minimum ten-day period. This will allow data to be collected on typical weekly fluctuations. Sampling should then be repeated at either two, or four intervals distributed seasonally throughout the year. In the same vein, measurements should be obtained at different times of the day, and in the case of vehicle weighings, repeated without notifying either the waste collection round or disposal site manager.

Repeated and varied sampling will allow you to determine the potential and frequency of irregular or extreme quantities of waste generation. An illustration of this point, is provided by *Table 2.1* which presents data for winter, summer, autumn, and spring waste characteristics in Seoul, South Korea, specifically the use of coal for winter heating. Note the extreme values occurring through a variation in seasonal activities. This example also highlights the potential effect of economic development on waste quantities and composition: a common phenomenon is the replacement of solid fuels by gas or electricity, so care is needed in extrapolating into the future (see Task 2.3, *Section 2.6*).

Table 2.1 Seasonal Variation of Wastes in Seoul (%)

Composition	Spring	Summer	Autumn	Winter	Average
Paper	16.1	22.8	14.3	8.1	14.3
Rubber, plastic	8.6	8.8	6.5	2	6.1
Fabric, leather	1.9	2.6	0.9	0.7	1.4
Vegetable/putrescible	26.2	45	23.3	16.8	25.9
Wood, etc.	2.7	1.7	2.6	1.4	2.1
Sub-total/Combustibles	55.4	81	48	29.1	49.9
Coal ash	37.2	10.2	45	68.9	44.2
Glass, metal, etc.	7.4	8.7	7.3	2.1	5.9
Sub-total/ non-combustibles	44.6	19	52.3	70.1	50.1

Note: Seasonal change is observed not only in the waste composition but also in the waste amount. In Seoul, solid waste generation in December is 1.5 times greater than in August, due largely to the use of coal for heating.

Source: J.W. Kim, (1989). Policy Responses Towards Improving Solid Waste Management in Seoul City. Paper presented at the International Expert Group Seminar on Policy Responses Towards Improving Solid waste Management in Asia Metropolises 16-21 October 1989, Kitakyushu, Japan.

A simple case study illustrates the possible pitfalls in measurement. A 1989 planning study in Uganda[1] undertook a household waste generation survey in one season only (due to project time constraints). The results showed 1.3kg/capita/day, compared with expectations of perhaps 0.3 to 0.6 kg/capita/day. Further investigations revealed figures in a household around 0.1 - 0.2 kg/capita/day on days when maize porridge was cooked, but in excess of 2.5 kg/capita/day when the local (in season) variety of plantain known as mataki was used.

1 ERM (1990). Solid Waste Disposal, Seven Towns Project in Uganda. For GTZ and the World Bank.

2.4.6 *Identifying Waste Composition*

Why Measure?

Identifying the composition and characteristics of wastes should be undertaken to determine:

- the proportion of recyclable wastes and the proportion of compostable wastes, i.e. the potential for reducing waste quantities;
- waste density and other waste constituents, which affects both waste collection, transport and the proportion and volume of wastes requiring final disposal;
- the proportion of combustible wastes; i.e. the potential for incineration; and
- the moisture content, i.e. the biodegradability and the incineration potential.

What to Measure ?

Sample surveys of waste have two principle objectives, namely, to determine quantities of waste, and to determine its composition and characteristics. In determining waste composition where point A quantification surveys have been undertaken, it is generally more efficient to use the same sample for both purposes (*Box 2.8*). However in determining waste composition in point C or D surveys, it will be necessary to select appropriate samples of incoming collection vehicles (*Box 2.9*). Bulk density can be measured as shown in *Box 2.10*).

Health and Safety

Hand sorting of municipal solid waste will expose the workers to disease vectors associated with rodents, flies or human faecal matter. Waste may also contain hazardous or healthcare wastes and sharp objects. Workers should be vaccinated as appropriate and should be issued with and wear appropriate protective clothing, including gloves and face-masks.

Box 2.8 How to Measure Waste Composition (Point A Surveys)

1. When using samples collected in a point A quantification survey, randomly select 25 containers that have been logged and weighed, and empty their contents into a large bin to determine the waste volume. The volume of the bin should be recorded beforehand.

