Environmental Management of Urban Solid Wastes in Developing Countries

A Project Guide

Sandra J. Cointreau

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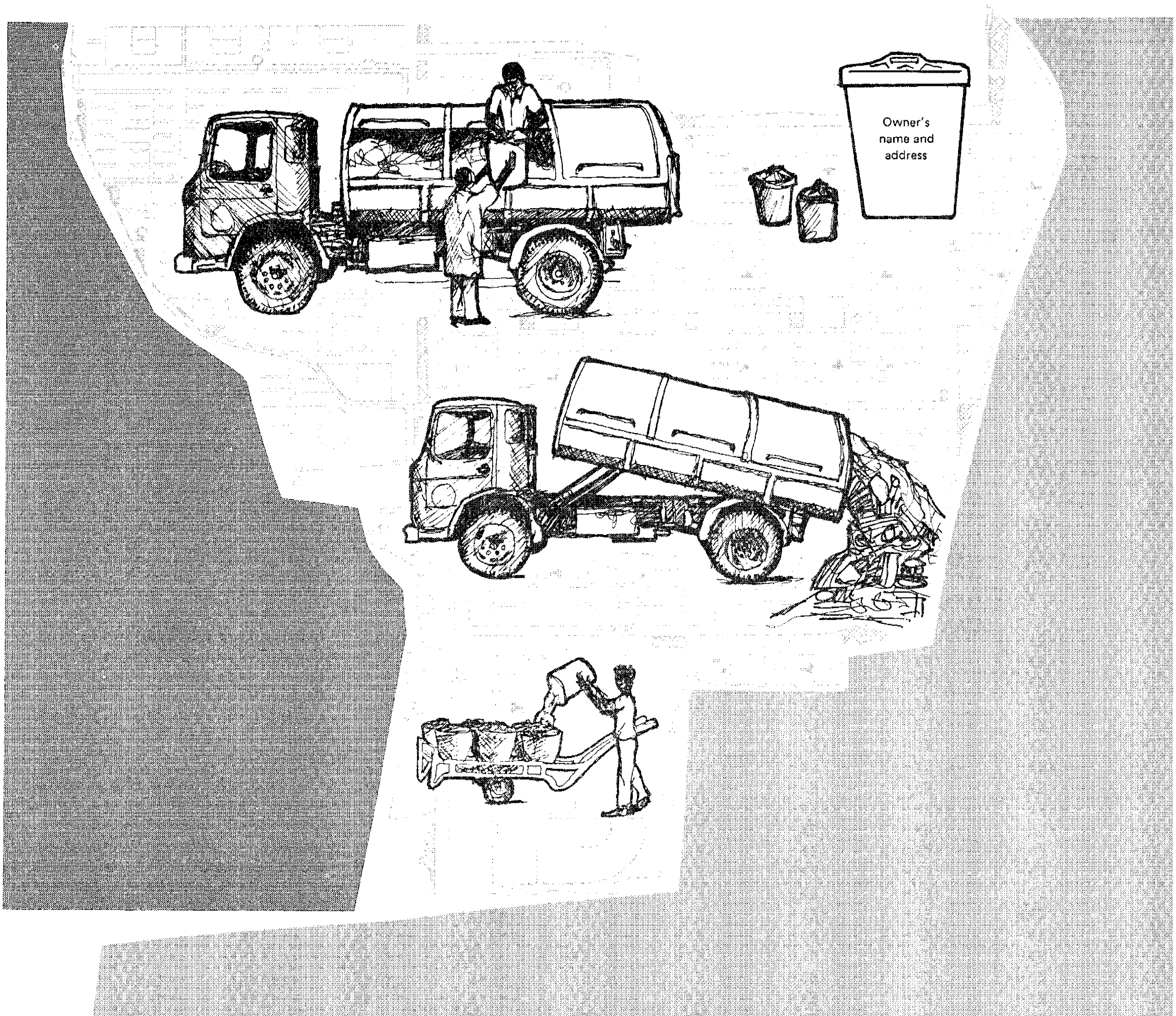

Urban Development Technical Papers

This series is produced by the Urban Development Department of the World Bank primarily to assist staff in the Bank and in cooperating agencies in the preparation and execution of urban projects in developing countries. It is hoped that the series will also make a contribution to the "state of the art" and hence be of service to practitioners in the field of urban development.

ENVIRONMENTAL MANAGEMENT OF URBAN SOLID WASTES IN DEVELOPING COUNTRIES

A Project Guide

by

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ENVIRONMENTAL MANAGEMENT OF URBAN SOLID WASTES IN DEVELOPING COUNTRIES

A Project Guide

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ABSTRACT

The project guide provides information and procedures for planning and implementation of solid waste management improvements. It is designed to facilitate project preparation, appraisal and implementation of Bank financed solid waste projects in urban areas. Current Bank objectives, policies, and project requirements are summarized. It should also be of use to a wide audience involved in solid waste collection and disposal in developing countries.

The project guide reflects the lessons and experience gained from World Bank solid waste projects. The text discusses establishment of an acceptable standard of collection and disposal service delivery, selection of appropriate technology, development of suitably phased action plans, arrangement of institutions for planning and management, arrangement of financial resources, development of regulatory and enforcement support services, provision of public education and participation programs, and incorporation of incentives and disincentives to facilitate project success.

Information on solid waste generation rates and compositions for countries of various levels of economic development is provided. Case study information on the formal and informal sector refuse collection and disposal activities prevalent in cities of developing countries is provided. Problems and issues to investigate when planning are highlighted through case study examples.

Annexes to the project guide include sample terms of reference for consultants, a data collection workbook for planning technical and management improvements, and worksheets for calculating municipal budget requirements to maintain, upgrade and expand solid waste management service.

SUMMARY

Purpose

This is a working document intended to assist Bank Staff in developing potential urban solid waste management projects or subcomponents. It should also be of use to a wide audience of persons involved in the collection, disposal and recovery potential of solid waste in lesser developed countries.

The project guide does not pretend to be complete. Solid waste management in less developed countries (LDCs) is not a well developed science and project subcomponents funded by the World Bank are in an early stage of implementation. The feedback from these is far from comprehensive; we are in a process of learning by doing; as lessons are learned and experience gained, the guide will be revised.

The purpose of the Guide is to create:

. an understanding that solid waste management is part of a broader urbanization problem:

. an awareness of need for competent management of solid waste in urban areas:

. an understanding of the various systems available for collection, transfer and disposal; and

. an approach to preparing solid waste management plans in light of potential problems and issues which may become apparent during project development.

Solid Wastes in the Context of Urbanization in LDCs

Management of solid wastes in developing countries cannot be considered in isolation. It must be seen in the context of other issues and problems posed by rapid urbanization, the pace of which will gather momentum in the eighties and nineties, by 2000 over 1 billion more citizens are likely to be living in towns and cities than there were in 1980.

The problems facing cities in developing countries can be summarized under three headings:

(a) Growth: Cities and towns are growing at rates of 4-7% per year. This means that cities with populations of over five million increase by more than 200,000 persons per year, and double every 10 to 17 years.

(b) Deficiencies: There are enormous deficiencies in basic services.

(c) Urban Management: Maintenance of services and operation of assets is poor and the fiscal base of most cities is weak.

In addition there are social and cultural issues related to a myriad of factors and conditions which give each city or town its own personality, these must be taken into account in developing a response to rapid urbanization.

Solid waste management frequently suffers more than other municipal services when budget allocations and cuts are made. Even though provision of collection and disposal services for municipal refuse often consumes as much as 20 to 40% of municipal revenues, it is not perceived as deserving higher priority. Efforts of people employed to collect, dispose and recycle wastes are rarely appreciated.

The existing situation is far from satisfactory and frequently a source of complaint by the public and anxiety to concerned officials. Lack of adequate financial resources renders municipal administrations vulnerable to pressures geared to selling expensive vehicles, mechanical equipment and high technology based on suppliers' credit. The real problems are organization and management, yet favored solutions frequently involve more mechanization.

Even in resource-scarce societies, wastes have not yet been seen by governments as a potential asset capable of reuse, unless blessed by contact with high technology. Recycling in LDCs is predominately in the hands of informal sector entrepreneurs, who at the lowest levels live in squatter settlements at refuse dumping grounds. There is little recognition of the trickle-up economic effect derived from direct, informal sector recycling, whereby municipal costs for refuse disposal are reduced, private sector jobs are created, and energy in manufacturing is saved through the use of recycled versus raw materials.

In summary, wastes are frequently considered to be a nuisance and not much more. Health and economic costs of failing to adequately collect and manage solid wastes are rarely considered. It is against this background that environmental management of urban solid wastes in developing countries should be planned and implemented.

Environmental Management Considerations

The first priority for managing solid wastes environmentally is getting the refuse out from underfoot. In cities of developing countries, 30 to 50% of the solid wastes generated is often uncollected. Uncollected refuse accumulates in drains, on open lands and provides a breeding area for disease vectors. The areas receiving the lowest level of service are the slum and shanty neighborhoods. Not only do the urban poor traditionally receive less attention from municipal officials responsible for the service, but workers who redeem paper, cans, bottles and plastics from "richer" refuse, have little or no incentive to service the urban poor.

The second priority is to provide affordable service, through use of least cost, viable techniques. Economic analysis of alternative means of collecting, transporting and disposing solid wastes is a necessary part of selecting appropriate technology. Analysis of alternatives should also consider employment objectives, real costs of imports, ease of maintenance, and limitations on capital.

To work toward building sustainable, environmentally conscious economies, management of urban wastes should encourage waste reduction at the source. In developing countries, refuse collectors and informal sector scavengers typically perform such waste reduction through their recycling activities, although front-end recycling is often discouraged. Public officials frequently do not appreciate the savings to the city attributable to the lessened quantity requiring transportation, handling and disposal resulting from these activities. Municipalities should encourage such recycling, instead of looking primarily toward public sector, capital-intensive resource recovery facilities at the disposal-end of the solid waste system; and assist the informal recycling sector by providing adequate services to protect the workers' health, facilitating the marketing of reusable goods, and providing low-cost loans for equipment which improve workers' productivity.

Categories of Urban Solid Waste

Wastes are generated in households, commercial and industrial premises, institutions and on the streets. Street refuse contains a mixture of refuse from many sources, as streets are used as dumping grounds by all and sundry. Where sanitation facilities are lacking, street refuse contains a lot of human faecal matter. Where a large animal population roams the streets or is used to pull carts, street refuse contains large amounts of manure. Streets are also often used for extensive dumping of construction and demolition debris. Streets littered with building wastes attract further dumping, and so the process continues.

Composition of Urban Solid Wastes

Many of the larger cities are in a state of transition. Part of their urban fabric consists of modern commercial development, and generates wastes similar in composition to those found in industrialized countries. Another part of their urban fabric consists of densely populated, low-income settlements, where people have more traditional eating and cooking habits and refuse is characterized by organics and ash.

Reliable data concerning the quantities and characteristics of urban solid wastes is difficult to obtain. Wastes are frequently carried to communal masonry bins or designated neighborhood dumping grounds, for collection by the city service. In these temporary storage and transfer places, wastes are subject to being eaten by animals, rained upon, picked over by human scavengers, naturally decomposed by micro-organisms, and mixed with dust and dirt.

The following table shows ranges of municipal refuse generation rates, compositional values, and density characteristics for cities in countries of low-income, middle-income and industrialized. From review of the table, a pattern arises demonstrating that the nature of municipal refuse is a function of relative consumption and production activities within countries, according to their stage of economic development.

PATTERNS OF MUNICIPAL REFUSE QUANTITIES AND CHARACTERISTICS
FOR LOW, MIDDLE AND UPPER INCOME COUNTRIES

	Low-Income Countries /a	Middle-Income Countries /b	Industrialized Countries
Waste Generation (kg/cap/day)	0.4 to 0.6	0.5 to 0.9	0.7 to 1.8
Waste densities (wet weight basis-kg/cubic meter)	250 to 500	170 to 330	100 to 170
Moisture Content (% wet weight at point of generation)	40 to 80	40 to 60	20 to 30
Composition (% by wet weight)			
Paper	1 to 10	15 to 40	15 to 40
Glass, Ceramics	1 to 10	1 to 10	4 to 10
Metals	1 to 5	1 to 5	3 to 13
Plastics	1 to 5	2 to 6	2 to 10
Leather, Rubber	1 to 5	-	-
Wood, Bones, Straw	1 to 5	-	-
Textiles	1 to 5	2 to 10	2 to 10
Vegetable/Putrescible	40 to 85	20 to 65	20 to 50
Miscellaneous inerts	1 to 40	1 to 30	1 to 20
Particle Size	5 to 35	-	10 to 85

/a Includes countries having a per capita income of less than US$360 in 1978.

/b Includes countries having a per capita income of more than US$360 and less than US$3,500 in 1978.

Relationship of Waste Character and Appropriate Technology

Several conclusions can be drawn from the above table, which subsequently influence selection of appropriate waste management technology. Municipal refuse in cities of developing countries differs from refuse of industrialized countries in that:

- waste densities are high, generally 2 to 3 times higher than those in industrialized countries;

- moisture contents are high, generally averaging about 3 times higher;

- composition is largely organic with the portion of vegetable/putrescible materials typically 3 times higher;
- there may be a substantial amount of dust and dirt in cities where sweeping and open ground storage is part of the collection system; and
- particle size is much smaller, often exhibiting less than half of the materials in the over 50 mm range than would be seen in refuse from industrialized countries.

As a result of the above conclusions regarding the nature of urban refuse in developing countries, the following considerations are commonly true relative to appropriate technology;

- compaction trucks which achieve a final density of about 400 kg/cubic meter and a compaction ratio of 4:1 in industrialized countries, commonly achieve a compaction ratio of 1 1/2:1 in developing countries;
- landfill dozer/compactors designed to achieve a final density of about 600 kg/cubic meter and a compaction ratio of 6:1 in industrialized countries, would achieve a compaction ratio of only about 2:1 in developing countries;
- incineration would generally not be self-sustaining in developing countries, much less produce recovery energy, because of the high moisture content characteristic of the wastes;
- biodegradation techniques, such as methane generation and composting are often technically viable because of the high organic content of the refuse;
- because of the smaller particle sizes characteristic of refuse in developing countries, size reduction facilities such as shredders would provide only marginal benefits to a resource recovery option; and
- materials which could be recovered by processes such as air flotation and magnetic separation are present in such small amounts that mechanical sorting for purposes of recycling glass, metals and plastics is generally not economical.

Relationship of Urban Settings in LDCs and Appropriate Technology

An important factor to be considered in designing a municipal refuse management system is the setting--particularly population density, climate, access to households, traffic conditions and land availability for disposal needs. Cities in developing countries are often characterized by:

- confined living quarters and little or no yard space available for waste storage dustbins;
- warm climates, some with high seasonable rainfalls;

- slum and shanty dwellings which are accessible only by narrow walkways or unpaved lanes;
- slow moving traffic, either because of the high number of bicycles and animal carts, or because of an excessive automobile population for the road network available; and
- limited lands available within a reasonable transport travel time (i.e., less than 1 1/2 hours round trip) which can be used as disposal sites.

Based on these setting characteristics, selection of appropriate refuse management technology must therefore consider:

- collection frequency in densely populated areas within developing countries should be every day or two, because the waste content is highly organic and warm temperatures lead to rapid decay of the wastes and to insect propagation, and space for waste storage on the resident's premises is often severly constrained;
- manual or animal powered pushcarts are often the principal mode of access and collection in slum and shanty neighborhoods;
- tractor or animal powered collection vehicles have potential if traffic speed is typically under 40 kilometers/hour; and
- long travel times between the collection service area and the available land disposal sites suggest that transfer stations, whereby waste is transferred from a small vehicle or cart to a large vehicle, may prove economically viable.

Often a city avoids selecting the most appropriate technology for its urban setting, because it has plans to upgrade roads and traffic conditions. It must be remembered that refuse management equipment is short-lived, with useful life periods for collection vehicles commonly estimated as being between 5 and 8 years. It is possible, and often desirable, to implement interim solutions using animals, carts and tractors, for example. These items are also quite salable, and may be auctioned if the city makes rapid progress in its upgrading program and wishes to retire these items before they are fully spent.

Management Support Systems

Unfortunately, most solid waste planning efforts emphasize technology--with such engineering activities as determining the number of trucks and the siting of landfills. Solid waste systems also require well-planned management, institutional, and financial systems to support the equipment and facilities infrastructure. Collection systems in particular are labor-intensive and rely on mobile, short-lived equipment. Through continuous planning and dynamic management these systems can be designed to have capacity meet demand on a continuous basis.

Most existing systems have two major flaws which discourage efficient use of equipment. These are: inadequate supervision of workers, and inadequate maintenance of vehicles. Instead of having one supervisor in the field for every 5 to 7 vehicles as in industrialized countries with notably cost-effective systems, there more likely is one for every 10 to 30 vehicles. In addition, few if any of these supervisors would have any means of traversing their service areas, as motor scooters and cars are seldom provided. Similarly, instead of a reasonable average downtime of 10 to 20% for motorized equipment, cities in developing countries typically have 20 to 50% of their fleet down for repairs and overhaul.

All too often, the institutional arrangements for provision of collection and disposal services are fragmented, with the municipal engineer and a few assistants located at city hall, and with all laborers and supervisors managed under decentralized administrations. Typically, there is no planning unit anywhere in the institutional framework. Record-keeping on maintenance and breakdown events, worker productivity and effectiveness, and vehicle load weights and daily trips is virtually non-existent in many cities. Good planning and effective management requires this information on a regular basis.

Few municipalities have any system of developing renewal funds for regular replenishment and expansion of their collection fleet. Financial management of the solid waste sector is characterized by intermittent purchases, under crisis conditions, of equipment from low bidders responding to poorly written specifications. Good financial management should include development of reliable sources of revenues, and planning information for justifying phased budgetary requests.

Projects Financed by the Bank

Projects developed for World Bank financing have been diverse. They have ranged in collection technology from labor-intensive systems relying on pushcarts in pockets of urban poverty, to capital-intensive systems employing compaction vehicles in commercial and institutional centers of the city. They have ranged in disposal technology from sanitary landfill to resource recovery process plants.

Most of the Bank-financed projects include improving institutional and financial arrangements for management of the solid waste service. This often involves centralizing management of various solid waste categories under one roof, and building planning capability. The goal of most projects is to build overall management capability, while providing the initial slice of a city's projected procurement needs.

Pilot testing of alternative systems is typically an inherent part of the Bank's solid waste projects. Since this sector is labor-intensive and relies heavily on public cooperation, pilot testing of techniques is vital to arrive at the one(s) which will be accepted by the workers and the populace.

Project Development

As in all World Bank projects or components of projects, solid waste management projects have these stages of activity: identification, preparation, appraisal, negotiation, implementation and supervision, and evaluation. Preparation is accomplished by the local government and its consultants, while Bank staff participates in all other stages of activity. This project guide provides information, terms of reference, data collection work sheets, analytical procedures and case study examples to assist in all stages of project development. The document focuses, however, on providing guidance to assist local preparation efforts, since thorough planning and assessment of systems at this stage is crucial to project success at all subsequent stages.

Conclusion

The collection, disposal and recycling of solid wastes is just one of the many problems facing developing countries. The first priority in the majority of cases would probably be to improve the management and organizational capability and to establish a financially stable institution capable of planning ahead, adapting to change, and handling wastes in an appropriate manner. Projects frequently involve feasibility studies, pilot operations, and the gradual introduction of change. Public management improvements should not necessarily exclude informal sector recycling and handpicking. On the contrary, they should facilitate it. Whether entrepreneurial or municipal, recycling offsets an important part of the cost of municipal sanitation. 1/

1/ The extent to which recycling can offset municipal costs (whether financial or economic) is one of the special considerations which will be reviewed in the course of the ongoing UNDP supported project entitled Research Development and Demonstration of Integrated Resource Recovery (GLO/80/004), for which the World Bank is executing agency.