2. Selected waste should then be spread over a cleaned/cleanable hard surface avoiding an earth base – possibly a plastic sheet, and separated into different types (categories can vary, one such set is shown in *Table 2.2*). Depending on the approach of your sampling programme materials such as metals, plastics, glass, and textiles may or may not be included in generation samples as these may already have been sold for recycling. If equipment for filtering is available it is advisable to start the separation process by screening the sample through a filter or mesh made up of approximately 15 mm holes. Waste passing through the mesh may then be termed 'less than 15 mm' and will not require further categorisation. The remaining larger wastes should be separated and placed into different containers for weight measurement, and calculated as proportions of the total.

3. Measurements should be repeated daily for the duration of the study, and data recorded in clear and precise formats. An example data sheet is provided in *Table 2.2*. Typical wet weight characteristics of urban solid waste contents for low, medium, and high income countries are presented in *Table 2.3*.

Box 2.9 *How to Measure (Point C & D Surveys)*

Waste components may also be determined on arrival at a transfer station, or alternatively at a disposal site. Again, remember to make sure that samples reflect the system of study, i.e. remember to be aware of, and account for, likely variations through changes in seasonal behaviour, and also variation in waste quantities and characteristics occurring in different socio-economic regions.

Once appropriate load/loads have been identified, it will become necessary to separate out a representative waste sample for analysis. This may be done by any of the three techniques described below.

1. ***The Quartering Technique -*** which may be used for sampling wastes directly from a truck, or a representative group of trucks from various neighbourhoods. Quantities of wastes should be pre-agreed and equal amounts taken from each truck (when sampling a number of trucks), on a hard standing cleared area. The samples are then mixed thoroughly (preferably with a mechanical shovel), raked into quarters and re-mixed, with the full process repeated until a representative sample weighing greater than 90 kilogram is obtained. From here the sample may be separated into its component groupings, and each weighed and recorded as a proportion of the total.
2. ***The Block Technique*** - can be used in instances where mixing a group of samples may be difficult. Essentially, the procedure for the quartering technique is followed, though omitting the mixing stages. Instead, the sampling team extract what they deem to be a representative sample from the tipped load(s), which is then separated and characterised. The accuracy of this technique is of course dependent upon the ability of the sample team to define a representative sample.
3. ***The Grid Technique -*** divides a cleared area into four squares, each assigned a number or letter. Waste is unloaded, mixed and separated with each square in the grid containing equal proportions. Waste characteristics are then determined for a number of randomly selected squares and compared to the weight or volume of the entire load.

Box 2.10 *How to Measure Waste Bulk Density*

Bulk density can be determined by simply obtaining a (1 m^3) representative sub-sample of the waste selected for analysis and loosely filling a container of known volume and weight with the waste materials. The density is then the weight of the container and waste, minus the weight of the empty container. The results are expressed in kg/m^3. Bear in mind, however, that waste densities will tend to increase along the management chain from point A to D due to settling and compaction.

Table 2.2 *Example Data Sheet for Waste Composition*

Category	Day 1	2	3	4	5	6	7	**Total** Weight	%
Paper								(a)	(a)/(A) x 100
Textiles								(b)	(b)/(A) x 100
Wood and leaves								•	•
Food wastes								•	•
Plastics and rubber		(weight measurement entries)						•	•
Metals									
Glass									
Soil and other items									
Miscellaneous								(j)	(j)/(A) x 100
Total								**(A)**	**100**

Source: WHO (1996). Guides for Municipal Solid Waste Management in Pacific Countries. Healthy Cities - Healthy Islands Document Series, No 6. World Health Organisation, Western Pacific Region. (See *Annex 2.1*)

2.4.7 *Other Measurements*

In addition to measuring waste components and waste density, other characteristics may also be needed for specific purposes. Most commonly these include waste moisture content and calorific value, and also waste particle size, which can be useful information if planning the installation of mechanical separators[2].

Table 2.3 Global Perspective on Urban Solid Waste Characteristics

Composition of Raw Waste (by wet weight %)	Low Income Country (1)	Middle Income Country (1)	High Income Country (1)
Food waste	40 to 85	20 to 65	20 to 50
Paper and carton	1 to 10	15 to 40	15 to 40
Plastic	1 to 5	2 to 6	2 to 10
Metal	1 to 5	1 to 5	3 to 13
Glass	1 to 10	1 to 10	4 to 10
Rubber, misc.	1 to 5	1 to 5	2 to 10
Fines (sand, ash, broken glass)	15 to 50	15 to 40	5 to 20
Other Characteristics			
Moisture content %	40 to 80	40 to 60	20 to 30
Density in Truck (2) (kg/m^3)	250 to 500	170 to 330	100 to 170
Lower calorific value (3) (kcal/kg)	800 to 1100	1000 to 1300 (4)	1500 to 2700
kJ/kg	3400 to 4500	4200 to 5500 (4)	6300 to 11300

Source: S Cointreau-Levine (1994). Private Sector Participation in Municipal Solid Waste Services in Developing Countries. Volume 1 - The Formal Sector. UMP Technical Paper, No. 13. The World Bank, Washington. ISBN 0-8213-2825-5.

(1) Country categorisation by income is based upon 1992 GNP. Waste data based on wet, "as received", condition (i.e. not oven dried).
(2) Compaction trucks achieve load densities of 400 to 500 kg/cm in both developing and industrialised countries, based on their hydraulic mechanism designs. Higher densities, up to 650 kg/cm, could result from high soil and water contents present at high levels in the wastes of some countries.
(3) For self-sustaining incineration, a year-round minimum greater that 1000 kcal/kg (4200 kJ/kg) lower calorific value is needed as an absolute minimum. For waste-to-energy plants, 1500-1650 kal/kg (6300-7000 kJ/kg) is the minimum calorific value required.
(4) Some Eastern European cities within middle income countries have marginally suitable levels calorific value for incineration (or waste to energy) of 1300 to 1600 kcal/kg (5500-6700 kJ/kg).. Actual values will, however, be city specific, and must be determined by any City that wishes to consider incineration as an option

Measuring Waste Moisture Content

Moisture content is simply the percentage difference between wet and dry weights of the waste sample. For example, the following formula may be used:

$$\text{Moisture Content} = \frac{\text{Wet weight - Dry weight}}{\text{Wet weight}} \times 100\%$$

Dry weight can be measured by allowing the waste sample to stand until it is' air-dry' , i.e. as dry as the ambient air. Alternatively if a refuse dryer is available, determination of the water content can be done after drying the sample for 5-7 days at a temperature of 90^{0}C.

2 L.F. Diaz, G.M. Savage, L.L. Eggerth and C.G. Golueke (1996). Solid Waste Management in Economically Developing Countries. International Solid Waste Association, Copenhagen. ISBN 87-90402-01-04.

Measuring Waste Calorific Value

It is possible to gain a rough approximation of waste calorific values based on information regarding the waste composition and water content. The procedure for estimation is detailed in *Box 2.11*. However, if the introduction of an incineration or composting plant is to be examined seriously, then chemical analysis of the waste streams to be used as feedstock will also be required. The most important items to be characterised are (calorific value), carbon, potassium and nitrogen contents, although this process requires specialised equipment. Details on how to obtain measurements of these values can be found in the other publications[3],[4],[5]. It is also important to be aware of the typical technical unsuitability of incineration as a waste management option in many developing countries due to low calorific value and high moisture content (see *Step 4C*).

Box 2.11 *Procedure for the Estimation of Lower Calorific Value* [2]

(1) Estimation of Higher Calorific Value (HCV)

Composition	Wet Base (%)	Dry Base (%)	HCV (kcal/kg)
a: Paper b: Textiles c: Wood and leaves d: Food wastes	a b c d	a+b+c+d-W	$\frac{(a+b+c+d-W) \times 4{,}000}{100}$
e: Plastics and rubber	e	e	$\frac{e \times 9{,}000}{100}$
f: Metals g: Glass h: Soil and other items	f g h	f g h	$\frac{(f+g+h) \times 0}{100}$
i: Water		W	
Total	100%	100%	40(a+b+c+d-W) + 90e

HCV (kcal/kg) = 40(a+b+c+d-W) + 90e

(2) Estimation of Lower (Net) Calorific Value (LCV)

$$\textbf{LCV (kcal/kg)} = \text{HCV} - \frac{W \times 600}{100} = 40\,(a+b+c+d) + 90e - 46w$$

(3) Technical criterion for the incineration of solid wastes (this criterion has nothing to do with financial feasibility, which should be studied separately). To provide for net generation of energy from waste, the LCV must on average be at least 7 M/J/kg and must not fall below 6 MJ/kg in any season

Source: K.Sakurai (1990). Improvement of Solid Waste Planning in Developing Countries. Institute for International Cooperation - Japan International Cooperation Agency, Technical Handbook Series, Volume 1, Ref IIC-JR-24.

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[3] L.F. Diaz, G.M. Savage, L.L. Eggerth and C.G. Golueke (1996). Solid Waste Management in Economically Developing Countries. International Solid Waste Association, Copenhagen. ISBN 87-90402-01-04.