I. THE NATURE OF THIS PROJECT GUIDE

A. Purpose and Scope of Contents

Continuing improvement in the efficiency and effectiveness of project development is an important objective of the World Bank Group. This aid is an attempt to glean from past project experience in solid waste management enough information to facilitate and improve future project experience.

The document does not rest on any effort of comprehensive literature search or surveying of solid waste specialists with developing country experience. The World Bank's Transportation and Water Department is undertaking a major research effort on integrated resource recovery. That research effort will review the interrelationships of waste collection, transfer and disposal systems with resource and materials policies and recycling technologies.

The purposes of this document are to create an awareness of the need for competent management of solid wastes in urban areas; an understanding of the various systems available for collection, transfer and disposal; an approach to preparing and implementing solid waste projects; and an anticipation of the potential problems and issues which may arise in project development. Chapters I through V are aimed at improving the project officer's general understanding of this sector. Chapters VI and VII and the annexes provide detailed guidance in project development of solid waste components.

The scope includes the solid waste components in urban development projects, water supply and drainage projects, and sanitation projects. No differentiation is made between project development steps for solid waste components under urban, water or sanitation projects. In each type of project, the key to upgrading the solid waste system is to deal directly with the city-wide institutional and financial management of its investment, operating and maintenance activities. This project guide would also be applicable to individual solid waste management sector projects.

B. The Intended User

This project guide is designed for use by World Bank project officers in identifying potential solid waste management project needs; guiding local governments and their contractors during preparation of solid waste management projects; and assisting solid waste specialists engaged in appraisal and implementation activities, and supervision of solid waste projects.

C. Project Experience

Solid waste management projects developed for World Bank financing have been diverse in nature, and responsive to site-specific needs of the project area. To date, the World Bank has introduced solid waste components into a number of its urban development projects, as well as into several of its water supply and drainage projects. In one case, the entire project was for purposes of solid waste collection and disposal; other projects have provided terms of reference and technical assistance monies for solid waste studies, while others have provided equipment and faciliities to address assessed needs for upgrading service delivery. The level of commitment has ranged from provision of a few carts and trucks to large-scale augmentation of an entire fleet and its corresponding maintenance facilities. The following examples illustrate the latitude possible in an eventual project design.

- In Cairo, Egypt, the project consists largely of pilot testing and then full scale implementation of composting. The project cost was appraised at $1.1 million. (1)

- In Alexandria, Egypt, the project primarily provides labor-intensive collection, transfer and sorting equipment and associated maintenance facilities. The total appraised cost was estimated at $1.1 million. (2)

- In Bamako, Mali, the project provides collection trucks and maintenance facilities for the city-wide fleet of collection equipment. The project was appraised at $1.5 million. (3)

- Urban projects in Manila, Philippines and Calcutta, India set aside significant portions of the solid waste budget for pilot studies on door-to-door collection, transfer, sorting and sanitary landfill. In both cases, pilot studies were allocated about 18% of the solid waste component's budget. The Manila project costs were appraised at $3.5 million; the Calcutta project costs were appraised at $11.1 million. (4) (5)

- In Tunis, Tunisia, much of the project budget is targeted for implementation of sanitary landfill and for closing open dumps. The disposal portion of the budget is about 61% of the total $3.4 million project cost. (6)

- Virtually all the budget for Jakarta and Surabaya, Indonesia is earmarked for collection and transfer facilities, leaving about 8% of the budget for maintenance facilities and 3% for sanitary landfill. The total project budget for the two cities is about $20.4 million. (7)

- In Onitsha, Nigeria, the water supply and drainage project provides funding for night soil collection equipment as part of the solid waste component. Of the total $3.7 million solid waste budget, about 34% is allocated for night soil equipment. (8)

- The Singapore Environmental Control Project is unique, in that all the project budget is for solid waste management. Of the total budget estimated at the time of appraisal, 85% was allocated to implementation of a 1,200 metric ton per day incinerator plant with energy recovery capability. The remaining 15% was allocated for collection equipment. The total project cost was appraised at $55.1 million, with the Bank to provide $25 million. Actual costs of the project were less than the appraised amount. (9) (10)

Note: Reference numbers refer to reference notes which follow the text.

Based on a scan of existing solid waste projects to date, budget allocations for solid waste management have ranged from a low of 4% to a high of 100% of the total project appraisal value. (11) (12) For most urban projects, however, solid waste components have generally comprised 6 to 14% of the total project base cost.

II. A DEFINITION OF URBAN SOLID WASTES IN DEVELOPING COUNTRIES

A. Categories of Urban Solid Waste

A waste is a material which is thrown away or aside as worthless. The definition of "solid" waste encompasses all those wastes which are neither wastewater discharges nor atmospheric emissions. A so-called solid waste may therefore be a semi-solid, solid or even a liquid.

The entire concept of waste is subject to the value judgment of the primary owner or potential consumer. A waste is viewed as a discarded material which has no consumer value to the person abandoning it.

For purposes of this document, urban solid waste (also commonly referred to as municipal refuse) is defined as: material for which the primary generator or user abandoning the material within the urban area requires no compensation upon abandonment. (1) In addition, it qualifies as an urban solid waste if it is generally perceived by society as being within the responsibilities of the municipality to collect and dispose of.

Categories of materials discarded in urban areas and generally viewed as a municipal responsibility include: household garbage and rubbish, residential ashes, commercial refuse, institutional refuse, construction and demolition debris, street cleaning and maintenance refuse, dead animals, catch-basin and drain cleaning wastes, bulky wastes, abandoned vehicles, and sanitation residues. Solid wastes from mining and agriculture are typically generated outside an urban area, and do not fall within the generally perceived responsibilities of a municipality. Industrial solid wastes require the attention of a municipality, and fall within municipal responsibility to manage in a manner that protects the public's health and safety. However, industrial wastes may be collected and hauled by the private sector. The following paragraphs briefly discuss major urban waste categories, and their particular significance within the overall context of municipal refuse in developing countries.

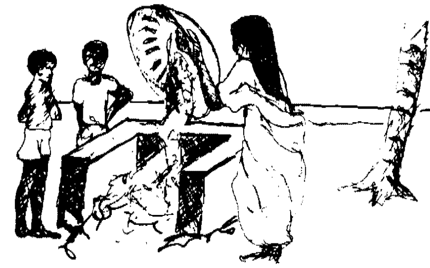
<u>Household garbage and rubbish</u>. Also referred to as residential refuse or domestic waste, this category comprises wastes that are the consequence of household activities. These include: food preparation, sweeping, cleaning, fuel burning and gardening wastes. They also include: old clothing, old furnishings, retired appliances, packaging and reading matter. Where diapers or bucket latrines are used, household wastes include faecal material. In developing countries, this category consists largely of kitchen wastes; while in developed countries, there is a large portion of paper and an appreciable quantity of glass, metal and plastics. The garden waste and bulky waste component of residential refuse often cannot be accommodated by the optimal system for regular storage and collection of residential refuse and may require a special system.

Commercial refuse. This category consists of wastes from stores, offices, fuel service stations, restaurants, warehouses and hotels. The wastes typically consist of packaging and container materials, used office supplies, and food wastes. In developing countries, markets may contribute the major portion of this waste category's refuse. At markets, there are unique problems of traffic congestion and access to collection. Since markets typically involve many vendors with very small stalls, there is not adequate individual or communal storage of the refuse while awaiting collection service. Most commercial refuse in developing countries is handled by the municipality. Exceptions occur in the case of very large hotels and major commercial offices, which are prone to engage a private hauler.

Institutional refuse. Schools, government offices, hospitals, police barracks and religious buildings are included in this category. Where the institution involves residents, such as in barracks, the wastes are similar to those from households. However, this category generally involves a large portion of paper rather than food. Hospital wastes, in developing countries are sometimes handled privately by the hospital and/or its contractor. Where they are not at least separately collected and disposed of, efforts to isolate them should be arranged by the municipality. Outside the case of hospitals, most institutional wastes in developing countries are directly managed by the municipality. Typically a separate system of collection is employed from that used to service households and commercial enterprises; and most often, the system involves portable metal bins of 6 to 8 cubic meter size which can be lifted onto a truck body or trailer for hauling.

Street sweepings. This category of waste always includes dirt and litter. However, in developing countries it may also contain appreciable amounts of household refuse, drain cleanings, human faecal matter and animal manure. In India, where the primary method of refuse disposal from households and commercial establishments is "placement" of wastes in individual or communal heaps along the roadside, street sweepings include a large portion of kitchen waste and paper. In any city where the sanitation services are inadequate, a portion of the population will directly employ open drains and roadsides for release of faecal matter. And where bucket latrines are engaged for sanitation, the collection service tends to be inadequate; resulting in blatant dumping of these buckets into open drains and along roadsides. (2) Throughout central Asia, there are cities with large populations of freely roaming cattle. In Lahore, Pakistan, for example, 12% of the municipal refuse composition was found to be animal manure. (3)

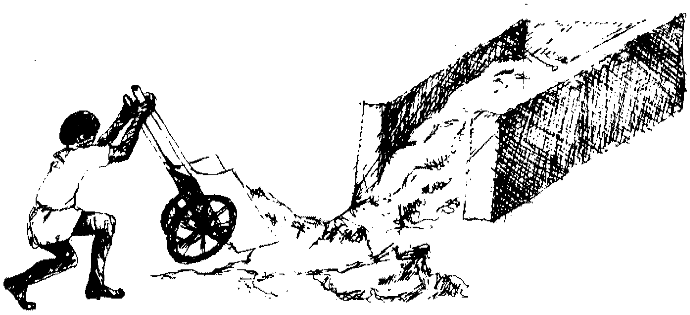
Construction and demolition debris. The nature of this material depends on the resources generally used in a given region or country for purposes of construction. Major multistory buildings are not typically a problem to developing countries in terms of construction and demolition debris, since these activities have sufficient capital backing and public exposure to provide an incentive for the owner/contractor to contain and haul the waste. However, activities related to small buildings--particularly where the construction material is clay soil--can contribute significant



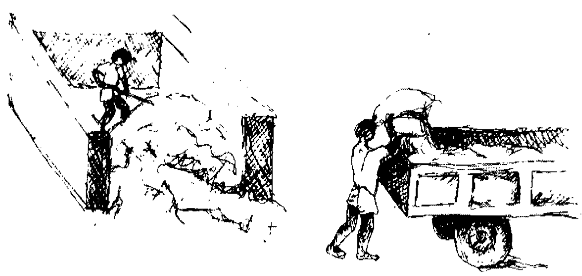
Resident discharging refuse at communal container

Municipal worker cleaning small open drain

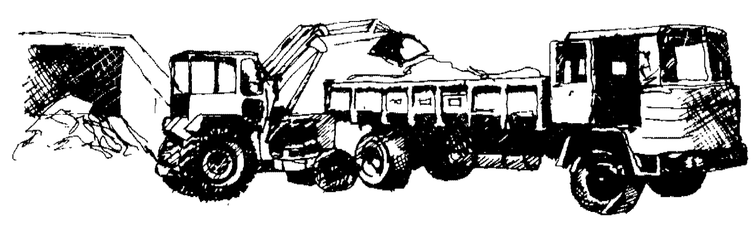
Municipal workers sweeping street refuse into piles



Municipal worker transferring refuse to large communal container



Manual and payloader unloading of refuse into open tipping truck



Refuse Collection Systems—Kanpur, India

quantities of waste to the municipal refuse. Very often, large heaps of soil and stone are dumped into the streets with the assumption that the municipality has the responsibility to collect and haul it. Special methods of collection are needed; and design of vehicle chassis should take the extra weight into consideration.

Sanitation residues. In developing countries where sewerage is not the major means of managing human excreta and sullage, there are sanitation residues from privies and latrines. The so-called night soil which accumulates in these sanitation systems and requires regular removal may be serviced by either the municipality or the private sector. In some cases there is co-collection of household sanitation residues and refuse; in others there is the potential for some of it to be illegally dumped by collectors into open drains--thereby eventually comprising a portion of street sweepings which include drain cleanings. In addition, there is often co-disposal of night soil with municipal refuse at open dump sites, whether sanctioned or not sanctioned by the municipality. Because night soil is commonly collected at night, there is little supervision of the workers. Being unaccountable, these workers have a strong tendency to dump the night soil in the closest possible inconspicuous location relative to their collection service area. The practice is not unique to developing countries, but it is more prevalent.

Industrial wastes. Industrial wastes come from processing and non-processing industries, as well as utilities. Packaging materials, food wastes, spoiled metal, plastic and textiles, fuel burning residuals, and spent processing chemicals are among the wastes within this category. The composition is site-specific, and depends on the natural resources and markets which provide the base for a given city's industrial activity. Small-scale industrial enterprises generally discharge their solid wastes into the collective milieu of municipal refuse. Large-scale industries, however, are usually either required to arrange for a private hauler or to pay a fee to the municipality for special service. In either event, most municipalities in developing countries apparently allow industrial wastes to be disposed within their landfills; and generally without charging any tipping fee to cover the costs of disposal. In the U.S.A, industrial refuse is not treated as part of municipal refuse; its quantity is about three times that of municipal refuse; and between 10 and 15% is considered hazardous. (4)

B. Waste Generation Rates

Securing comparable data is difficult. For those few project development efforts which involved field data collection, the methods of sampling were generally not reported, and no relationship was drawn between the resulting data and any key determinants of the resulting data. It appears that few of the efforts to collect and weigh samples also involved surveying of the residents participating in the sampling effort for the purposes of establishing determinants of the generation rates developed.

In only a few instances did the researchers note difficulties encountered in their sampling programs. Since their comments are useful to future efforts, since they explain certain anomalies in some of the data, and since they caution the reader to be conservative in the use of any data developed thus far on waste generation rates, some of their remarks are summarized below:

. Kanpur, India: Many problems were faced during this survey. First of all many people refused to keep the tins (for sampling) in their houses. Some saying that the waste would not be removed every day and would therefore cause more uncleanliness. To get rid of problems of this type, announcements were made over the All India Radio, Kanpur, saying that this survey was in the interest of the public, to keep the city cleaner. After this the public cooperated to some extent. After some time it came to our knowledge that all this had led to the misunderstanding that this survey of the waste collection was being done by the Mahapalika (municipal corporation) so as to tax the people for the waste accumulation, like the Sewer Tax. Thus people stopped putting the total wastes of the day into these tins and would only put a part of it ... (In addition, since dairies are located within the city limits), buffalo and cows while going out for grazing scatter dung all over the roads... Also, most of the footpaths in the city area are Kuccha (unpaved), thus enormous amounts of silt are also collected on roads. Apart from this, Malva (construction debris) is also thrown on the streets, footpaths or rubbish depots by the construction of roads and buildings. Over the Malva, street sweepers dump refuse. All this has to be removed by garbage vehicles to dumping grounds. (5)

. Surabaya, Indonesia: Plastic bags were used for these tests; if rigid domestic wastes containers were in use, densities would be higher as householders would tend to compress wastes within the containers. (6)

. Bandung, Indonesia: The impact of income and living habits on solid waste generation is not known in a concise, measurable way, although it can be shown that there is a general positive relationship between waste generation and income level. Income level is notoriously difficult to measure and ... as a surrogate for this factor, the surveys recorded the housing type in accordance with the definitions of the Indonesian Census ... The survey method was set up on the premise that the selected RW's (neighborhoods of a certain size and structure in Indonesia) did in fact conduct regular daily collection of waste throughout the area. In this case, the waste generated from a group of houses over a week would be measured and the population contributing to this would be surveyed... Two main problems arose... The first was that the contributing population was difficult to measure. The second was that the census classification of house types proved to be an inadequate basis for emphasizing different levels of waste generation. (Furthermore), far from a regular pattern of collection being provided, most RW's surveyed were covered by the handcart teams in a haphazard manner." (7) (Note: In this case the researchers conducted a second survey to overcome the problems caused by irregular service in the collection area, and the corresponding validity of estimated population served. It appears, that there was no ready means for overcoming the lack of competent income level data.)

. Cairo, Egypt: The first such study undertaken as part of this project was at Manshiet Nasser, where a regular waste collection service had never existed. The relatively low waste generation rate observed at Manshiet Nasser may be attributed to a number of factors, many of which may prove to be characteristic of other low-income neighborhoods in Cairo. Primary among these is the very low income level of the community, which has a significant impact on patterns of consumption and waste generation. Secondly, many members of the community raise chickens, rabbits, goats and other animals at home, and these animals are fed mostly food wastes. Finally, combustibles in the waste stream are frequently used for fuel for baking. Thus the waste component profile is characterized by an unusually low content of food wastes, and an unusually high content of dirt mixed with animal manure... The unusually high dirt content may be partially attributed to the eagerness of residents to clean up their homes and get rid of dirt after years of deprivation of refuse collection services." (8) (Note: This was a survey of household refuse only, whereby samples were collected from the dwelling. The percentage of dirt by weight averaged 60.6%. Lack of resident cooperation was not a problem in this sampling effort--probably because it was designed to involve the efforts of a locally accepted leader to describe the purpose and method of sampling at the onset of the program.) (8)

Not only is it difficult to collect competent data from the various sources of generation in developing countries, such as households and commercial establishments, but it is difficult to translate that data to quantify the amount that actually needs to be collected. Relatively few cities in developing countries provide door-to-door service to dwellings, each with an appropriately sized and designed dustbin. The waste is often carried by residents to open collection points, masonry bins, and metal containers. There the waste is subject to three activities that markedly reduce its weight: (i) natural biodegradation and volatilization of waste constituents; (ii) picking out of recyclables by human scavengers; and (iii) eating of the food wastes by animal scavengers. On the other hand, the waste is also subject to activities that increase its weight: (i) rainfall may soak the waste; (ii) animal manure may be added; (iii) direct faecal discharge and night soil may be added; (iv) waste generating sectors which are not supposed to be served by the municipal system, such as small-scale industries, may throw their wastes in with the rest; and (v) soil and stone may be added from street sweeping and construction/demolition activities. In India, a country-wide survey of refuse composition indicated that ash and earth comprised between 31 and 47% of the total municipal refuse waste stream. (9) In Lahore, Pakistan, 12% of the total urban solid waste being collected was animal manure and 21% was night soil. (10)

Table 1 provides data on waste generation rates in terms of kilograms per capita per day. The data are arrayed by income level of the country where the surveyed city was located. The data are essentially only applicable to very large urban areas since this is where most of the surveys in developing countries have been taken. Also, most of the World Bank's solid waste projects have occurred in urban areas with more than one million residents.

Table 1: URBAN REFUSE GENERATION RATES

City or Country	Waste Generation Rate
Industrialized Countries:	
New York, New York, U.S.A (11)	1.80 kg/cap/day
Hamburg, Germay (12)	.85
Rome, Italy (13)	.69
Middle-Income Countries	
Singapore (14)	.87
Hong Kong (15)	.85
Tunis, Tunisia (16)	.56
Medellin, Colombia (17)	.54
Kano, Nigeria (18)	.46
Manila, Philippines (19), (20)	.50
Cairo, Egypt (21), (22)	.50
Low-Income Countries	
Jakarta, Indonesia (23)	.60
Surabaya, Indonesia (24)	.52
Bandung, Indonesia (25)	.55
Lahore, Pakistan (26)	.60
Karachi, Pakistan (27)	.50
Calcutta, India (28)	.51
Kanpur, India (29)	.50

Note: For those cities in developing countries where the total refuse mix was subdivided into major categories of waste, data indicate that the residential portion of the total refuse was between 60 and 80%.