[4] K.Sakurai (1990). Improvement of Solid Waste Planning in Developing Countries. Institute for International Cooperation - Japan International Cooperation Agency, Technical Handbook Series, Volume 1, Ref IIC-JR-24.

[5] Decision Makers Guide to Municipal Solid Waste Incineration (2000), prepared by RAMBOLL for the World Bank.

2.5 REVIEWING WASTE MANAGEMENT OPERATIONS

2.5.1 *Waste Management Operations*

Task 2.2 requires the collection and assessment of data relating to the present operational waste management system. This will be required both as a benchmark, and as an on-going resource in undertaking monitoring and performance measurements.

Task 2.2 therefore presents an overview of the *key* information that you will need to gather and record in assessing the baseline characteristics of your MSWM operations.

Data should be recorded in a clear and precise format, bearing in mind that the collection process should remain flexible enough to respond to any gaps that are identified as a result of initial data gathering activities. This will also facilitate later updating and monitoring of improvements/performance (see Step 7 on performance indicators)

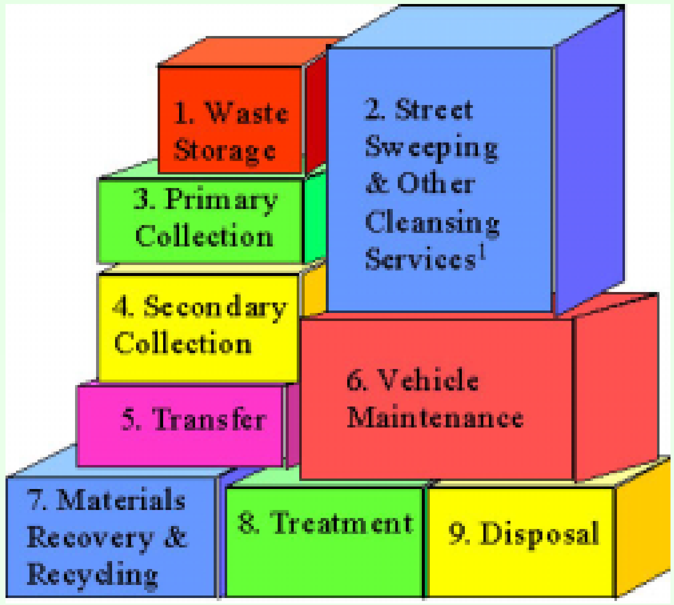
2.5.2 *What Operating Sub-systems should be included?*

As shown in *Figure 2.2* below, waste management operations can be sub-divided into a number of operating sub-systems.

An audit of practices in each of these `building blocks' should be carried out. Where external MSWM specialist (or team of specialists) are used, they should work in close co-operation with the service operators in evaluating the existing system. This work will form a major foundation of the Strategic MSWM Plan.

Operations need to be understood from the bottom up. The service operator is the best source of information on the existing system. The task should be completed by a MSWM specialist, working in close cooperation with the service operator. Time should be spent in communities, on collection rounds and at waste management facilities to help build understanding of constraints and opportunities, weaknesses and strengths in the system.

Figure 2.2 *Operating Sub-systems*



[1] Other cleansing services can include drain cleaning, gully emptying, beach and shore cleaning, snow and mud removal, construction and demolition waste removal, waste backlog removal and clean-up after natural disasters, and related services such as litter prevention, grass cutting or maintenance of public toilets. In some countries nightsoil removal, septic tank and cesspit emptying may also be included.

2.5.3 *What Should be Measured?*

The assessment of the present waste operational and management situation should be based on a clear definition of the nature of the information required (eg quantitative and qualitative), the level of detail required and the time frame involved. Further guidance is given in *Box 2.1*.

Above all, the data collection activity must be managed well to ensure that the process remains focused. Sources of information can include existing departmental records, official statistics, observation studies and survey by interview, telephone or checklist questionnaire. It is important to remember to check key data for accuracy and consistency.

2.5.4 *Available Tools*

There are a number of tools available to assist you in defining baseline characteristics of SWM systems. Different tools will be appropriate in different circumstances, and a range of checklists are provided in the *Annexes* to the Planning Guide. Available tools are summarised in *Table 2.4*. It is likely to be necessary to adapt your chosen tool to your specific needs and circumstances.

In addition to general sampling surveys, it may be useful to supplement these data with a number of more detailed case studies in selected areas. For example, the inclusion of a time and motion study (see *Step 4B*) for waste collection or street cleansing, can provide detailed insights into the efficiency of current operations.

Assessment of user preferences and willingness to pay may also provide you with valuable information on perceived service performance.

Box 2.12 presents an example of the range of survey 'fieldwork' undertaken as part of a waste planning study in the Chennai Metropolitan Area, India.

Table 2.4 Summary of Selected Tools for Data Collection and Their Uses

Annex	Description	Scope	Relevance of Tool
Annex 2.2	*Annex 2 of Guides for Municipal Solid Waste Management in Pacific Countries, Healthy Cities, Healthy Islands Document Series, No 6. World Health Organisation, Western Pacific Region, 1996.*		
	11 Page questionnaire designed to facilitate the assessment of the current situation of the MSWM service in an urban area.	Mainly technical, including waste quantities, composition and operational aspects. Also, who delivers each function, finance and staff deployment.	Not too detailed, useful as a starting point before considering more detailed tools.
Annex 2.3	*Step 6 of Methodological Guidelines for Sectoral Analysis in Solid Waste - Preliminary Version, Technical Report Series Number 4. Pan American Health Organisation, 1996.*		
	Detailed checklist on data and information gathering for assessment of the waste management system. Usually takes format of a list of questions.	Institutional, Technical & Infrastructure, Financial Management, Health, Environmental and Socio-cultural aspects.	Originally targeted at utility companies and municipal economic enterprises. May need to be adapted/expanded for general use in municipalities and local governments.
Annex 2.4	*Annex D of Environmental Management of Urban Solid Waste in Developing Countries - A Project Guide. Prepared by S.J. Cointreau, World Bank, Urban Development Technical Paper No. 5, 1982.*		
	Data collection workbook covering waste quantities and composition. Format consists of structured forms for 20 individual topic areas.	Technically orientated usually with emphasis on hard data.	• Very detailed tool. • Good for use by MSWM specialists.
Annex 7.2	*Information Management for Municipal Solid Waste Management Services, WHO-PEPAS, 1992.*		
	Guidance to municipal solid waste authorities in developing information systems. Contains a useful section on indicators of MSWM.	The focus is principally technical focusing on resource input and output indicators of the MSWM system.	Useful for identification of the long-term data needs to be considered at the outset as well as in ongoing performance monitoring.

Box 2.12 ***Summary of Detailed Fieldwork Undertaken in the Chennai Metropolitan Area Solid Waste Planning Study, India***

No.	Survey Title	Data Collected
1.	Municipal Data, Visits & Questionnaires	Populations and areas, MSWM related personnel and pay rates, vehicles and equipment, waste tonnage collected and transported.
2.	Waste Sampling and Analyses	Separation into fractions of 90 waste samples of 0.5 m^3 each. Analyses by weight.
3.	Waste-picker Survey interviews	Interviews with over 100 rag-pickers to verify the volume of materials being salvaged and the market values.
4.	Socio-economic Survey	Survey of Zone Vl public opinions on current and proposed waste collection systems; willingness to pay for improvements.
5.	Street Survey	Street by street survey of a collection Zone to identify the residential, commercial, industrial and slum areas to assess the current waste arisings in preparation of the pilot project.
6.	Waste Density Analyses	Waste density in the landfill after compaction.
7.	Site Search for new Transfer Stations	Identifying locations suitable and available as transfer stallions.
8.	Mechanical Workshops Survey	Boundary surveys of depots and layouts for remedial works planning and workshops' design.
9.	Transfer Stations Surveys	Boundary surveys of the existing operational transfer stations in preparation for remedial civil works.
10.	Existing Landfills Survey	Topographical surveys of existing landfills.
11.	New Landfills Site Search	Long list of potential landfill sites.
12.	Short-list Landfill Site	Detailed investigation of short-listed sites, soil analyses and environmental assessment.
13.	Soil and Water Analyses by Borehole Sampling at Existing Disposal Sites	Borehole tests for soil and water analyses.
14.	Surface Water Analyses at Existing Disposal Sites	Water analyses around existing sites and analyses of leachates.
15.	Preparation of a Pilot Project	Street survey to ascertain key equipment required for the Pilot Project
16.	Environmental surveys for Transfer Stations	Existing operations and environmental condition. Proximity to sensitive receivers.
17.	Environmental surveys for Landfills	Existing operations and environmental condition Proximity to sensitive receiver

Source: ERM (1996). Municipal Solid Waste Management Study for the Chennai (Madras) Metropolitan Area. For the Chennai Metropolitan Development Authority and the World Bank.