There is no valid way of extrapolating the data in the table to get a range of values for small cities. In the U.S.A., the country-wide average for municipal refuse generation is 1.4 kg/cap/day; while in India, it is 0.37 kg/cap/day. (30) (31) (32) In both cases, the country-wide average represents about 75% of the large city values shown in the table. The difference among rates for small cities versus large cities, is primarily dependent on the difference in commercial activity between the two--with large cities having higher waste generation rates that reflect the higher commercial activity.

For purposes of project identification, where an indication of service level must be estimated and data from the project preparation stage have not yet been developed, the following municipal refuse generation rates are suggested:

residential refuse	0.3 to 0.6 kg/cap/day
commercial refuse	0.1 to 0.2 kg/cap/day
street sweepings	0.05 to 0.2 kg/cap/day
institutional refuse	0.05 to 0.2 kg/cap/day

If industrial solid waste is included in municipal refuse for collection and/or disposal purposes, from 0.1 to 1.0 kg/cap/day may be added at the appropriate step where the municipality must estimate service delivery requirements.

These generation rates are subject to considerable site-specific factors, as discussed in the preceding paragraphs. In lieu of reasonable data, most solid waste planners have been using a refuse generation combined rate of 0.5 or 0.6 kg/cap/day for the World Bank's projects.

C. Waste Characteristics

Under the heading of waste characteristics, these subjects are discussed: (i) waste density; (ii) waste composition; (iii) waste moisture content; and (iv) size distribution of waste materials. The first item is particularly important to the planner. Waste density information when coupled with waste generation rates expressed by weight, allow the payload capacity of the collection equipment to be estimated. When this payload capacity is then divided by the number of trips feasible for the various regions of the city, it is possible to estimate the number of vehicles required to be on the collection routes each day.

The waste generation rates were shown in the preceding section to be highly variable from city to city. Correspondingly, waste density values exhibit a large range from one city to the next. When the waste generation data's uncertainties are coupled with the uncertainties concerning waste density, estimation of the needed fleet payload capacity proves to be fraught with uncertainties. Nevertheless, the following paragraph provides available data together with information regarding the determinants of waste density values.

Where refuse production is high, density tends to be low--and vice versa. Lower density values associated with industrialized countries are related to the high percentages of non-putrescibles, such as paper, plastics, glass and metals, which often result from packaging of consumer goods. These materials have large void spaces and low moisture content, which explains to some degree their low density values. In addition to composition, the density of refuse in developed countries tends to be largely unchanged between the point of generator storage and the collection vehicle. To illustrate this discussion, Table 2 provides data compiled from available literature. The values shown reflect densities at the pick-up point.

Table 2: URBAN REFUSE DENSITIES

Country	Waste Densities
Industrialized Countries:	
United States (33)	100 kg/cubic meter
United Kingdom (34)	150
Middle-Income Countries:	
Singapore (35)	175
Tunisia (36)	175
Nigeria (37), (38)	250
Egypt (39)	330
Low-Income Countries:	
Thailand (40)	250
Indonesia (41), (42)	250
Pakistan (43)	500
India (44), (45)	500

Note: Most of the above data reflect waste densities at the source of generation, after placement in household containers or building containers. The high numbers shown for Pakistan and India are believed to reflect the density of refuse at the open collection points which predominate as part of the collection systems used in these two countries.

In addition to the data provided in the preceding table, consultants working on several World Bank projects have developed interesting data on how densities vary from one step to another in refuse management. Their findings are briefly summarized in the following comments:

. In Tunis, Tunisia, where refuse at the household was measured as being 175 kg/cubic meter, refuse in the portable communal containers was measured as being about 200 kg/cubic meter; in curbside stationary communal containers it was about 300 kg/cubic meter; in non-compaction trucks it measured 400 kg/cubic meter. (46)

. In Kano, Nigeria, where refuse at the source averaged 250 kg/cubic meter, refuse which had been deposited in heaps at communal collection points, picked over by scavengers, rested for a couple of days, and loaded by payloader onto an open tipper truck, exhibited a density of about 600 kg/cubic meter. (47)

. In Jakarta, Indonesia, measurements from a World Bank sponsored pilot project showed refuse densities of about 200 kg/cubic meter in the standardized household bins; measured at 370 kg/cubic meter in the pushcarts; and was 600 kg/cubic meter after being compacted in the hand-loaded baler located at the pilot transfer station. (48)

. In Calcutta, India, refuse exhibited densities of about 550 to 600 kg/cubic meter in the non-compaction collection vehicle. After disposal by open dumping, whereby no compaction was performed, and resting within the dump for six months, the refuse had naturally consolidated to a density of about 1,100 kg/cubic meter. (49) (50)

There is one important piece of knowledge to be learned from the above information: equipment designed to reduce volume by compaction is generally not justifiable for developing countries. The nature of refuse in industrialized countries is characteristically low in density. Compaction equipment, such as rear-loading compaction trucks, is essential to most cities in developed countries. Managers and engineers trained in these countries tend to assume that the same technologies are appropriate in developing countries. The above information clearly shows that this would be the exception, and not the rule. To further illustrate:

- compaction trucks are typically designed to compact refuse to about 400 kg/cubic meter; (51)
- landfill dozer/compactors are designed to compact refuse to about 600 kg/cubic meter; and (52)
- balers are designed to achieve densities of 600 to 1,000 kg/cubic meter. (53)

Table 3 presents the extent to which competent data on waste composition could be obtained for this effort. Compositional differences are accountable to economic, cultural, climatic and geographic differences among cities. Seldom do reports providing data provide information on the determinants of the waste composition being presented. Though most categories of waste are mixed together during collection, Table 4 indicates that there is a variance in composition by source. For certain types of resource recovery source segregation of refuse by category may prove attractive.

Table 3: URBAN REFUSE COMPOSITION DATA
(in percentage by weight)

Type of Material	Brooklyn, N.Y. (62)	London, England (63)	Rome, Italy (64)	Singapore (65)	Hong Kong (66)	Medellin, Colombia (67)	Lagos, Nigeria (68)	Kano, Nigeria (69)	Manila, Philippines (70)	Jakarta, Indonesia (71)	Lahore, Pakistan (72)	Karachi, Pakistan (73)	Lucknow, India (74)	Calcutta, India (75)
	Industrialized			Middle Income						Low Income				
Paper	35	37	18	43	32	22	14	17	17	2	4	<1	2	3
Glass, ceramics	9	8	4	1	10	2	3	2	5	<1	3	<1	6	8
Metals	13	8	3	3	2	1	4	5	2	4	4	<1	3	1
Plastics	10	2	4	6	6	5	-	4	4	3	2	-	4	1
Leather, rubber	-	-	-	-	-	-	-	-	2	-	7	<1	-	-
Textiles	4	2	-	9	10	4	-	7	4	1	5	1	3	4
Wood, bones, straw	4	-	-	-	-	-	-	-	6	4	2	1	<1	5
Non-food total	74	57	29	63	60	34	21	35	40	15	27	4	18	22
Vegetative, putrescible	22	28	50	5	9	56	60	43	43	82	49	56	80	36
Miscellaneous inerts	4	15	21	32	31	10	19	22	17	3	24	40	2	42
Compostable total	26	38	71	37	40	66	79	65	60	85	73	96	82	78
TOTAL	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Note: The above values have been rounded to the nearest whole number, unless the amount was less than 1.0.

Table 4: VARIANCE IN REFUSE COMPOSITION BY SOURCE OF GENERATION
(in percentage by weight)

	Bandung, (76) Indonesia			Colombo, (77) Sri Lanka		
Type of Material	Residential	Market	Commercial	Residential	Market	Commercial
Paper	10	8	12	8	8	28
Glass, ceramics	<1	<1	<1	6	<1	8
Metals	2	<1	1	1	<1	1
Plastics	6	2	7	1	<1	1
Leather, rubber	-	-	-	-	-	-
Textiles	4	<1	3	1	1	1
Wood, bones, straw	<1	<1	1	1	0	2
Non-food total	22	11	24	18	10	41
Vegetative, putrescible	72	84	69	80	88	58
Miscellaneous inerts	6	5	7	1	2	1
Compostable total	78	89	76	81	90	59
TOTAL	100	100	100	100	100	100

Note: The above values have been rounded to the nearest whole number, unless the amount was less than 1.0.

Moisture content is often not reported for the compositional samples taken. Not only is the moisture content for the total refuse mix not provided, but there is virtually no information on the moisture content of the various components of the total waste mix. Because moisture content for each component of refuse differs greatly, as shown in Table 3, compositional percentages on a dry weight basis would be quite different from those on a wet weight basis. Unless adjustment is made to the dry weight basis or to some common moisture level, the results are not truly comparable. (54) Nevertheless, although few of the surveys reviewed as a part of this effort provided data on a dry weight basis, some attempt at comparison will be made in order to provide a frame of reference for the user of this project guide.

It is interesting to note that the food component in Table 5, comprises only about 18% of the total refuse composition but has a moisture content of about 70%. Wastes from urban areas in developing countries have a much higher percentage of food waste in their overall refuse mix. The data provided below demonstrates that they apparently have a correspondingly higher moisture content. It is also apparent from the data below that the moisture content of refuse in developing countries is somewhat dependent on climate, especially in places where waste is stored on open ground while awaiting collection.

City or Country	Moisture Content	Vegetable/Putrescible Content
Industrialized country:		
Brooklyn, New York, U.S.A.	22% (55)	22%
Middle-Income countries:		
Singapore	40% (56)	5
Onitsha, Nigeria	45% (57)	-
Manila, Philippines	60% (58)	43
Low-Income countries:		
Bandung, Indonesia	80% (59)	75
Calcutta, India	29% (60)	36
Lahore, Pakistan	52% (61)	49

Table 5: COMPOSITION DATA AND MOISTURE CONTENT FOR THE U.S.A.

	Combined Residential and Commercial Refuse Generated (78)		Moisture Content (79)	
Type of Material	As Generated	As Disposed	As Discarded	As Disposed
Paper	31.0%	37.8%	7.0%	23.1%
Glass	9.7	10.0	0	3.0
Metal	9.5	10.1	0	5.5
Plastics	3.4	3.8	2.0	13.0
Leather, Rubber	2.6	2.7	2.0	13.0
Textiles	1.4	1.6	7.0	20.0
Wood	3.7	3.7	15.0	15.0
Non-food product Total	61.7	69.7	---	---
Food Waste	17.6	14.2	70.0	63.0
Yard Waste	19.3	14.6	50.0	34.0
Miscellaneous inorganics	1.4	1.5	2.0	4.0
Total	100.0	100.0	---	---
		Weighted Average	27.0	27.0

Note: It is assumed that the data presented in columns 1 and 2 are on a dry dry weight basis; however, the publication did not indicate the basis as either wet weight or dry weight. The data represent 1971 conditions, and was reported in 1974. Increasing efforts of recycling would be expected to result in different "as disposed" values in column 2 for present conditions.

For the weighted averages presented in columns 3 and 4, the estimates were based on compositional data for one semi-seasonal state in the U.S.A., the compositional values were quite compatible with the U.S.A. averages shown in Columns 1 and 2.

The so-called compostable faction of refuse includes readily biodegradable organics and fine grained inerts, such as sand and ash. Table 3 indicates that at least 60% of most LDC refuse is compostable. In general, a moisture content of 50 to 60% is considered optimum for composting. (80) Most of the municipal refuse from developing countries would have a viable initial moisture content for composting to take place without the addition of water or a high-moisture waste, such as night soil, or a bulking agent such as chipped coconut husks or banana stalks. Composting also calls for carbon to nitrogen ratios that promote microbial growth and subsequent decompositon of the wastes. Generally, an initial C:N ratio of 30 to 35 is considered optimum. Information is scanty on C:N ratios in refuse of developing countries; cities in India tend to range from 20 to 26. (81) Data reported for Bandung, Indonesia showed a C:N ratio ranging from 87 to 108. (82) Where the nitrogen content of the refuse is so low that the C:N ratio is very high, animal manure or night soil can be added to the waste to adjust the C:N ratio downward.

For conversion of refuse to methane gas, through anaerobic digestion by microorganisms, only the vegetable/putrescible faction is considered. Table 3 indicates that over 40% of the refuse in LDCs would be amenable to anaerobic digestion to methane. Since a moisture content of 85 to 93% is the normal range for digestion, addition of human wastes, or animal manures is sometimes recommended. Methane gas can be generated rapidly in either a covered tank or clay pit, or more slowly in a landfill. To remove methane from a landfill, pumps must be hooked up to perforated pipe or gravel packed trenches placed within the layers of anaerobically decomposing refuse.

Table 3 also indicates that the quantity of paper, glass, plastic and metal recyclables is relatively low for the low-income countries versus the middle-income and industrialized countries. Despite this tendency, the low wage rates prevalent in these countries may very well make sorting to recover these recyclables feasible.

In estimating the combustible fraction of refuse, the paper, plastic, textile, wood, food and yard waste materials are generally added together. Based on information from Table 3, the combustible fraction of refuse in developing countries often ranges from 50 to 80% of the total mix of materials. On the other hand, data from England, Switzerland and the United States, shows a range of combustibles comprising 60 to 75% of the total refuse mix. However, two factors associated with waste from developing countries tend to render their refuse less viable for incineration: moisture content and ash (inert) content. The moisture content for the LDC refuse tends to range between 40 and 70%, while that of the industrial countries is generally between 20 and 25%. (83) The portion of miscellaneous inert materials that would generate ash residues from incineration are between 20 and 40% in those developing countries having open on-ground collection points (i.e., Kano, Lahore, Karachi, Calcutta). Inerts generally range from 10 to 15% of the total refuse mix in industrial country urban wastes. (84)

Particle size distribution of refuse materials affects two issues in planning disposal: (i) the need for compaction and soil cover in landfill; and (ii) the need for size reduction by shredding prior to composting, biogas generation, or incineration. There is a paucity of data on particle size distribution of refuse materials. In the literature from developed countries, it is generally assumed that the waste needs to be shredded as part of a resource recovery scheme; and literature which exists primarily discusses the size reduction possible from use of various types of shredders. In the literature from developing countries, this is a fine point in data collection that is not included in the budgeted effort because the emphasis is on collection rather than on disposal.

Data from Great Falls, Montana, and Richmond, California, show that about 80% and 50% of the particles in raw waste samples were greater than 50 millimeters, respectively. And the data show that less than 10% of the raw waste samples had particles under 10 mm. (85) (86) Data from Bandung, Indonesia, show that about 35% of the total refuse mix was greater than 50 mm; about 12% was less than 10 mm. (87) In Lucknow, India, only about 6% of the refuse was greater than 50 mm, while about 43% was less than 10 mm. (88) This information implies that particle sizes tend to be smaller in municipal refuse in developing countries. Since the output of a typical shredder produces a mix of particle sizes with about 25% above 50 mm and 40% below 10 mm, (89) a number of cities in developing countries would not benefit from size reduction. For landfilling specifications, it is normally required that 80 to 90% of the shredded refuse be less than 80 mm; and for refuse-derived fuel production, it is normally required that 80 to 90% of the shredded refuse be less than 40 mm. (90) For composting, it is recommended that 80 to 90% of the particles be less than 150 mm. (91). Based on needs of various disposal options for specific particle sizes, on typical outputs of shredders, and on particle size distribution in developing countries, it appears that a planner would be hardpressed to justify the need for size reduction.

III. SOLID WASTE MANAGEMENT: A BASIC NEED

A. Health and Secondary Environmental Aspects of Urban Solid Wastes

Chapter II provided information describing the types of materials which may be present in the mixture of wastes called municipal refuse. There was information provided on the basic composition of refuse, and the likely rates of generation per urban inhabitant. There are four main health and environmental aspects associated with the mix of wastes as described in Chapter II.

First, most municipal refuse contains human faecal matter. In developed countries, its presence is largely attributable to the prevalent practice of using disposable diapers for infants and toddlers. In developing countries, its presence is more likely to be attributable to inadequacies of the sanitation infrastructure and management.

Second, most municipal refuse is likely to contain some industrial waste. Even in cities where private haulers are engaged to service industrial establishments, small-scale enterprises are likely to use the municipal system for at least some of the time. Furthermore, many cities which require private hauling of industrial wastes allow co-disposal of those same wastes within the municipal landfill. While the level of industrial activity is much lower in developing countries than it is in developed countries, the degree of hazard associated with the wastes generated are likely to be similar. It is roughly estimated that 10 to 15% of the industrial wastes in the U.S.A. are considered hazardous. (1)

Third, the decomposition by-products of materials within urban solid waste can release chemical constituents into drainage, seepage, and atmospheric emissions associated with either treatment or disposal of the refuse. In developing countries where open dumping of wastes in wetlands or borrow pits is the most prevalent form of disposal, the principal pathway for these chemicals would be leachate into ground and surface waters.

Fourth, smoke from continuous burning of dumps creates extensive pollution in many cities of developing countries. Refuse in dumps has a high organic content and where exposed and sun-dried at the surface, spontaneous combustion occurs readily. Where methane gas is being continuously generated by anaerobic decomposition of organics within the refuse, fires can spread underground and go on for years.

Life expectancy in low-income countries is markedly lower than in industrialized countries; averaging about 50 years for low-income countries as opposed to about 74 for industrialized countries. (2) In general, the short life expectancy reflects very high death rates among children under five years of age. In the poorest regions of low-income countries, half of all children are reported to die during the first year of life. For people who survive beyond age five, life expectancy is within six to eight years less than normal levels in developed countries. The primary cause of death is faecally related disease: responsible for one quarter to one half of the deaths under age five. (3)

When considering that human excreta is a critical vehicle for transmission and spread of a wide range of communicable diseases, municipal refuse is often overlooked as an important pathway for the pathogens contained in excreta. The most obvious route is direct, whereby refuse collection workers, scavengers and playing children are in contact with faecally contaminated refuse and then place their contaminated hands in their mouths or on their food.

A less direct route occurs when vectors such as flies and cockroaches transport disease carrying agents in their intestinal tracts, subsequently contaminating food they contact. Furthermore, pathogens and irritants leading to infection may be directly inhaled as wind transports fine-grained refuse materials from the open collection points or from the activities of transfering refuse from one place to another. This is most apparent in the refuse collection system in which payloaders pick up refuse from the ground and place it in open trucks; dust from the refuse is unavoidable; residents tend to stand around and watch the activities of the very large and noisy equipment.

One of the results of inadequate solid waste management is that residents tend to compensate by discharging their wastes in the most convenient open area or drain. In many cities of developing countries, and particularly in the neighborhoods housing the highest percentages of the urban poverty group, municipal refuse clogs drains and causes stagnant waters. Where these open drains contain human sullage and faeces, there is potential for the Culex pipiens and fatigans mosquitoes to breed in the stagnant waters, a vector of filariasis. (4)

Data are limited on the pathogenic nature of municipal refuse, as generated and as disposed. One study on parasites in urban refuse from 12 Indian cities showed that two intestinal worms were commonly found--Ascaris lumbricoides (roundworm) and Trichuris trichiura (whipworm). These were found to be particularly high in samples from refuse in slums and low-income neighborhoods (probably because of the inadequacies of sanitation facilities available). Also, the highest incidence of parasites occurred during the monsoon season. (5)

Once excreted, the survival of pathogens in refuse is dependent on their basic nature, as well as their environment. Viruses tend to decrease in number following excretion; bacteria may multiply if they find themselves in a nutrient-rich, conducive environment; protozoa normally pass through an asymptomatic carrier state, with the carrier responsible for eventual transmission; parasitic worms, or helminths, generally decrease in number following excretion, except for trematodes which can multiply in their intermediate hosts. (6) Survival of most bacteria and viruses within faeces appear to be up to 5 months, while helminth ova may survive for many months. Despite this general trend, bacteria have been shown to survive for years in suitable environments; and a recent study of landfills showed faecal-indicator bacteria existing 9 years after one municipal landfill was closed. (7) (8) Helminth ova have recently been shown to survive both anaerobic digestion and air drying, and to be infective after several years of storage (9)—this information is most relevant when considering waste reuse for such activities as soil amendment.