2.5.5 Institutional Aspects

The various checklists and questionnaires supplied in the *Annexes* refer to institutional as well as technical issues, and your appraisal of the current operation system will need to address these aspects. This will include an appraisal of the current legal, administrative, budgetary, and institutional arrangements. A brief checklist of issues to be covered by the review, to complement the technical points of the operating system, is provided in *Box 2.13* below.

Box 2.13 Checklist of Organisational and Institutional Issues

Political Aspects (these concern: formulation of goals and priorities, determination of roles and jurisdiction, and the legal and regulatory framework)

- Legislation, regulations and their implementation/enforcement
- Jurisdictional arrangements
- Goals and priorities

Institutional Aspects (these concern: distribution of functions and responsibilities corresponding to organisational structures, procedures, methods, institutional capacities and private-sector involvement)

- Distribution of functions, responsibilities and authority
- Management/organisational structures
- Interactions between departments, between different municipalities and between metropolitan/district municipalities
- Institutional capacities
- Informal and private sector involvement
- Personnel administration

Social Aspects (including the patterns of waste generation and handling of household and other users, community-based waste management and the social conditions of waste workers)

- Social conditions of waste workers
- Orientation of MSWM service to service needs and demands of population
- Public awareness of solid waste problems and priorities;
- Extent of community participation in waste collection services
- Socio-economic issues for waste-pickers

Financial and Economic Aspects (including cost-effectiveness of MSWM systems, income generation, capital investment, budgeting and accounting, cost recovery and cost reduction)

- Levels of subsidy and economic incentives
- Cost reduction procedures/incentives
- User charge system (level of charge, collection mechanism, collection efficiency)
- Financing, accounting and cost recovery

Source: adapted from P.Schübeler (1996). Conceptual Framework for Municipal Solid Waste Management in Low-Income Countries. UMP Working Paper Series, no 9. Swiss Centre for Development Cooperation in Technology and Management (SKAT), St Gallen.

2.6 PREDICTING FUTURE CAPACITY REQUIREMENTS

2.6.1 The Projection of Future Conditions

The future capacity requirements of a waste management system will depend upon changes in key parameters over time. These include, primarily:

- Population;
- Socio-economic conditions; and
- Projected service coverage.

Population Estimation of population growth can be a very complicated process, and the inclusion of a methodology within this Planning Guide is unlikely to increase its accessibility. Moreover, the MSWM plan will usually only be undertaken within the context of the City's overall development plan, and it is therefore more practical for waste planners to use the most up to date available population projections. In addition, waste planners can also use published sources of population estimates and projections from ministries and statistics institutes.

It is, however, important that population projections for waste management planning take into account any expected changes in city boundaries. In many metropolitan areas, population growth in central city areas is surpassed by that in periphery areas.

Socio-Economic Conditions Waste generation quantities and characteristics are strongly related to regional economic conditions, and will change with economic growth. Other socio-economic factors that will affect waste generation include:

- Housing development plans;
- Rural/urban drift;
- Road construction programmes; and
- Improvement programmes for marginal settlements.

Socio-economic conditions that enable an increase in standards of living of the regional economy will influence the per capita rate of waste generation and the composition of waste generated. Per capita waste generation levels will generally increase, in correlation with increases in the standard of living. In addition, quantities of paper, plastic, and non-combustibles (eg, metal and glass), will typically increase. In turn, these increases may enhance the calorific value and recyclability potential of generated wastes respectively. At the same time, relative quantities of leaves, wood, soil, and ashes, are likely to decrease, leading to reductions in waste moisture content and density.

Care must be taken in such extrapolations, however, as increasing quantities of paper, plastic, glass and metals in the waste as generated, may simply increase the supply of recycled materials to the informal sectors, rather than affecting the quantities and composition of waste disposed of.

Projected Service Coverage The future levels of service coverage will influence the quantities collected and disposed in practice. Extending services to all communities may take some time, and infrastructure and equipment needs should be phased in accordance with the planned schedule for service extension.

As living standards increase the level of service expected by the population will increase. The *Strategic Plan* should anticipate increasing service demand over the planning period.