KANO, NIGERIA

Industrial dump site in Nassarawa which has been a traditional cattle watering hole

Regarding the second health and environmental issue, whereby some portion of the municipal refuse may be industrial waste and whereby some portion of the industrial waste may be hazardous, only a few comments will be made within the context of this project guide. Not because the subject is unimportant, but because it is vast, and highly site-specific. The World Development Report 1980 provides some indication of the industrial activity in low-income and middle-income countries, versus industrialized countries. The gross manufacturing output per capita is used as an indicator and presented in 1970 dollars per capita: for low-income countries it tends to range between $10 and $50; for middle-income countries between $50 and $1,000; and for industrialized countries it tends to range between $1,000 and $2,500, with the United States exhibiting a high value of $3,126. (10) Based on this fundamental index, one would expect industrial waste generation rates in industrialized countries to be roughly 100 times as much as those in low-income counties.

Presented as Annex B is an excerpt taken from the U.S. Federal Register of May 19, 1980. It lists the various industrial sources of wastes considered hazardous. The criteria to define hazard relate to ignitability, corrosivity, reactivity, and toxicity. The organic chemicals industrial sector is considered the primary source of hazardous wastes for the industrial activities mix in the U.S.A. Where industries identified in Annex B are present in urban areas of developing countries, an effort should be made to provide separate handling, collection and secured disposal of these materials. A code of hazardous waste regulation should eventually exist in all countries, whereby these special wastes are tracked and their ultimate disposal locations recorded for future monitoring which may be needed.

Groundwater contamination is the most common method of damage from hazardous waste disposal cited in documented cases. (11) It is also the most common means of environmental degradation associated with municipal refuse disposal. Waste which is placed in landfills or open dumps and then subjected to either groundwater underflow or infiltration from precipitation gradually releases its initial interstitial waters and its subsequent decomposition by-products into the waters moving through the waste deposit. In very dry countries, where the groundwater level is below the bottom of the deposit, where precipitation is limited, and where flooding of the deposit cannot take place, groundwater contamination from disposal activities would not be an issue. However, where there are influent waters to the waste disposal deposit, the issue of groundwater contamination must be reviewed with respect to the value of the groundwater reservoir as an existing or pending source of potable water supply and as a contributor of recharge to rivers or lakes with important aquatic life.

Leachates from landfilled refuse exhibit a wide range of chemical concentrations, as shown in Table 6. The concentrations change in time, with respect to infiltration inflow, seasonality, overall waste decomposition, and waste consolidation. Generally, leachate concentrations peak just after a waste deposit becomes fully saturated and gradually decrease as the soluble components slowly seep away.

Table 6: RANGE IN COMPOSITION OF LANDFILL LEACHATE

Constituent	Range (12) (mg/l)	Range (13) (mg/l)	Range (14) (mg/l)	Range (15) (mg/l)
COD	40-89,520	0-89,520	100-51,000	16,000-22,000
BOD_5	81-33,360	9-54,610	--	7,500-10,000
TOC	256-28,000	--	--	--
pH	3.7-8.5	3.7-8.5	4.0-8.5	5.2-6.4
TDS	584-44,900	0-42,276	--	10,000-14,000
TSS	10-700	6-2,685	--	100-700
Conductivity (mhos)	2,810-16,800	--	--	6,000-9,000
Alkalinity (CaCO3)	0-20,850	0-20,850	--	800-4,000
Total hardness	0-22,800	0-22,800	200-5,250	3,500-5,000
Total P	0-130	--	--	--
NH_4-N	0-1,106	--	--	--
NO_3 + NO_2-N	0.2-10.29	--	--	--
Ca	60-7,200	5-4,080	--	900-1,700
Cl	4.7-2,467	34-2,800	100-2,400	600-800
Na	0-7,700	0-7,700	100-3,800	450-500
K	28-3,770	2.8-3,770	--	295-310
Sulfate	1-1,558	1-1,826	25-500	400-650
Mn	0.09-125	0.06-1,400	--	75-125
Mg	17-15,600	16.5-15,600	--	160-250
Fe	0-2,820	0.2-5,500	200-1,700	210-325
Zn	0-370	0-1,000	1-135	10-30
Cu	0-9.9	0-9.9	--	0.5
Cd	0.03-17	--	--	0.4
Pb	0-2.0	0.5.0	--	1.6
Phosphate	6.5-85	0-154	5-130	--
Total N	--	0-1,416	20-500	--

In an environment within a landfilled waste deposit where the materials are wet and there is little oxygen, microorganisms which metabolize their food through anaerobic digestion produce a by-product of their metabolic activities: methane. If the landfill is well contained, for example--within a clay borrow pit, this may create an opportunity for methane recovery and utilization. However, in most cases, the waste deposit is surrounded by relatively porous soil. In these cases, there is potential for the methane to migrate underground and seep into the basements of buildings. There, it may build up to levels that are potentially explosive. In developing countries where land resources are scarce and valuable, urban residents may build directly over the landfill without realizing that precautions should be taken to avoid methane accumulation. In Onitsha, Nigeria, new middle-income level housing was being constructed on the landfill while disposal was still ongoing. (16)

B. Solid Waste Management: A Public Sector Responsibility

Collection and disposal of refuse within an urban area has been traditionally perceived as the responsibility of the local municipal government. Since there are essentially no economies of scale in the equipment and facilites employed in service delivery, and there may well be some diseconomies of scale in creating additional layers of bureaucracy, management of municipal refuse is one of the few responsibilities that is not regionalized.

Solid waste management has a large transportation component. It is important to minimize the travel times and distances of the collection and transfer vehicles in order to provide minimum cost service. Furthermore, if there is resource recovery of certain material or energy value in the waste, it is important that transport distances to the market area be limited. As a result, not only the collection, but also the disposal of refuse takes place within the immediate vicinity of the metropolitan area.

Another reason for solid waste management typically remaining in the hands of the local government is that no one else wants it. The delivery of service to collect and dispose of refuse is commonly given little status or priority. Managers and workers providing cleaning services are usually given lower grade levels and lower salaries than counterpart personnel in other divisions or departments of the municipal organization. This is especially true in developing countries where cleaning services may be handled only by a certain sect or class of people.

Even in cities where all or a portion of the cleaning service is contracted out to the private sector, it is the municipal responsibility to hire the contractor and monitor the service provided. In many cities, the municipality remains the agent to do the billing, handle complaints and provide disposal systems; while the private contractor performs collection and transfer.

Provision of services to collect and dispose of municipal refuse is expensive, even when the most primitive methods are employed. It is not unusual for the costs to comprise 20 to 40% of a municipal budget. The average of municipal budget allocation for refuse management reported for India was 10%; however, in the cities of Kanpur and Calcutta in India, it was 22 and 26%, respectively. (17) (18) (19) Annual cost per person amounted to $0.50 for India, while costs in Kanpur and Calcutta averaged $1.50 and $1.80. Collection and transportation made up 70 to 80% of these amounts, with disposal (most often by composting) making up the rest.

Costs are not necessarily low in cities relying on private collection. Private collection typically favors middle- and upper-income levels. If private haulers are directly engaged by residents, low-income people often cannot afford the expense. If the private haulers are performing the service for personal gain because of the recyclables they wish to recover, they would tend to serve only those residents with "rich" waste. In Lahore, 40% of the refuse is collected by farmers at no cost to the city. About 26% of the residents receive no service, and yet the refuse management budget costs all residents about $2 per person annually and comprised 24% of the municipal budget. (20) In Cairo, the municipality must collect an average in revenues of about $2 per person annually for indirect collection of only about 50% of the city's refuse. (21) One of the reasons for this is inefficiencies in having municipal crews working solely on the left-overs of the primary private sector system. In Cairo a crew which is manually sweeping and shoveling up the discards of unserved residents can collect only about one-third as much in a given day, as the crew which is emptying household containers from door-to-door into the donkey or bullock cart. (22)

Private contractors concentrate on the "cream" of the refuse. (23) What may be considered "cream" at one time, may not at another time--as a function of the market demand for various recoverable, recyclable materials within the refuse. If given a monopoly, or left to its own devices, the public risks its essential sanitation. At a minimum, the public should: (i) monitor the private sector's handling and recycling of the most attractive, lucrative wastes; (ii) provide a minimum base whereby the public sector handles the filthiest, least profitable wastes, and (iii) have the management capability and planning foresight to implement contingency systems to handle all wastes should the private sector fail.

C. Objectives of The World Bank's Solid Waste Projects

The overall goals of municipal refuse management are to: improve and safeguard the public health and welfare, reduce waste generation and increase resource recovery and reuse, and protect environmental quality. Specific objectives of solid waste projects are compatible with objectives staged for other sectors serving basic needs of the urban public:

- provide universal access to an acceptable level of service;

- build an institutional arrangement which has capability to perform continuous planning of solid waste systems to conform with the continuously changing urban setting;

- supply the institution with the equipment, facilities and skilled personnel to administer and perform waste management to an acceptable service delivery standard; and

- develop a system of generating financial resources to meet operating, maintenance and depreciation costs of existing systems, as well as the investment costs for expanded or improved systems.

These goals and objectives are to be pursued within the framework of developing a solid waste project. Outside this framework, there are goals and objectives that solid waste projects themselves may help to address. For example, within the context of a water supply and drainage project, a solid waste component may be vital to realization of the projected health benefits assessed for the improved water supply and drainage. Also, for increased drainage and sewage (attributable to increased water use) to flow freely, refuse collection must be adequate to maintain open drains and sewers. Another example: within urban development projects there are low-cost loans and basic infrastructure provided as incentives for low-income neighborhood residents to upgrade their area. If refuse removal is not a part of the package of upgrading, the continued accumulations of uncollected refuse provide a disincentive to those same residents.

As discussed in Section B, refuse is a local government responsibility in virtually all instances. The various needs of providing service may be handled under either one cleansing agency or a combination of agencies, i.e., public works, mechanical engineering, and health. In either case, the responsibilities fall within so-called line agencies of urban management: not within peripheral agencies created for special needs, i.e., housing or transportation. An attempt to improve the institutional and financial capability of the urban management entities providing cleansing services inherently involves some effort of improving the overall urban management system.

Running a good package of municipal services is vital to the Bank's urban development projects. (24) In any project area where housing has been improved or water supply and sanitation facilities have been provided, long-term project success depends on municipal services which are expected to maintain the network of roads, drains, etc., that complement these facilities. Solid waste management projects provide a bridge for the World Bank planner to review the overall needs of municipal administration. (25) The potential for spin-off benefits to municipal administration to be derived from solid waste management improvements is particularly applicable to the financial aspects.

Money for providing collection, transfer and disposal of refuse usually comes from the general municipal revenues. Direct user charges for refuse service are not common for two reasons: residents see refuse service as a basic need which the municipality has a responsibility to meet within its general directive, and there are no viable means of shutting off service to a resident who doesn't pay his bills. In those few instances where direct charges are levied, and are collected in an efficient and effective manner, the bills are tied in with provision of service which can be curtailed upon lack of payment: i.e. water supply. Therefore, provision of financial arrangements which support a solid waste activity almost invariably involve the following: (i) reviewing the municipal tax assessment activities; (ii) reviewing the projection of municipal needs and the subsequent planning of revenue generation; (iii) reviewing adequacy of the municipal accounting system; and (iv) reviewing the municipality's approach to planning and providing allocations of revenue resources to the various needs of the urban area. Performance of these reviews, coupled with recommendations to improve each of these activities within municipal financial management, is essential to the success of the solid waste project--and provides benefits indirectly applicable to the success of urban development projects.

D. History of the World Bank's Solid Waste Lending Activities

The World Bank adopted a formal health policy in 1974 and began to formally sponsor activities directed at improving health. The primary reasons for this thrust were not only to address the basic needs of the poor; but also to improve the productivity and availability of labor, to make better use of existing nutritional resources and to remove disincentives to the development of natural resources and commercial activity in areas which might have unusually high disease incidence. (26)

Solid waste management needs which have been sponsored as part of World Bank projects total a small portion of the overall lending targeted toward improving health. Reportedly, between 1977 and 1980, the Bank financed basic health care and vector control activities costing over $400 million; family planning and nutrition activities with total project costs of about $160 million; and water supply and sanitation activities costing about $3.9 billion. (27) In this same time frame, solid waste projects having a total appraised cost of about $50 million have been negotiated (this total excludes the Singapore Environmental Control Project which was appraised in 1975).

The foreign exchange portion of solid waste project costs, as presented in various appraisal reports prepared by World Bank staff, has ranged from a low of 18% to a high of 73%. Following are a few examples from appraisal documents: Calcutta, India--18%; Singapore--73%; Manila, Philippines--49%; Onitsha, Nigeria--55%; Bamako, Mali--54%; Tunis, Tunisia--63%. (28) (29) (30) (31) (32) (33) Typically, virtually all the foreign exchange cost was covered for equipment and technical assistance. Often, a portion of the local costs was covered. Several of these projects, such as the ones in Tunis and Calcutta, received additional financing from other lending or aid entities. It is to be expected that countries with the lowest income level would have the lowest foreign exchange percentage as part of their solid waste project costs. Labor-intensive collection of refuse by wheelbarrow, donkey cart, and pushcart is often the most appropriate technology. In densely populated zones of a city, these types of equipment are often the only types which can obtain access to the refuse generators.

It is important for planners of solid waste projects to recognize that solid waste management has very high local costs. Not only would it be likely, as indicated in the previous paragraph, for local investment costs for equipment, facilities and technical assistance to comprise about half the project appraisal value; but operating and maintenance costs are likely to be particularly significant. It is essential that these costs be fully considered in project assessment, relative to the local government's ability to provide the continuous renewal of funds needed to "keep the fleet on the road." Cities in developing countries have central workshops that are often little more than graveyards for vehicles that cannot be properly maintained. Lending which provides more of such equipment, and does not address the larger issue of operation and maintenance must be considered irresponsible.

To provide a simple reference point for the reader, typical costs in industralized countries show that it is common for the annual operating and maintenance costs for one rear-loading collection vehicle to equal the purchase price of the vehicle. The natural trend in these countries, where labor wages and benefits are costly, is toward more mechanized systems: driver operated vehicles that completely eliminate the need for crew workers to load refuse into the hopper. This trend leads to operating and maintenance yearly costs that are more likely to fall within 60 and 80% of the vehicle purchase price. (34) While the portion of operating and maintenance costs in developing countries is not expected to be so high relative to investment, it is substantial. In Kanpur, India, and Onitsha, Nigeria, for example, one year's operating and maintenance cost per vehicle was estimated to be about 35% and 80%, respectively, of the vehicle's procurement price. (35) (36)

Constant energy requirements are part of the system, as well as daily repairs. The system is labor-intensive to operate, even in the most developed countries, when compared to systems for water supply, sanitation, and housing, which the Bank might be more accustomed to financing. This all gets back to the issue of urban management, and the need to review urban administration and finances as a part of solid waste project development.

IV. PROBLEMS AND ISSUES

A. Traditional Social, Cultural and Economic Baseline Conditions Which Affect Solid Waste Management Systems

Each city has its own personality. Its people have evolved a unique pattern of behavior. As a city grows, newcomers tend to adapt to existing ways. When it comes to refuse management, the pattern may have some advantages that the governing body wants to keep and perhaps enhance; or it may have disadvantages that prove difficult to weed out of the system. A few illustrations from cities in developing countries are discussed below to provide a glimpse of the baseline conditions which influence not only the existing municipal refuse management system, but also the options which are feasible to implement.

Many cities of developing countries have an informal refuse collection service provided by scavengers. In Cairo, Egypt, two sets of immigrants to the city control the door-to-door collection of refuse. The Wahis, a Moslem group, have long-term contracts with building owners to provide refuse collection. The Zarrabs, a Coptic Christian group, actually perform the refuse collection for proprietary rights to the wastes' recyclables. The key issue is that service is only provided to the upper middle-income and wealthy residents of the city, who have refuse that is rich in recyclable materials. The rest of the city's residents haphazardly discard their wastes; and the local government is burdened with an expensive clean-up system for streets and drains. (1) (2) (3)

Cairo, Egypt, is not unique in having scavengers provide important refuse collection and/or disposal services. In Lahore, Pakistan, 40% of the refuse is picked up by farmers for use as animal feed and soil amendment. (4) There are reportedly 5,000 scavengers working the approximately 160 hectare open dump for Mexico City's refuse. Each has his own area and works for a leader who defends a group of plots. There are numerous pay-offs in this system, with one of them reportedly being to the drivers of the municipal refuse trucks: They may charge a scavenger up to $15 to unload on his plot. (5) As in Cairo and Mexico City, middlemen are common to the system of scavenging in Medellin, Colombia. There, they purchase recycled materials from the landfill scavengers and resell them for processing and reuse. A number of these middlemen have grouped together into cooperatives, to give themselves greater leverage in the market place, as well as some collective funds for buying, sorting, and transportation equipment. (6)

In addition to the scavenging activities of the private sector, there are those of the public sector. These may occur even when there is a strong private sector activity. For example, there is regular friction between the landfill scavengers at Mexico City's dump and the municipal refuse collection crews. Apparently, the municipal workers pick out the most valuable refuse before they arrive at the dump, and then charge the scavenger a fee for dumping on his turf. (7) Refuse collectors in Bangkok, Thailand provide door-to-door service using large baskets and two-wheeled

JAKARTA AND SURABAYA, INDONESIA

Scavenging by municipal refuse workers and private pickers at the dump sites during unloading of collection equipment

BANGKOK, THAILAND

Municipal refuse collectors use baskets and dollies to reach dwellings, then scavenge through the refuse at the curbside before loading into the vehicle. Items are sold to middlemen en route to the disposal site

dollies. At the curbside before loading into the trucks the collectors pick through the refuse. Recyclables are sorted and placed in baskets on top of each truck, to be sold en route to the disposal facilities. (8) In Jakarta, Indonesia, the municipal refuse collectors pick through the wastes as they are unloading the trucks at the dump. Scavengers at the dump are also trying to pick out recyclables during the unloading operation. Needless to say, there is usually a traffic jam at the dump and the unloading time is long. (9) The World Bank's Surabaya, Indonesia, project has opened up a new area of scavenging activity: the transfer station. When the pushcart collectors arrive at the transfer station, they dump their refuse onto the paved area--not into the transfer container. "The cart man, scavengers, goats, chickens, cats and millions of insects then pick through the load. For this favor the scavengers help load into the container when the picking is finished." (10) Apparently, the cart man is saved a lot of effort, and the system works as long as there is a tough enforcer running the depot to ensure clean-up.