2.6.2 *How to Estimate the Future Generation of MSW*

In the example in <ins>*Box 2.14*</ins>, a simple estimation method of the future solid waste amount is illustrated based upon a hypothetical case study, in which exponential growth is assumed at the following annual rates:

- Population - 4%
- Waste/capita/day - 2%
- Industrial/institutional wastes - 8%
- Service coverage (linear growth) - 2%

Box 2.14 *Calculation of Future Waste Quantities (Example Case)*

1998

Population	500,000
Service Coverage	70%
Generation Rate of Household Waste	600g/capita/day
Commercial and Institutional Waste	50 tonnes/day

Total Amount = (500,000 x 0.7 x 600 / $10^{6)}$ + 50 = 260 tonnes/day

2003

Population (4% per year increase) 500,000 x 1.04^5 = 608,000	608,000
Service Coverage	80%
Generation Rate of Household Waste (2% per year increase) 600 x 1.02^5 =	662g/capita/day
Commercial and Institutional Waste (8% per year increase *) 50 x 1.08^5 =	73 tonnes/day
Total Amount = 608,000 x 0.08 x 662 / 10^6 + 73 =	395 tonnes/day

Key Note: Locally collected data and analysis of trends is essential. The variables used in this case should not be taken as standard for Cities in developing and transition countries

Source: Adapted from K.Sakurai (1990). Improvement of Solid Waste Planning in Developing Countries. Institute for International Cooperation - Japan International Cooperation Agency, Technical Handbook Series, Volume 1, Ref IIC-JR-24.

2.7 UNDERSTANDING SHORTFALLS AND CONSTRAINTS

2.7.1 *Defining Shortfalls and Constraints*

A number of common problems exist which are typical of MSWM around the world. It is important to identify the true character of the problem and establish an initial understanding of the shortfalls and constraints in the MSWM system.

Problems may be characterised as either

- Internal to the MSWM system such as lack of equipment or planning capacity, etc). They mostly rest mainly on management initiative;
- Both internal and external like accelerated waste generation, lack of co-ordination etc. which will generally require close cooperation with related sectors; and

- external problems such as uncontrolled urbanisation, population explosions etc. will generally have to be accepted and adapted to.

Box 2.15 provides a checklist of the main areas on which to focus analysis of shortfalls and constraints.

Box 2.15 Checklist for the Identification of Shortfalls and Constraints

1. Service coverage
overall waste collection service coverage
socio-economic character of areas with no services
extent of service to the urban poor

2. Service level of waste collection
- collection frequency
- collection point
- type of waste covered by municipal MSWM

3. Service level of street sweeping and other cleansing services.
- service frequency
- length and classification of street, drain and beach etc covered by the municipal MSWM service

4. Waste quantities and composition:
- collection amount
- disposal amount
- waste characteristics

5. Efficiency of waste collection:
- vehicle efficiency
- labourer efficiency
- cost-efficiency

6. Efficiency of street sweeping, drain and beach cleansing, grass cutting:
- labourer efficiency
- cost effectiveness
- supervision

7. Working conditions:
- safety
- sanitation
- workload

8. Sanitary and environmental conditions:
- waste picking
- collection and haulage
- processing
- marginal settlements
- site management

9. Resource recovery:
- realistic targets
- source separation scavenging
- market for recovered resources
- public awareness

10. Private-sector participation:
- availability of developed performance contracts
- obligatory selection of lowest tender?
- contract period

11. Management of equipment:
- adequacy of existing equipment
- maintenance

12. Public awareness and participation
- storage and discharge manner
- participation in primary collection
- willingness to pay fees
- complaints
- fines

13. Awareness of decision makers:
- awareness of key MSWM issues
- political priority of MSWM
- accountability

14. Revenue and expenditure of MSWM services:
- budget allocation for MSWM services
- fee schedules (collection, disposal)
- affordability and value

15. Administrative support:
- planning capability
- personnel administration
- public relations and health education

16 Institutions and organisation
- institutional set-up of MSWM service
- coordination with local parties (eg govt departments, ministries, agencies NGOs, private sector, etc)

17. Legislation and enforcement:
- laws, regulations, standards
- guidelines related to MSWM
- law enforcement

18. Support for federal / central and state / provincial governments:
- technical support
- financial support

Source: adapted from K.Sakurai (1990). Improvement of Solid Waste Planning in Developing Countries. Institute for International Cooperation - Japan International Cooperation Agency, Technical Handbook Series, Volume 1, Ref IIC-JR-24.

2.7.2 *Analysing Operating Sub-systems*

Box 2.16 provides a checklist with which to evaluate the effectiveness and efficiency of individual operating sub-systems and the waste management system as a whole.

Box 2.16 ***Checklist on the Effectiveness and Efficiency of the MSWM System***

Effectiveness

Evaluating service effectiveness involves asking, among others, the following questions:

- How adequately is the waste contained whilst awaiting collection?
- How quickly is the waste removed from the collection point after it is put out for collection?
- How clean is the collection service area between collection service days?
- How quiet, pleasant and reliable is the collection service provided?
- How environmentally acceptable is the disposal facility?

Efficiency

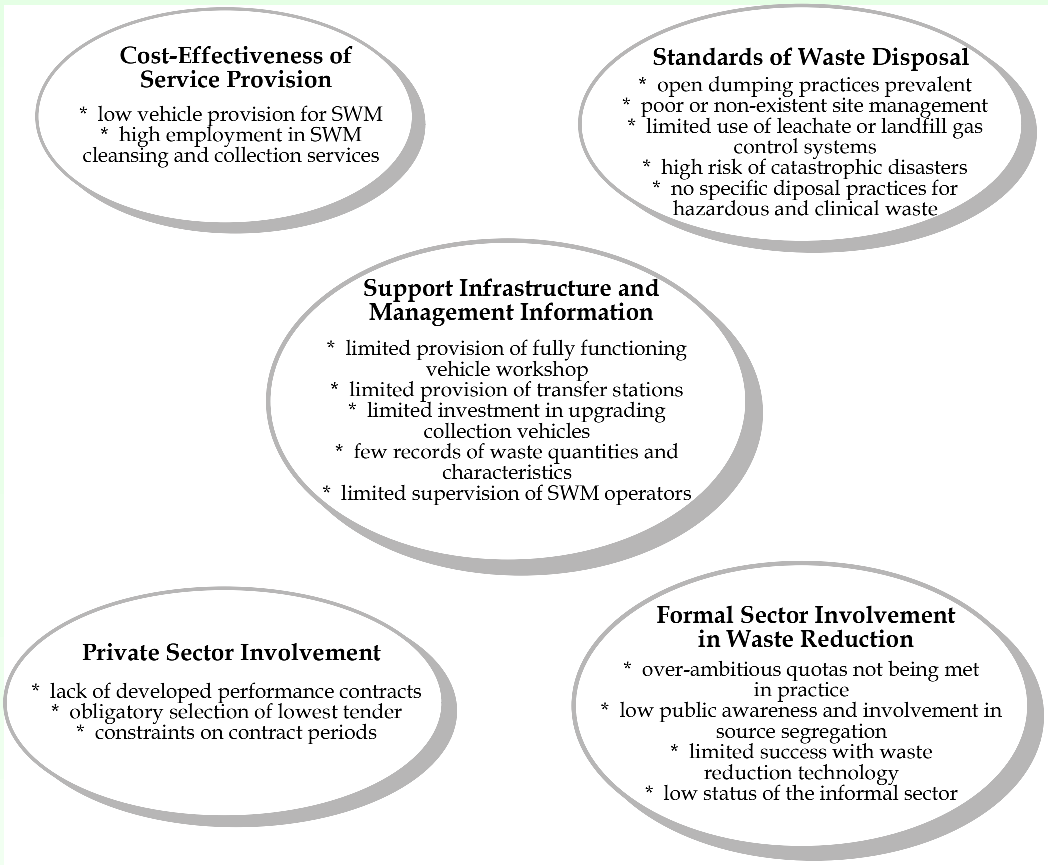
The efficiency of service is evaluated differently, with the key questions being:

- Are the overall costs of collection, transport and disposal as low as possible for the provision of effective service?
- How well are local resources being used in order to minimise foreign exchange requirements?
- Is priority being placed on optimising productivity of capital investment items, such as collection vehicles?
- Is waste reduction and waste recycling directly at the source of waste production being optimised so that the waste requiring service is minimised?
- Are the funds collected for the service, through taxes or user charges, passing reliably and efficiently to the service delivery entity?

2.7.3 *Shortfalls and Constraints in MSWM Systems*

Shortfalls and constraints vary widely between countries and different types of MSWM system. An example of typical shortfalls and constraints in operating systems is shown in *Figure 2.3*. The checklist of Dos and Don'ts available in the Overview for Decision Makers is also a useful tool to help evaluate shortfalls and constraints.

Figure 2.3 Case Study of Shortfalls and Constraints in SWM Operations at the Municipal Level



Source: ERM (1996). National Waste Management Strategy for the Republic of Turkey. For the Ministry of Environment in associa tion with METAP.