Scavenging is not the only traditional activity which may influence the refuse management system, even though it is probably the most obvious one. In some places religion or values may be a factor. In Kano, Nigeria, for example, the population is predominantly Moslem; most women are in "purdah" and confined to their compounds except for special occasions. The result of this restriction is that children are generally responsible for transporting the household refuse to the pick-up point. (11) If a system of portable metal containers were employed, waste would probably end up on the ground, because the children would not be able to lift the refuse into the container's opening. This problem was also witnessed in Onitsha, Nigeria, where children perform the chore of refuse transport to the pick-up points, even though it is a predominantly Christian city. (12)

In Human Factors in Project Work it was stated: "The public sector is usually represented by a hierarchically structured and usually centralized and rigid bureaucracy, which may be closely tied to the political, economic, or professional elite. The project population is often represented by a neighborhood or community organization, loosely structured and informal. An understanding of the social and behavioral as well as other characteristics of the parties involved is required to design ways to bridge these gaps." (13)

B. Equitable Service Delivery--Meeting the Needs of the Urban Poor

The illustrations used in the preceding section touch on this issue in refuse management in developing countries. Inequitabilities in service occur for a number of reasons. Sometimes it is because of traditional attitudes or behavior patterns which have developed, other times it is because of inappropriate technology, and there are occasions of blatant discrimination.

In cases where the municipality relies heavily on an informal private sector to perform refuse collection and disposal services, there is the risk that certain populations will not be served. As discussed in the preceding section, these populations are likely to be the urban poor, either because these residents cannot afford the service fee, or because their refuse is not sufficiently high in recyclables to justify the private entrepeneur's service. This type of inequity occurs in Cairo, Egypt. (14)

In Tunisia, there are thirteen municipalities which form the District of Tunis. In general, within a given municipality, service is fairly equitable. However, there are major differences among municipalities based on their different income level. Some of the wealthiest municipalities inefficiently provide too much service, with residents accustomed to having collection vehicles pass their dwelling two and three times a day and picking up refuse that is placed curbside at any time of the day. The differences in costs spent on refuse collection among municipalities ranged from about $14 to $113 per metric ton of refuse collected. (15) (16) One of the efforts which occurred in supervision of the solid waste project was a request for prioritization of municipalities on the basis of need for improved service; in order to avoid the tendency for project monies to be made available to all the municipalities, with those having the best administration and planning (and more than likely, the best financial resources) able to make early claims to those funds.

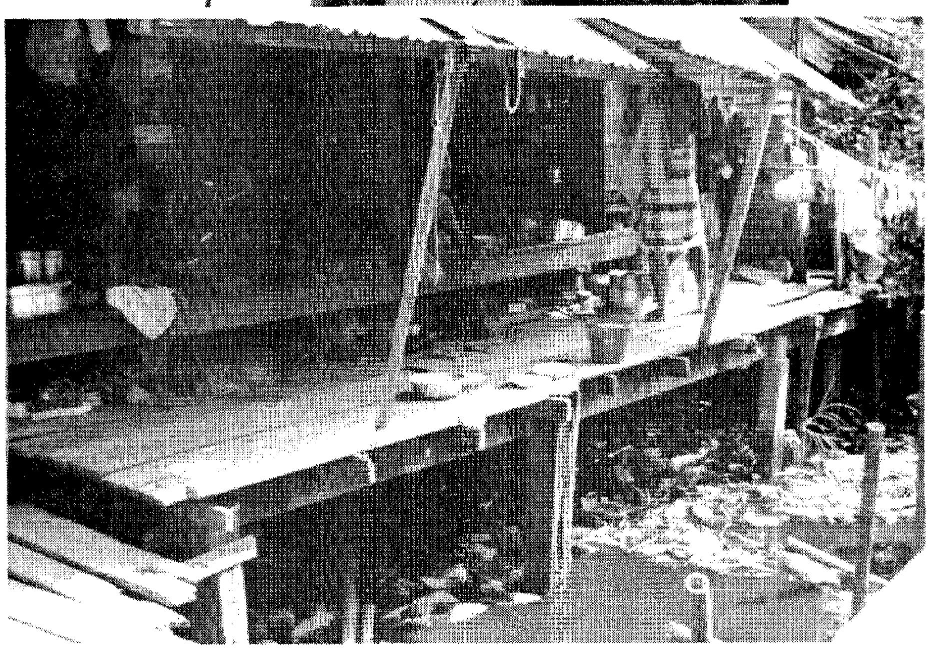
In Onitsha, Nigeria, there were essentially seven service areas for refuse collection. The number of trucks assigned to each was a function of the route length and number of people in the area. Although there was not a large discrepancy in the number of vehicles and workers assigned among the service areas, there was a large discrepancy in service level. This was found to be primarily a function of the selection of technology. One method of collection using non-compaction side-loading trucks was attempted city-wide. While it worked well in the wealthier neighborhoods that had good roads, little traffic, and residents who obeyed the ordinance requiring curbside placement of standardized household containers--it was unable to meet the needs of the low-income areas. Service levels ranged from a low of about 10% in the neighborhood with the largest portion of urban poor, to about 80% in the upper-income residential areas. The project for solid waste was designed on the basis of reallocating existing equipment to the areas where it was shown to be working, and providing a new system in the other areas where it was not. (17)

Many cities in developing countries have areas where the residents are considered squatters. Often, the local government questions whether refuse collection service should be extended to these people. Since these areas typically house the largest portion of population below the urban poverty threshold, it is important to determine whether there are such areas being overlooked and to plan for the extension of service to meet their needs.

It is not always readily apparent that unserviced areas exist; and there are times when the local government is not even aware of the disparities. In Kanpur, India, for example, many low-income people live in privately owned "ahatas," which are basically tenant communities living on private pockets of land within the city. Within the confines of these ahatas, it is the responsibility of the landowner to provide refuse service to residents. The refuse is then to be taken to the periphery of the ahata, to a municipal collection point. The level of service provided within the ahata is largely a function of the owner's sense of responsibility to his tenants. (18)

BANGKOK, THAILAND

Uncollected solid waste accumulates around homes and in canals in the "squatter" housing areas



In most cities where service to the poor is relatively low, it is commonly attributable to accessibility. Local governments often provide a system of refuse collection which involves trucks servicing all paved roads: the communal containers, open collection points, and individual household dustbins that are placed along them. If an area of inaccessible residents is not very large, residents are likely to bring their refuse to the border to dump it. Sometimes this refuse is along the route of a collection vehicle. Other times it accumulates in open areas that are not accessible to truck pickup. If the area of inaccessible residents is large, residents are likely to dump the refuse between houses, in drains, and on remote corner lands--where it accumulates, and partially degrades. The "kampungs" of Jakarta and Surabaya, Indonesia, were good examples of this. Solid waste projects as part of urban upgrading for these neighborhoods involve the use of pushcarts to provide door-to-door service to residents, and transfer of the wastes to metal containers which can be lifted or trailed to a disposal site. (19) (20)

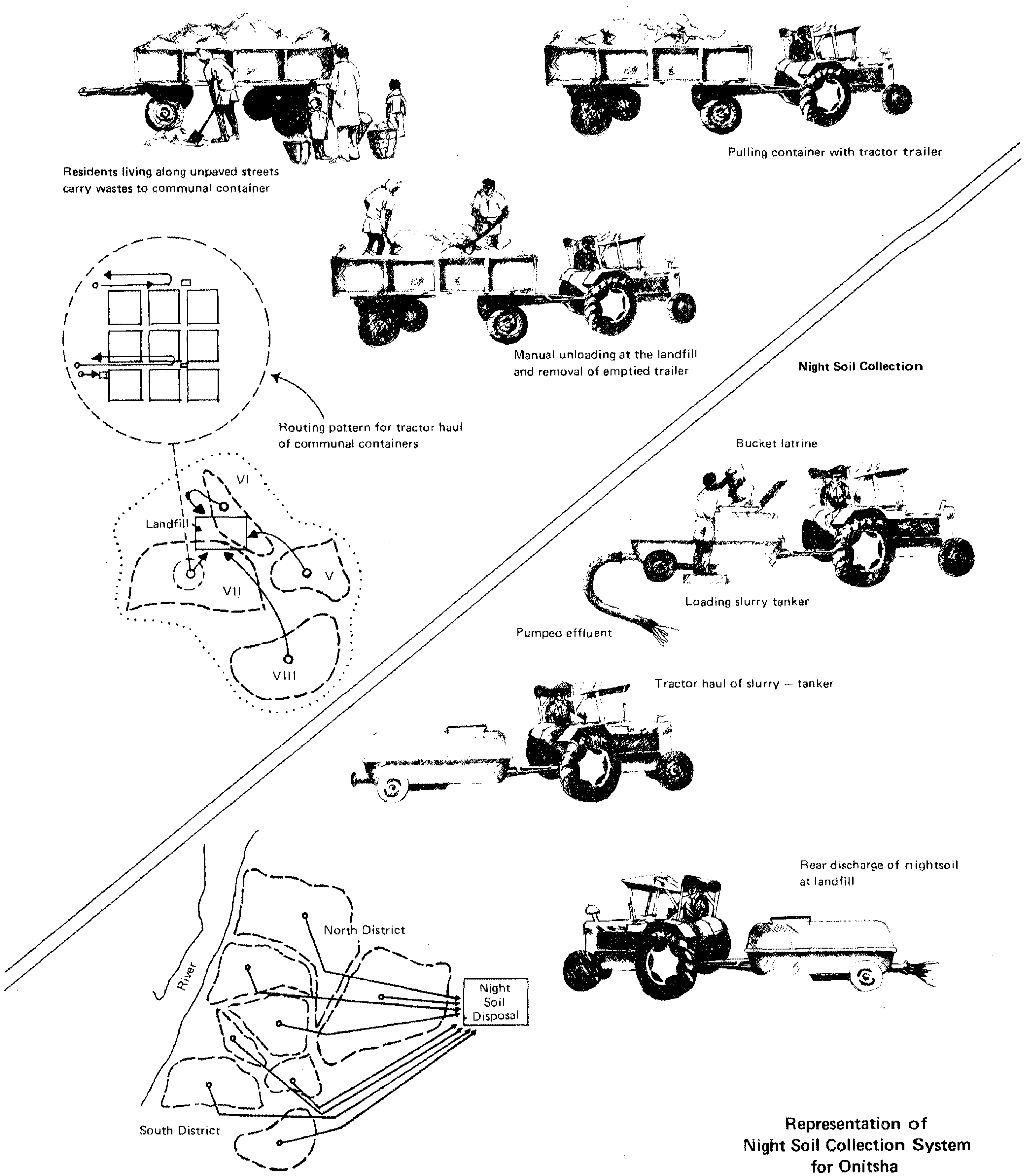
In order to solve the problems of inequitable service, it is often necessary for the local government to augment their present mechanized collection fleet with labor-intensive systems that can enter into zones of limited accessibility. There tends to be a discriminatory attitude on the parties in power against the people living in these low-income areas, an assumption that their neighborhoods are dirty because the people are dirty and too lazy to carry their refuse to a paved route where service is provided. There is a general lack of recognition of the disincentives that the absence of walkways, clean drains, and other basic infrastructure create to residents making this level of effort. It is essential that projects be designed to address these attitudes. Pilot projects or demonstrations are geared toward educating the target population, as well as toward changing the attitudes of the government officials--in effect, to create a bridge of cooperation between the urban poor and the governing elite.

C. Planning and Management Arrangements

Previous sections, particularly sections B, C and D, of chapter III highlighted the importance of planning and management in the solid waste sector, for reasons of: (a) the service depends on labor-intensive techniques for collection and transfer of refuse; (b) resident cooperation with the system requires public education and encouragement; (c) refuse collection and disposal equipment is short-lived, and requires regular budget planning for replacement and expanded needs to be met; (d) daily preventive maintenance and ability to meet major repair needs is essential to keeping the fleet on the road, and can only be accomplished through good planning of spare parts and supplies procurement; and (e) collection equipment is mobile and there are many stages of mechanization available; as city baseline conditions and needs change, the system could be continuously responsive to those changes.

Representation of Refuse Collection System in Onitsha's South District

Communal Container Collection:



Representation of Night Soil Collection System for Onitsha

There are many problems in the overall management schemes for municipal refuse in developing countries. The most often encountered problem is decentralized responsibility for various activities of refuse management. Many cities have adopted a management system whereby refuse collection is administered under the department of health; disposal is handled by the works or mechanical engineering department; and the fleet is centrally maintained for all city vehicles by the works or mechanical engineering department.

When refuse collection is placed within the health department, it is typically at the bottom of the organization tier structure. In this case, there may be supervisors assigned to administer the activities of the workers, but there are seldom planners, managers, and field foremen included in the organizational framework. The refuse service personnel are so low in the scheme of things that they have virtually no voice when it comes to obtaining funds for regular replacement and maintenance of equipment.

Another aspect of this arrangement of responsibilities is that the department performing the collection (i.e., by street sweeping) is often not responsible for the transfer and haul (i.e, by truck). Neither department can take any initiative to upgrade their part of the system without the other taking a corresponding initiative. What would be the point of sweeping up more refuse and servicing more residents, if the refuse heaps remained at collection points? How would it be possible to introduce some mechanization in the collection activities, without tying it down to the capabilities of the transfer and haul equipment? The problems that have been briefly mentioned have been noted in Kanpur, India; Onitsha, Nigeria; Calcutta, India; and Lahore, Pakistan; where the World Bank is developing solid waste projects. (21) (22) (23) (24)

In other places, i.e., Surabaya, Indonesia, the refuse collection and disposal services have been combined into one organization entity. Even so, that entity was placed low organizationally: as a division under the works department. (25) Low status of the workers and division management makes recruitment and retention of competent personnel difficult. Access to budget is impeded by the low status of the division chief and his reliance on his department head to give priority to his division's needs. A condition of the World Bank loan for a solid waste collection, transfer and disposal system in Surabaya is the upgrading of the cleansing division to a department status.

Preventive daily maintenance of refuse equipment should be in the hands of the cleansing service agency. Repairs and major overhauls may be appropriately handled by either a workshop under the cleansing service agency or the central municipal workshop. If they are handled by a central workshop, it is important that this facility be well managed and that there be clearly established and reliable procedures for addressing vehicles as they come in. In Bangkok, Thailand, there were regular complaints by the cleansing service that their vehicles were given second priority by the central workshop. While it could not be established that this was true, it created a friction and disincentive that was counterproductive to the provision of collection services. (26) In Kano, Nigeria, the central workshop was so inadequate that the cleansing agency arranged for maintenance with the equipment suppliers.

The costs were high, but the equipment was being kept on the road and service was being rendered. (27) In planning a solid waste project, one typically works with the cleansing service division or department. If provisions for supplies, spare parts, mechanics training and expanded workshop facilities are not coupled with additional refuse vehicles, a $20,000 to $120,000 piece of equipment may rest in the workshop area for weeks to months at a time--awaiting a special part. Or it may be retired forever, because of lack of mechanical know-how.

It seems that virtually none of the refuse management organizations encountered in our project areas had one or more persons assigned to planning. Staff in the organizations are typically so tied up with the daily crises and complaints regarding regular provision of service, that there is no time to assess the cost-effectiveness of the existing systems, study and plan improvements in productivity and efficiency, analyze the options available for expanding service, and monitor the changing market demand for recoverable resources relative to landfill constraints. These types of activity require a special expertise, and also should be removed from the mainstream of operations.

As a final note, there are some cities in developing countries where no organizational entity is responsible for disposal. The entire activity of disposal is institutionally non-existent. This is true for the District of Tunis where each municipality in the District has responsibility for collection. These municipalities have collectively agreed on a couple of locations for disposal and take their trucks there for dumping. A major effort of the solid waste project is to create a responsible entity for at least the management of disposal, and perhaps to also provide planning and management assistance to the municipalities. (28)

D. Financial Resources and Arrangements

Local governments draw capital for purchasing solid waste equipment and facilities from two basic sources: current revenues and borrowings. (29) Grants from the national government are not common in the solid waste sector. There is, for example, less justification for solid waste grants than for education grants, which are justified on the basis of education benefiting the overall national character and generating national economic growth. (30)

Use of current revenues depends on a municipality's ability to raise surpluses beyond those necessary for operation and maintenance of all services. Purchases are made and fully paid as they are needed. This is the common method of financing collection equipment purchases in industrialized countries. However, in developing countries, the income base from which revenues are derivable is markedly lower while the cost of equipment is at least comparable and probably higher. Indeed, most specialist equipment will have to be imported, adding freight costs and foreign exchange risks to the financial burden. This may sometimes be offset by customs duty concessions.

The municipal income base as a function of individual income may be only one-fiftieth to one-twentieth of the base available in industrialized countries. Since people in developing countries generate less solid waste per capita than those in industrialized countries, this discrepancy is somewhat offset--the refuse generation rate may be about one-third to one-half of the rate in industrialized countries. Nevertheless, it is clear that the planner must either adopt a lower standard of solid waste delivery, or seek systems that are less capital-intensive than those in industrialized countries. The initial method of finance has limited relevance; all costs are eventually borne from current revenues either directly or as debt service.

Borrowing options include: short-term, medium-term, and long-term options. In countries with large revenue generating capacities, short-term and medium-term financing is useful for financing purchases of collection equipment, which is short-lived; and long-term financing is generally reserved for major capital financing events, such as construction of a resource recovery plant. In developing countries which need major financial assistance to get their refuse management service upgraded, long-term financing is acceptable for collection equipment as well as major facilities, as long as renewal funds are established for asset replacement. Loans to members countries from the World Bank Group fall basically within the long-term category: 10 to 20 years for pay-back.

Financing through long-term borrowing includes two broad methods: project financing and general obligation financing. (31) Project financing requires revenues generated by the solid waste project (e.g., user charges or recovered resource sales) must offset all future operating and capital recovery costs. On the other hand, general obligation financing is secured by the full-faith-and-credit of a municipality which has the ability to levy and collect taxes. Most World Bank projects, such as those in water supply and sanitation, are project financed. For solid waste management projects, however, general obligation financing for collection equipment, transfer facilities and disposal systems is probably more appropriate.

There are several problems with general obligation financing which discourage lending in the solid waste sector. In developing countries, records on personal income and appraisals of property are generally inadequate. As a matter of course, people do not report all their income. Tax assessors in many cities readily report a low property value in return for a personal pay-off. These problems are not unique to developing countries, but are believed to be more prevalent. The result is a seemingly lower level of revenue generating ability than is available. For a solid waste project to be financed by general obligation methods, a true appraisal of the municipality's debt limit is essential.

Another problem is that revenue raised through taxes becomes a part of the general city treasury, and thus is available to other city expenditures to draw on. A World Bank appraisal which assessed that a specific solid waste project was affordable under existing and projected conditions might find that unexpected demands from other sectors were drawing on funds anticipated for solid waste management. This problem is exacerbated by the low institutional status and the common decentralization of responsibilities prevalent in the solid waste sector. Coupled with lack of planning units in solid waste organizations, this results in: limited access to the budget, and lack of ability to justify budgetary needs.

Unless these problems are adequately dealt with by fully projecting capital and operating requirements of the solid waste project, determining their affordability relative to revenue generating ability of the local government, and then arranging competent institutional and financial mechanisms: the project can be likened to "Cinderella's Coach"... as a fleet which falls to pieces at midnight, in hopes that the fairy godmother will come along with more capital. The key to successfully avoiding this plight is revenues enough to cover all expenses of operation, maintenance, administration, interest, and depreciation (or its equivalent), while taking inflation and expansion requirements into account. (32)

The above paragraphs noted that local governments basically draw capital for refuse equipment and facilities from current revenues or borrowings. It is possible for a local government to shift the burden of raising capital to the private sector. This basically involves contracting with private enterprise for the service, thereby shifting the capital-raising burden to the private firm. There are many types of contractual arrangements, and they warrant consideration by the local government. Some contracts, such as the one for Buenos Aires, Argentina, provide a refuse collection service whereby equipment owned or leased by the cleansing service firm is operated and maintained by the same firm. Reportedly, the costs of private collection in Buenos Aires are less than half those of the public system. The reason given for this savings was that the city, in the process of its economic development, had moved to more mechanized equipment but had not reduced its labor force appreciably. The private firm proposed slightly higher levels of mechanization and reduced the labor force from about 6,000 to 1,500 workers. (33)

It is important for developing countries to be wary of contractual offers whereby the equipment or facilities are sold to the local government and the private firm commits only to assist for 1 to 3 years in the operation and maintenance of the system. During this period, the private firm provides training for the eventual transfer of responsibilities. Often, the equipment and facilities are sophisticated, intensively mechanized and expensive. The private firm does everything possible to make the system look good during its "training" period, without regard to whether it is an appropriate level of technology for the local government to be using.

This is particularly true for centralized, single purpose resource recovery facilities, such as composting plants with economies of scale in production of a material whose value does not justify the high transportation costs of dispersing and using it. If a resource recovery facility is truly justifiable on the basis of a proven market demand for the product, there should be no problem in getting a private concern to own and operate the facility. If the risk is too great for the private concern to accept long-term ownership and operation, it is likely that the risk is also too great for the public sector.

The previous paragraphs have mainly centered on capital financing. For solid waste systems, it is essential that the operating and maintenance costs be carefully assessed for any lending project. It has been discussed in Chapter III that solid waste collection equipment is relatively short-lived and that operating and maintenance costs are substantial. The solid waste sector is, for example, the antithesis of the water supply sector which provides large scale, often regional, infrastructure having a long life and requiring an operation and maintenance effort proportionately smaller in relation to the capital investment.

Operating and maintenance costs may be obtained from two sources: current revenues and user charges. Originally the concept of user charges was advanced because of the fundamental economic theory that demand for goods or services declines as price increases. It was theorized that direct user charges for solid waste service would limit the generation of waste. Recent research in industrialized countries has not been able to support any significant price elasticity, and suggests that user charges as a means of deterring waste generation are not effective. Not only that, separate charges cost money to collect. User charges, because of the addition of billing and collection costs, increased solid waste collection service costs an average of 3% in the U.S. (34)

Once again, we return to revenues: the ability of the local government to generate them, and the ability of the solid waste sector to obtain and use them properly. These problems can be resolved only through a well administered system of budgeting control for the municipality as a whole, coupled with a sound basis for levying and collecting general local taxes. A good budgetary system must begin by establishing physical and operational criteria on which to base financial requirements. The mere provision of funds in a budget without regard to the level of activity supported establishes an immediate potential for an over-burden of financial resources. An aid to performance budgeting would be the checklist shown in Annex E.

While it has been mentioned in earlier sections of this project guide, it is mentioned here again--management of solid waste in developing countries is often fragmented. Door-to-door collection comes under one agency, transfer and disposal under another, and maintenance under yet another. Interagency coordination and planning to meet the total needs of the system is sorely lacking. If one entity has an energetic and competent leader, his efforts get frustrated by the limitations from the other entities. The easiest way to relieve this situation is to have one institutional entity handle all aspects of solid waste management, and to be sure that this entity has: (i) equal status with other agencies in the municipality, all vying for a portion of the current revenues, and (ii) planning capability in a special unit, in order to assess and justify financial needs. Accordingly, centralization and upgrading of institutions for solid waste management has been promoted through Bank financed projects in India and Indonesia.

E. Selection of Appropriate Technology

Every country has an economic optimum of mechanization for solid waste collection, transfer and disposal systems. Life cycle costing of the equipment, labor, materials and supplies must be done on various levels of mechanization in order to determine this optimum. The optimum level is true for a snapshot in time and changes as a country develops economically and as certain resources (e.g., fuel) demand new prices as a function of supply and demand conditions.

When capital and operating costs for various options are developed, selection of the most appropriate technology must consider:

- Foreign versus local investment and maintenance costs;
- employment needs and objectives;
- available skill levels and training opportunities;
- cash flow required for operation of equipment;
- land availability and value; and
- resource recovery potential and environmental consequences.

It is not necessarily most appropriate to select the system with the lowest cost per metric ton of refuse handled. In a capital-short country where jobs are scarce, a labor-intensive solution with a higher total cost per metric ton may be preferred.

Frank Flintoff has observed: Engineering training world-wide is standard and based on Western methods. This is valid in many fields, such as electricity generation, car assembly and water distribution. But most Third World engineers who work in solid waste management assume that their aim should be to equip their cities with compactor trucks, suction sweeping machines, highly mechanized composting plants, or moving grate incinerators. In solid waste management there is a wide range of options for almost every process, whereby labour can be traded for machines and draught animals for motor trucks. (35)

Not only is Mr. Flintoff's statement supported by the significant differences in capital availability and labor wages between developing countries and industrialized countries, but even in major differences in fuel costs and supplies for maintenance. Furthermore, as Chapter II clearly illustrates, the refuse in developing countries is denser and more fine-grained than the refuse in industrialized countries. For that reason, much of the mechanization necessary in the industrialized countries for purposes of volume and size reduction would not be useful in developing countries.

Composition of refuse in developing countries differs from that in industrialized countries. It tends to be high in putrescible organic matter, and to have a relatively low portion of paper, glass or metals. Moisture contents are markedly higher for refuse, as generated, in developing countries. These features lend the refuse to recovery techniques that are unique from the common approach of mechanized sorting of recyclables and incineration of combustibles which is underway in industrialized countries. For developing countries, biological treatment systems of simple composting or methane generation would be more applicable--provided a demand for the recovered materials or energy can be developed.

A combination of techniques of collection and transfer is usually required to meet the needs of a city in a developing country. It was mentioned earlier how a single system fairly evenly distributed over the city of Onitsha, Nigeria, led to very low service levels in the neighborhoods of the urban poor (10 to 30%) while providing reasonable service in the wealthier neighborhoods (over 80%). This was largely because of the limited access to residents by paved roadway in the poorer neighborhoods, the inability of the poor to comply with the household dustbin ordinance, and the heavy traffic congestion partly attributed to motor parks and markets in these neighborhoods. Since most cities in developing countries have pockets of densely populated, inaccessible neighborhoods, innovative systems based on local resources and capabilities must be devised. In the hilly areas of Tunis, this involves the use of donkeys with baskets affixed to their backs. In India, wheelbarrows and bullock carts are used. In Thailand, the canal-based residencies are amenable to hand carried baskets or to two-wheeled dollies with baskets.

V. COMMON STEPS IN SOLID WASTE SERVICE DELIVERY

A. Storage at the Source

Technology is said to be "socially appropriate when: (a) project populations will want and correctly use what is provided; and (b) the technology can smoothly fit into the user's life-style and the society without any negative side effects." (1) Selection of appropriate technology, both socially and economically appropriate, for solid waste systems begins with storage at the source.

All steps in solid waste management are related. The efficiency and effectiveness of collection is intimately related to the method of household or communal storage selected. A change in any one part of the solid waste system has an effect on the other parts of the system. Furthermore, solid waste equipment is by nature mobile and short-lived. It lends itself to the opportunity of being continuously responsive to the changing setting and needs of the urban area which it serves. As baseline socioeconomic conditions of the area change, not only may the collection and transfer equipment considered appropriate change--but the associated storage method may correspondingly change.

Frank Flintoff, in Management of Solid Wastes in Developing Countries, provides a full discussion of the various methods of storage, collection and transfer available and considered appropriate to meet the needs of developing countries. (2) For inner-city centers of urban areas in developing countries, more intensively mechanized equipment than arrayed by Mr. Flintoff may have some application--especially for large commercial, institutional and apartment buildings. To augment Mr. Flintoff's material, with respect to such areas, a good source of information is the American Public Works Association's Solid Waste Collection Practice. (3)

Briefly, the types of storage for solid waste which are available are first divided into two basic categories: separate unit (i.e., household) storage, and communal storage.

Separate unit storage may be either standardized or nonstandardized by the collection agency. Nonstandardized containers range from temporary containers such as cardboard cartons, plastic bags, and crates to permanent containers such as plastic or metal bins. Standardized containers are usually plastic or metal bins, with the name and address of the owner painted in standardized format, and with lids. Plastic bags are generally considered inappropriate for standardized application in LDCs: they are expensive, in hot climates where decomposition occurs rapidly the bags may burst, they are subject to being torn by scavenging animals, and they interfere with some resource recovery systems.

While proven to improve collection productivity, standardized containers have one major disadvantage in developing countries. They are relatively valuable items--attractive to thieves and for alternative uses such as food and water storage. Ways to remedy this disadvantage include: permanent labeling of each container, fixing the container to a post or metal chain, uniform provision to all residents of one container, regulations requiring proper use (together with enforceable penalties for loss or misuse), and reliable routing and scheduling of collection services so that curbside placement times are limited.

The size of the container depends on the weight and density of wastes being disposed, and length of storage with respect to the frequency of collection. Collection frequency is affected by the climate of the urban area, and the open space of the individual premises upon which waste is being stored. The hotter the area, the more frequent collection of waste is recommended. Odors, insect breeding, and vector attraction are limited by increased frequency of collection. The more densely populated an area, the more frequent the collection. In many densely populated neighborhoods in cities of developing countries, there is no external area allocated to the home that is adequate for storage of wastes for more than a day.

Communal storage units may be either stationary or portable. Stationary units include enclosures such as four-sided masonry units with a door opening and no roof, depots which are essentially single-story buildings, and bins such as three-sided masonry structures. Portable units may include large steel drums, liftable metal containers (for use with trucks rigged with hydraulic lifts), wood or metal trailers (for use with tractors), or roll-on metal containers (for use with trailer truck bodies).

In general, none of the stationary units is recommendable. Wastes are typically strewn about the site by scavenging activities of various animals and people. Residents, offended by the site, do not walk into the unit or to its opening to discharge their wastes. Breeding of flies and other disease vectors is not limited because of the open nature of the container. Manual labor is required for removal of the wastes. At least with open dumping on an appointed area of the ground, complete and rapid removal of the waste is possible through the use of equipment such as a payloader--a practice which any stationary structure would inhibit.

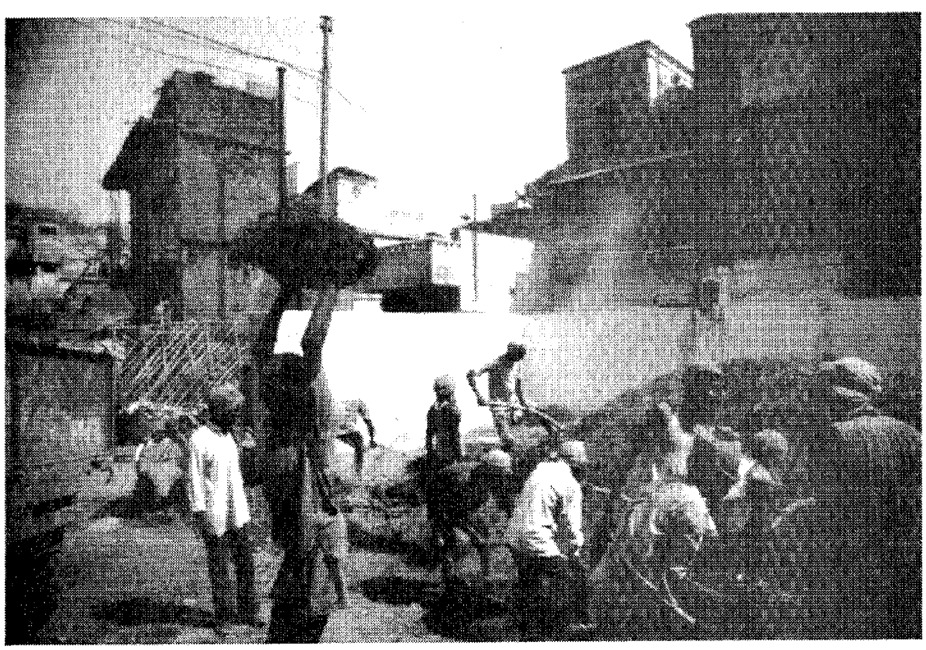
Portable units are particularly appropriate for large buildings in center city areas, as well as for densely populated single family dwellings in inaccessible areas. An advantage of the portable unit is that it allows the transport unit to be used most efficiently, by shuttling back and forth to the disposal site with a number of filled containers. The transport unit does not lose any potential haul time because of collection activities. Typically, the transport unit leaves an empty container to replace the full container, so that the area is never subject to blatant dumping because of inadequate equipment availability.

In both separate unit containers and communal containers where services are provided seven days a week, it is recommended that at least 50% excess capacity be allowed. If the container is designed for daily removal in a system that provides service 6 days a week, then at least 100% excess capacity

KANPUR, INDIA

A municipal worker dumping his wheelbarrow of collected solid waste at a large masonry enclosure, amidst pigs, cows and human scavengers. Since the enclosures are unsupervised, wastes are not typically confined within the three-walled enclosure area

Manual loading of trucks by municipal workers, at a three-walled masonry enclosure



should be allowed. (4) Capacity should be based on peak loading periods, such as those encountered on the first day of the workweek during seasonally high loading times attributed to tourism, agricultural produce availability, etc.

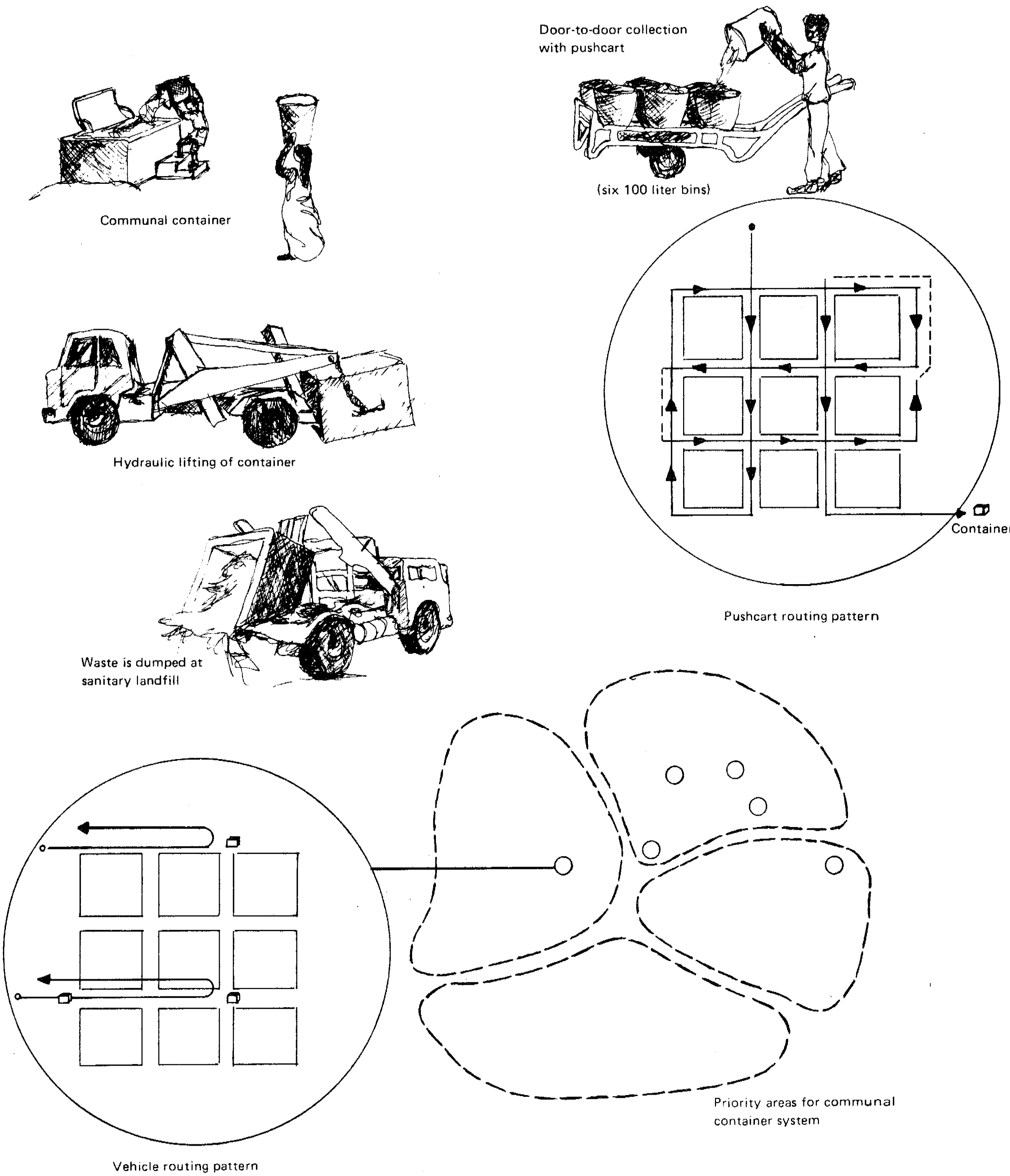
If recycling of materials found in wastes is an objective, for reasons of cost recovery, employment development, or waste reduction, the first opportunity for recycling occurs at this step in the process. Source separation of recyclables allows efficient recovery of materials such as paper, glass, plastics and metals. In some cities, source separation is accomplished by having two containers: one for "wet" waste, and one for "dry" waste. In other cities, only paper is set aside for either separate collection or for separate handling on a single collection vehicle. Requirements for deposits to be made on returnable bottles are prevalent in many developing countries, and few bottles find their way to the dustbin. Source separation is becoming increasingly successful throughout the world. The programs which are succeeding attribute their success to public education, reliable collection service, and an economic incentive--whereby costs of collection are shown to be lowered by the cooperative citizen effort.

B. Discharge to a Collection Point

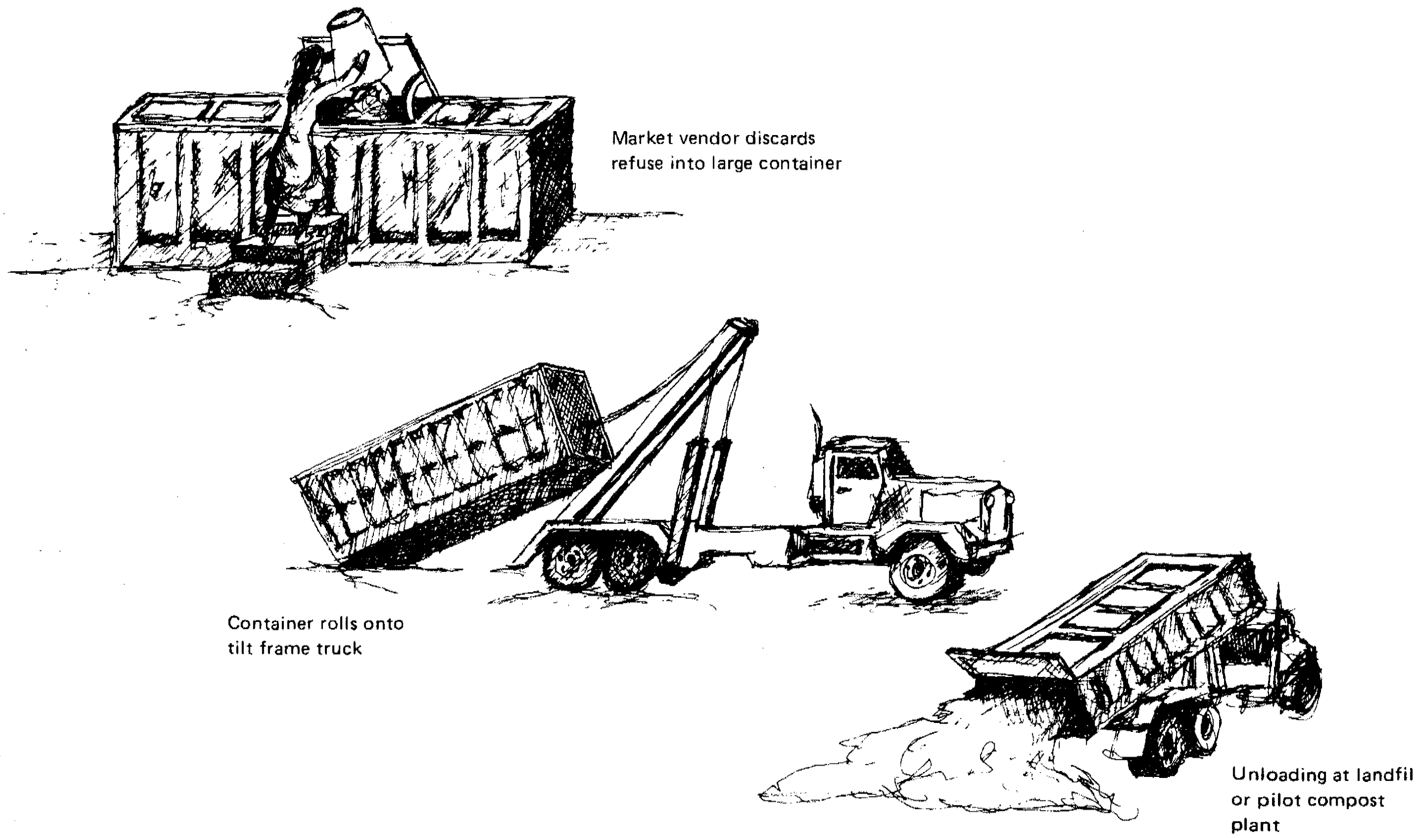
In the case of communal storage containers, citizens bring their solid waste to stationary or portable containers at fixed locations. The containers are available on a 24-hour basis, and residents can discharge their wastes at any time of the day or night. When a full portable container is ready for haul to the disposal site, an empty one is left in its place.

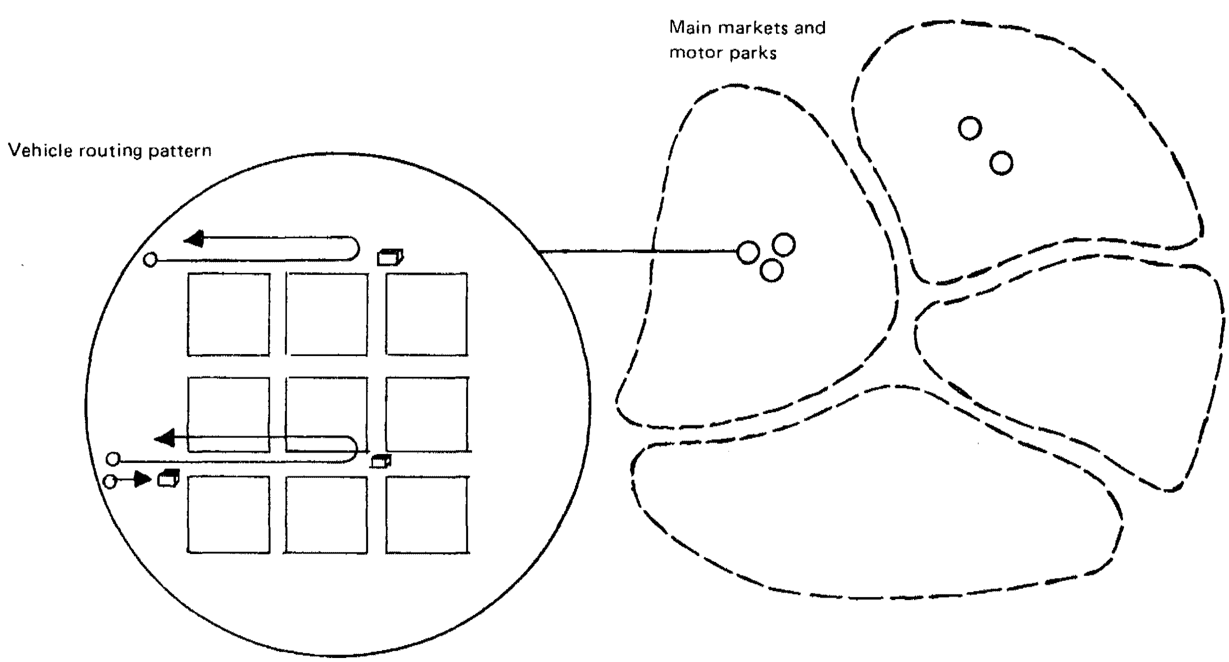
Separate unit containers, such as household dustbins, require a different form of citizen participation in the system. If the method of collection involves the collection worker walking to the permanent container location, such as a backyard or an alley, the citizen has minimal responsibility. However, if the container is supposed to be placed curbside for certain hours of the day, the resident is obliged to put out the container and bring it in according to schedule. Many municipalities have inspectors who issue a penalty to citizens that leave their containers on the curb for too long, as they are subject to vandalism and may roll out into the traffic lane of the roadway.

Block collection requires the greatest amount of resident involvement. In this type of system, nonstandardized containers (such as baskets) are common. The collection vehicle is obliged to follow a schedule and a route, and thus appears in a given area at a specified time. A bell may be rung to alert citizens, but in any event they are expected to emerge from their dwellings with their refuse ready for discharge into the collection vehicle.



Portable Communal Container System





Portable Communal Container System

To design an appropriate level of citizen involvement requires an understanding of the people living in each neighborhood being served. Block collection, for example, may be successful in low income neighborhoods where children and women are home to attend to the refuse disposal, and may also be successful in wealthy areas where servants are present to perform this function. On the other hand, in middle-income areas, especially where there are "two-career" families, block collection may be completely inappropriate.

Curbside collection is particularly successful for middle- to high-income areas, where the individual homes are located on paved roadways and yard space is available for placement of individual household containers.

In all these systems, well planned routing of collection equipment and careful adherence to a collection schedule encourages a positive citizen participation in the system.

C. Collection

As mentioned above, there are several handbooks dedicated to presenting available technology. Only a brief discussion of collection technology will be provided here. There are three basic types of collection techniques: those that rely on humans, those that rely on animals, and those that rely on engines.

Human-powered collection equipment includes such items as pushcarts, pedal tricycles, wheelbarrows, and two-wheeled dollies with baskets. Such equipment is particularly useful in neighborhoods with limited access, such as narrow walkways. In general, paving or some sort of smooth surface on the access lanes is necessary for this type of equipment to be effective. World Bank solid waste projects in Indonesia, Manila, India and Egypt are using pushcarts as a principle mode of house-to-house collection within the lowest income neighborhoods. The solid waste collection systems being implemented in these countries are generally tied to improvements in the basic infrastructure of specific low-income neighborhoods.

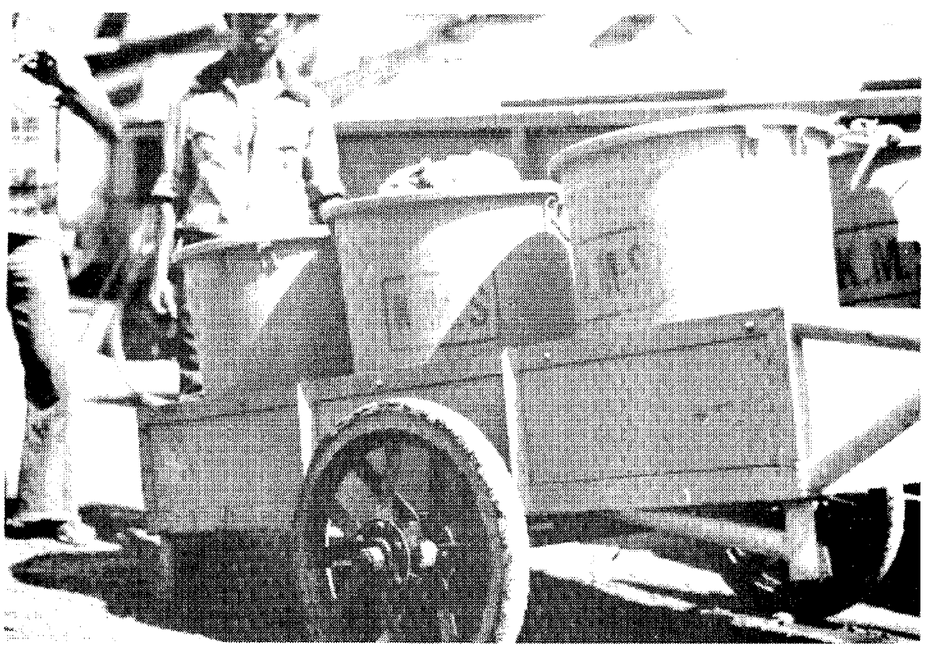
One important aspect of the pushcart system to be considered is the design of the cart relative to loading and unloading. Traditionally, carts have been large boxes made of wood or wire mesh. Pushcarts provided in Bank projects normally include portable bins which can be readily unloaded into the portable container of a truck or tractor, located at a local transfer station. In Surabaya, Indonesia, some pushcart collectors modified the pushcarts provided--returning to the traditional design of the large box. Their response was encouraged by unexpected scavenging activity at the transfer depot, with an arrangement between scavengers and pushcart collectors whereby carts are dumped onto the paved area of the depot for ease of "picking" and subsequently loaded into the containers by the scavengers. Apparently, good supervision of the depot is essential if the scavengers are to remain true to their word, and leave the area clean. (5)

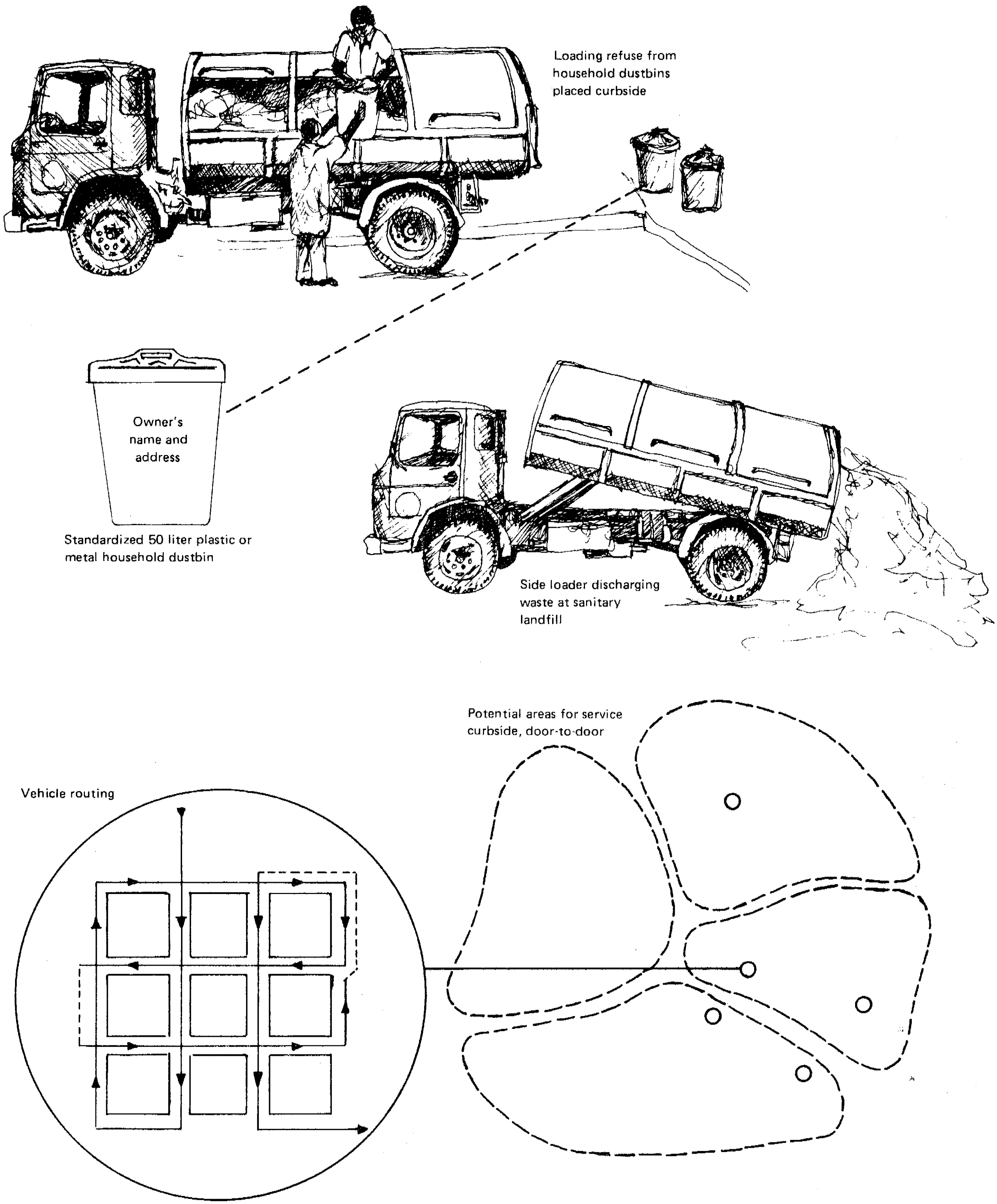
KANPUR, INDIA

Refuse is traditionally collected from curbside collection points, which are essentially open ground without any structural containment, by sweepers using wheelbarrows

SURABAYA, INDONESIA

As part of a World Bank financed pilot project, this pushcart is being used in inaccessible neighborhoods which have recently been upgraded by construction of walkways and drains. Waste is brought to a transfer depot within walking distance, and is placed in a portable metal container which is then hydraulically lifted onto the back of a truck and hauled to the dump site





Door–to–Door Collection by Vehicle

This type of response would have been difficult, if not impossible, to anticipate. Since transfer stations are a new entity in Surabaya, Indonesia surveying the collectors in advance of project implementation would probably not have yielded information about this eventual behavior. However, since the first neighborhood of pushcart collection was set up as a pilot project, full-scale implementation may take this into consideration. In fact, all Bank projects with pushcart collection have been set up with initial pilot project areas. Useful information developed by these projects is expected, in time, to allow this project guide to be updated and improved.

Animal powered collection equipment may either take the form of drawn carts or the animal may be directly saddled with containers such as baskets. The horse, mule or ox drawn carts have several distinct advantages: they do not consume fossil fuels and they are very quiet. This mode of collection is particularly applicable in cities where a large part of the traffic is slow-moving, such as bicycles and tricycles. It may also be feasible even in cities having a predominance of fast moving (motorized) traffic, so long as refuse collection takes place in the early morning before traffic builds up.

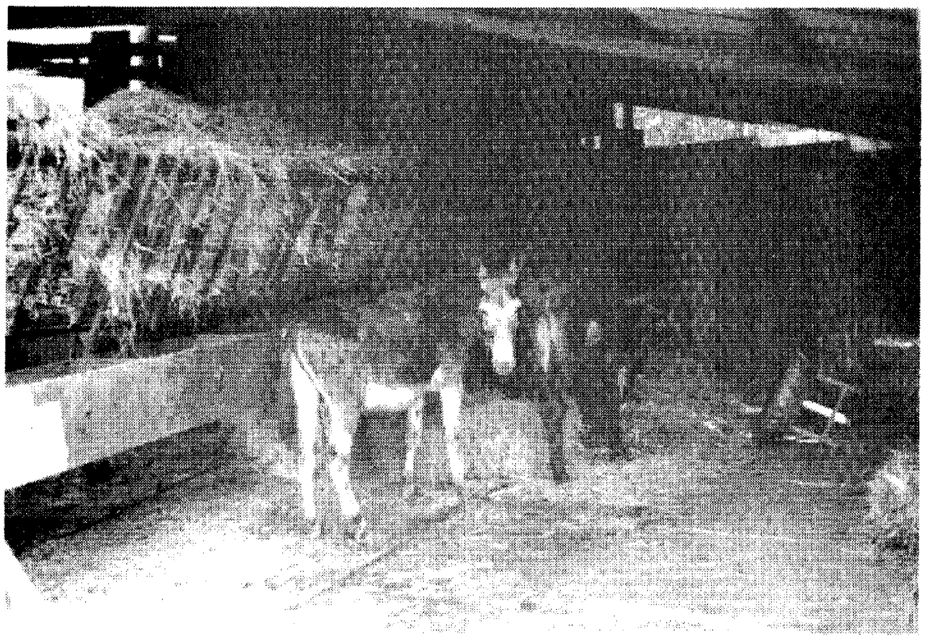
Direct collection with container-laden animals is vital in some cities. In Tunis, for example, hilly unpaved and narrow lanes are the only means of access to some neighborhoods. In other cities, where paved sidewalks are available, there may be regular stairways which would impede any type of wheeled equipment.

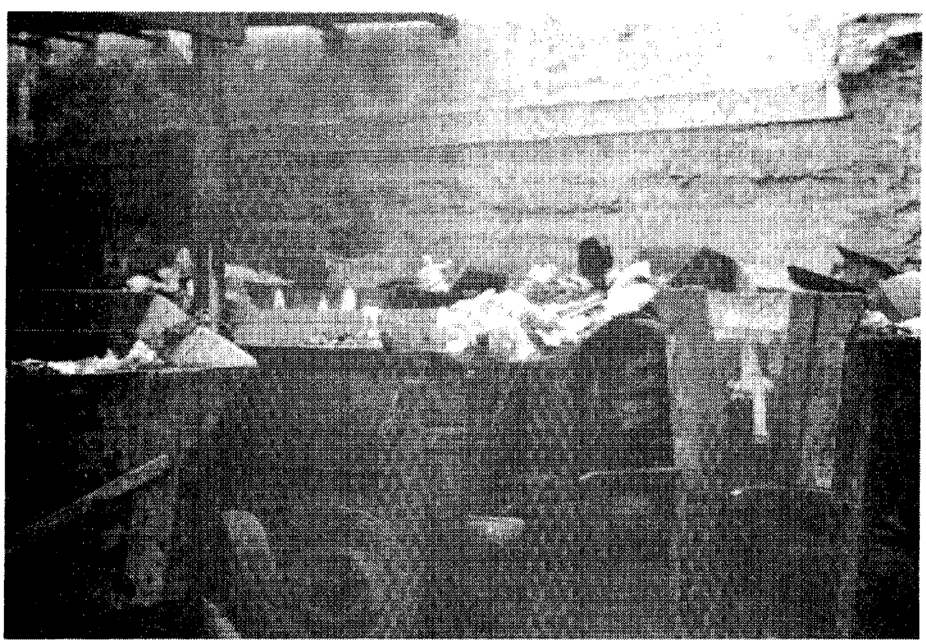
There are many forms of motorized collection vehicles. The smaller units include tricycles with hydraulic tipping containers mounted on back, for collection in areas accessible by narrow paved lanes. In urban areas where slow-moving traffic is tolerable, tractors can be used to pull wheeled containers or trailers that hydraulically lift containers. Trucks may also be used with portable containers.

Some cities use a combined system of loading equipment with flat-bed trucks. The typical version involves a medium-sized payloader in concert with a number of tipping trucks. One major advantage of this system is that the transport vehicles are productively engaged throughout the workday: no time is lost by the transport vehicles in traversing a collection route and awaiting individual loading of wastes from various containers. Only a short wait in line at the collection point being loaded, a few minutes for the payloader to fill the truck, and off it goes to the nearest dumping site.

TUNIS, TUNISIA

Donkeys are stabled at the central workshop and parking area. They are regularly used to collect refuse in hilly neighborhoods lacking paved roadways or walkways. More level areas considered inaccessible are served by wooden pushcart





SAMPLE PROBLEM--LEVEL OF MECHANIZATION, KANPUR, INDIA

Manual versus Mechanized Loading: A Comparative Estimate of Costs

May 1980 exchange used: US$1 = Rs 7.8.

	Mechanized	Manual
Tipping vehicle (depreciation: 7 years)	28,600 Rs/year	28,600 Rs/year
Driver	4,200	4,200
Crew	3,900	31,200
Operation	18,000	12,000
Maintenance	16,000	16,000
Subtotal	70,700 Rs/year	92,000 Rs/year
	(227 Rs/work day)	(294 Rs/work day)
	(8 Rs/m^3) /a	25 Rs/m^3 /b
Payloader (depreciation: 10 years)	35,700 Rs/year	
Driver	4,800	
Operation and maintenance	40,000	
Subtotal	80,500 Rs/year	
	(258 Rs/work day)	
	(2 Rs/m^3) /c	
Comparison	10 Rs/m^3	25 Rs/m^3

/a each truck loaded by payloader makes 3 trips/workday and moves about 30 m^3.

/b each truck loaded by workers makes 2 trips/workday and moves about 12 m^3.

/c each payloader works with 4 trucks and loads about 120 m^3/workday.

Note: This table illustrates the calculations required but does not include interest costs. In actually choosing a least-cost feasible solution an economic comparison should be made between alternatives: this implies that capital and operating cost cash flows (excluding depreciation) at various appropriate discount rates should be calculated for each alternative.

A number of cities in developing countries employ manual loading of motorized haul equipment. In many cases, this tends to lower the vehicle's productivity. Since vehicles tend to be more expensive than labor in developing countries, every effort should be made to optimize vehicle productivity rather than labor productivity. Where collection points (refuse heaped on specific ground areas designated for collection by the motorized system) are large and readily accessible, payloaders can be used to replace manual loading systems. In places where manual loading is intermittent, because people are not cooperating with the locally required system of household containers, greater emphasis on inspection and enforcement of ordinances may resolve the problem.

Much of the motorized equipment available for collection is appropriate only for cities where labor is expensive relative to vehicles, namely for cities in industrialized countries. Recent trends in the United States are toward compaction vehicles requiring only a driver to operate the equipment. Such vehicles involve standardized containers being issued to households, which are lifted by a mechanical arm and have the contents dumped into a hopper without removal of the container's lid (which is on a hinge) or any other type of direct contact by a collection worker. In industrialized countries, the emphasis is on maximizing the metric tons/hour/worker, rather than the tons/hour/vehicle.

In all the collection equipment and systems discussed here attention should be given to two activities: loading and unloading. Loading height is particularly important, and is generally recommended to be below 1.5 meters. Unloading operations can be facilitated by adding tipping gear to specified trailers or trucks, or by having liftable units for removal (such as bins placed in a pushcart or even in the back of a flatbed truck).

Earlier sections of this guide discussed the density of solid wastes commonly found in developing countries. Based on density, there is seldom justification for compaction equipment on the refuse collection vehicle. In city centers where there is a high concentration of offices for government or commercial activity, such equipment may be justifiable. But as the compaction gear adds to the weight of the truck thereby increasing fuel requirements, and the gear requires special maintenance care, caution is advised on the degree to which it is employed.

D. Transfer and Haul

Waste that is collected from an area may be either directly hauled to the disposal site by the collection equipment, or it may be transferred to another size or type of equipment for hauling. In general, transfer takes place from relatively small pieces of equipment to large pieces of equipment.

There may be more than one transfer operation along the path that refuse traverses from its source of generation to its disposal site. For example, refuse may be collected by pushcart and brought to a neighborhood transfer depot, where the waste is then dumped into a tipping truck; thereafter, this tipping truck may bring the refuse to an area-wide transfer station, where the waste is then dumped into a roll-on container which is transported by large trailer truck.

Each collection equipment type has some economically viable radius of transport. Many options would generally have to be considered and compared to select those most viable for a specific area. If the disposal site is relatively near the collection service area, say within 15 kilometers of distance and under 45 minutes of round-trip travel time, direct haul by motorized collection equipment would normally prevail. Where more time is involved, transfer to a larger vehicle allows the collection vehicle to maximize its time on the route--and for the collection crew to also maximize its time providing collection.

Typically a transfer facility is a two-staged facility. Refuse from the collection vehicle is dumped onto a platform or into a hopper, for subsequent loading into the haul vehicle located on the lower level. If the waste is dumped onto a platform, a simple grading/spreading machine is normally used to push the refuse into the vehicle below. In industrialized countries, the haul vehicle is commonly a large roll-on container (hooked up to a ram compaction device) that is loaded onto a trailer truck. In Tunisia, pushcarts were pushed up a ramp onto an unloading platform. The unloading platform was designed to be level with the bed of the truck, and the pushcart workers were able to walk directly onto the truck to unload their wastes.

In Surabaya, Indonesia, Frank Condon noted: The <u>manned</u> daily operated transfer point is a key element (in the pushcart collection system within limited access neighborhoods). If employees are at the station, then the collectors are more reliable, the trucks come in on schedule (almost) and the residents can see some action. At this stage of the game, I believe that the local transfer station is the center of gravity for success in improved Kampung sanitation. (6)

In some cities, transfer stations provide an opportunity to switch to a more energy efficient mode of transportation--particulary to barge or rail transport. Because the capital costs of the loading and unloading facilities associated with these types of transport may be high, economies of scale would be applicable. A city would probably have to have at least 500,000 residents, before these transfer options would become economically viable with regard to total annual costs. A positive feature of barged transport is the long life of the equipment. A barge may have a useful life of 50 years, as opposed to a truck having a useful life of only 7 years. As the costs of fossil fuel increase, these options should be given increasingly more attention in the assessment of transfer costs and benefits.

TUNIS, TUNISIA

Direct transfer of wastes from a pushcart to a flatbed truck

SAMPLE TRANSFER ANALYSIS, ONITSHA, NIGERIA

Estimated Costs of Refuse Transfer Options for Onitsha's South District

(600 m^3/day of combined residential, market and industrial waste)

	Direct Haul by Collection Vehicle	Transfer by Truck	Transfer by Barge and Tugboat
Owning & Operating Costs for Transfer Station (600 m^3/day			
Civil Works	0	80,000 N	160,000 N
Stationary Equipment	0	30,000	20,000
Vehicular Equipment	0	0	160,000
Annual Depreciation (10% equipment, 4% civil works)	0	6,200	24,000
Operation & Maintenance (20% equipment)	0	6,000	36,000
Total Owning & Operating Cost per Year	0	12,200	60,400
Owning & Operating Cost per m^3 of waste	0	0.06 N/m^3	0.27 N/m^3
Transportation Costs			
Assumptions	8 m^3 closed tipper 2 trips/day 7-year life 15,000 N/1 truck	30 m^3 trailer truck 4 trips/day 7-year life 60,000 N/1 truck + 2 trailers	600 m^3 barge 1 trip/day 30-year life 810,000 N/1 tug + 2 barges
Annual Depreciation	2,200 N	7,600 N	27,000 N
Driver's Salary	1,600	2,200	3,500
Crew's Salary	5,500 (5 men)	1,100 (1 man)	2,200 (2 men)
Insurance, tax (approx.)	1,500	2,000	6,000
Annual Operating & Maintenance	3,800	15,000	80,000
Total Annual Transportation Cost	14,600	28,900	118,700
Transportation Cost per m^3 meter of waste	2.5 N/m^3	0.66 N/m^3	0.54 N/m^3

Note: February 1980 exchange rate used: US$1 = N 0.58. This table illustrates the calculations required but does not include interest costs. In actually choosing a least-cost feasible solution an economic comparison should be made between alternatives: this implies that capital and operating cost cash flows (excluding depreciation) at various appropriate discount rates should be calculated for each alternative.

A transfer station can serve many functions. Not only is it a place where waste is passed from one form of transport to another, in order to optimize productivity of the collection equipment and crew; but it is a place where the waste can be compacted, processed, or sorted and recycled. With a flexible attitude on the part of the local government, the quantity of waste requiring ultimate disposal can be greatly reduced by allowing private scavenging activities. It is even possible for the local government to design such activities into the transfer facility layout, by providing an area for sorting to occur, and perhaps even providing some special equipment to facilitate baling of paper or washing of bottles and cans.

In Jakarta, Indonesia, the pilot solid waste project includes a hand loaded baling compaction unit in the transfer system. Waste is brought by pushcart to a platform. It is loaded into the baler for compaction into units that are sized to enable manual loading of the bales onto a flatbed truck. In this system, the need for tipping gear on the truck is eliminated, and therefore vehicle capital and maintenance costs are theoretically lowered. One problem, however, is that the bales are dense and workers tend to overload the truck relative to its design capability--leading to higher than normal maintenance costs. Since primarily wetlands are available as dumping sites, the limited porosity of the bale minimizes the quantity of leachate which the bale could release, thereby lessening the potential of groundwater contamination. Since baled refuse is reportedly less attractive to burrowing animals, is not prone to being windblown, and is generally unattractive to scavengers, a number of landfill-associated problems are avoided.

E. Disposal

Open dumping remains the most prevalent form of disposal witnessed in developing countries. Very little of available budget for waste management is typically allocated to disposal. Since no monies are available for disposal, proposals for sophisticated resource recovery systems that "turn garbage into gold" are very attractive to local politicians. In most cases, reality would not bear out the promises and yet another "white elephant" would quietly stand as a tribute to poor planning analysis.

Landfill with special design to render the disposal site sanitary and neat, and to minimize the potential for gas and leachate generation and migration, is still the most cost-effective means of disposal available to most cities, both in developing and in industrialized countries. Only where there is either a potentially strong economic market demand or intrinsic need for the by-products of resource recovery should such waste processing not be considered.

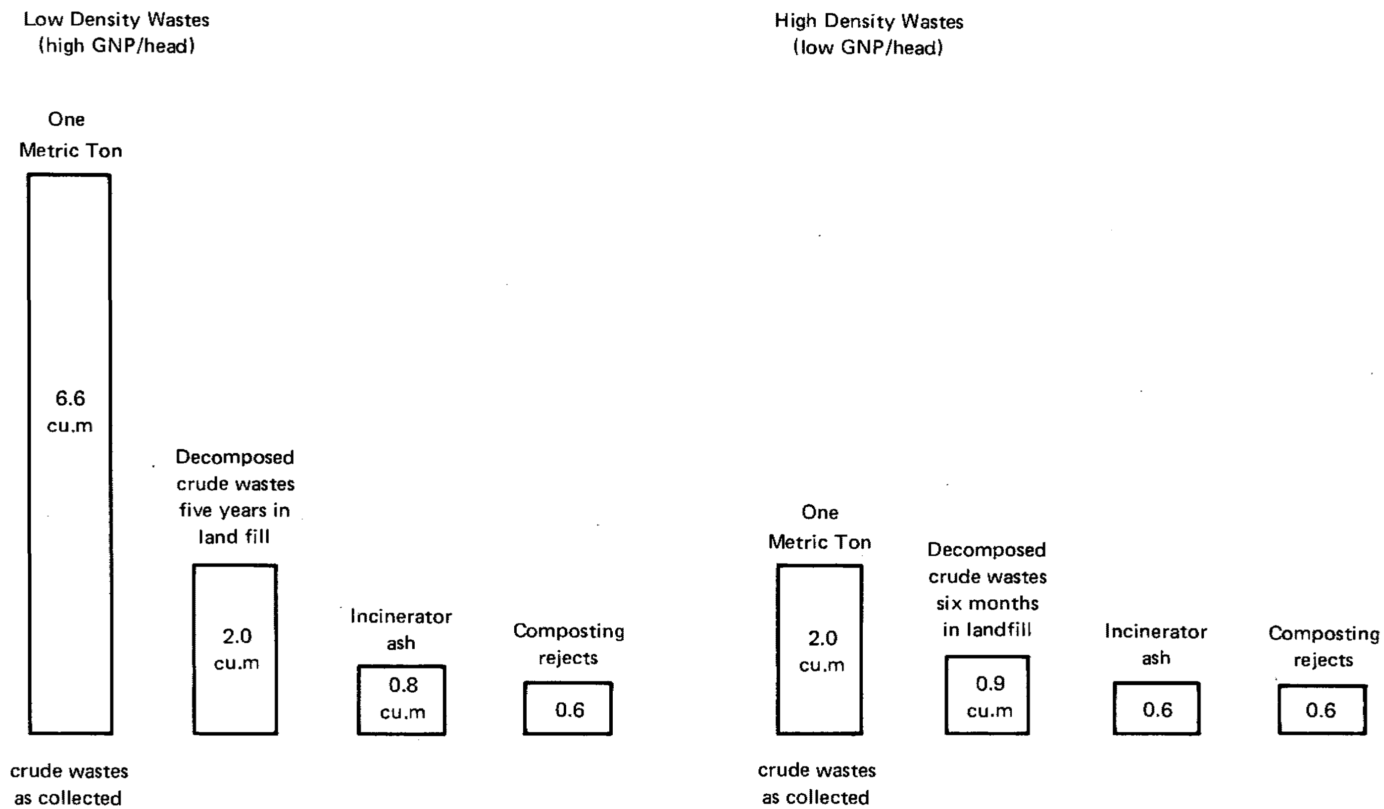
The resource recovery options which are probably most appropriate in developing countries are based on biological decomposition of the organic fraction of the waste. Because of climate conditions which generally allow year-round outdoor treatment by biological systems, and because of the organic moist nature of the wastes, developing countries may find composting, biogas conversion, and methane recovery from landfills technologically feasible. Careful market evaluation, which includes a pilot/demonstration step for validation of market demand and acceptance, is essential.

The number of publications presenting an array of resource recovery options is extensive. Basically all these references promote highly mechanized systems and are directed toward audiences in industrialized countries. Only incineration with energy generation is truly proven among the non-biological techniques. Other systems using techniques such as pyrolysis and refuse-derived fuel, remain to be adequately established in industrialized countries--much less in developing countries.

The United Nations Development Programme, in concert with the World Bank as executing agency, is sponsoring a global research and development project starting in 1981: to develop the state of the art of appropriate technology for resource recovery in developing countries. Particular attention will be given to systems that integrate more than one type of waste stream, and that integrate more than one type of technology.

Typically the main argument for resource recovery in a city is lack of landfill space. Local government officials may be willing to consider spending heavily for resource recovery, but are often unwilling to spend a lesser amount for equipment that extends the life of landfill sites, methods that reduce the amount of waste requiring disposal, or transfer systems that allow more distant sites to be utilized. The following chart shows that some amount of landfill capacity would be needed for any common mode of disposal available.

Chart 1: PROBABLE LAND SPACE REQUIRED FOR SANITARY LANDFILLING OF UNTREATED WASTES COMPARED WITH SPACE REQUIRED FOR RESIDUES OF TREATMENT



Source: "Management of Solid Wastes in Developing Countries"
By Frank Flintoff

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VI. INGREDIENTS OF A SOLID WASTE PROGRAM

A. Establish an Acceptable Standard of Service Delivery

Every city has financial constraints. Priorities for solid waste service must be established both within the solid waste sector and among all the city service sectors.

Within the solid waste sector, issues to be addressed in establishing priorities and then setting standards for service include: which categories of waste are included within the accepted responsibility of the local government for collection and disposal, what level of control is desirable over waste categories that are not serviced by the public sector, what portion of the waste generated in each category is the target for collection service, what level of citizen participation and convenience is acceptable in the collection technique selected, what level of household storage and service is acceptable in the collection technique selected and what frequency of collection is acceptable, which informal sectors of recycling or resource recovery are to be preserved or enhanced or discouraged, and which environmental issues must be addressed in planning adequate disposal systems.

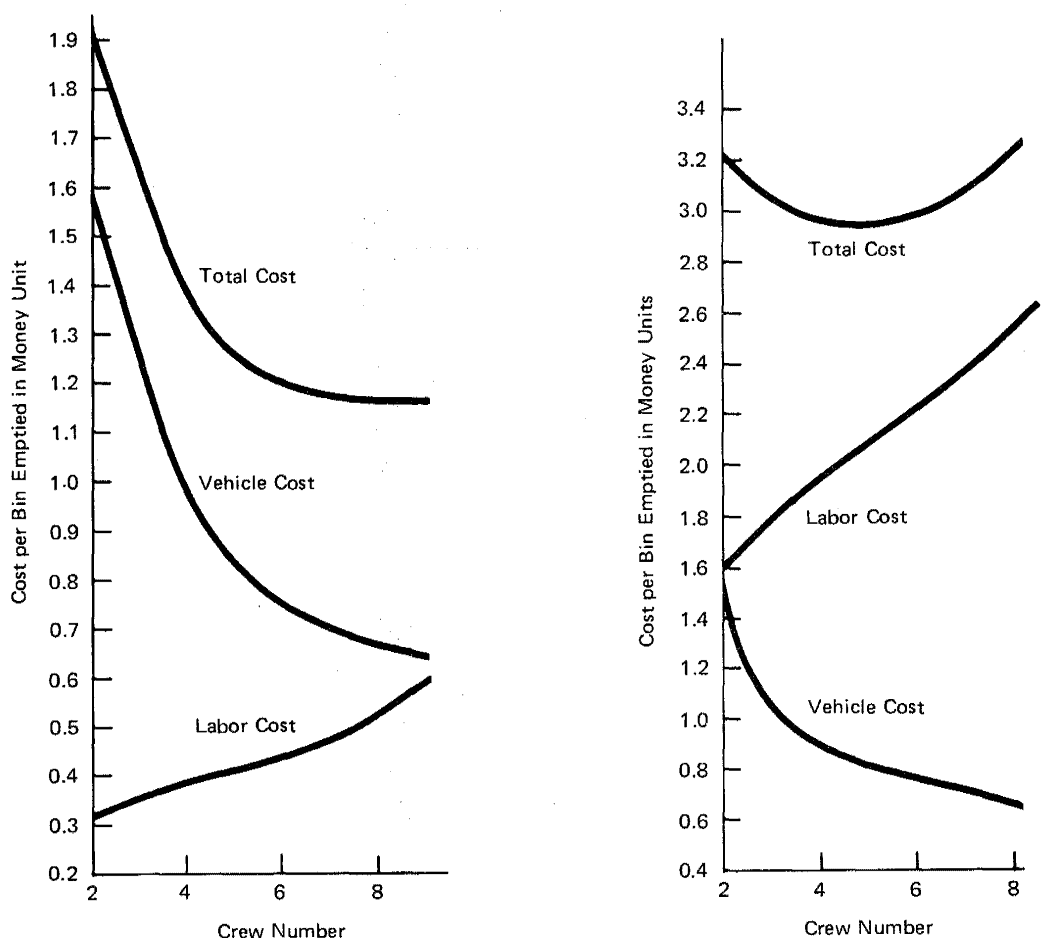
Among a city's many service obligations, decisions relative to the well-being of the residents and the cost/benefit assessment of various actions should be made. While it is very difficult to directly link solid waste management service levels to health statistics, qualitative judgment concerning the local priorities should be addressed through a multidisciplinary assessment by the various officials and departments involved in health-related services.

Once priorities are established, the standard of service is very much linked to the availability of revenues which can be allocated to the solid waste sector. If a minimum level of service is determined, then the portion of the budget available for solid waste management becomes whatever is the least-cost amount to achieve that level. More often, the funding limit is established, and the level of service becomes whatever one can achieve within that amount.

B. Select Appropriate Technology

Prevailing wage rates in an urban area significantly affect refuse management costs and are a key determinant in selection of cost-effective technology. In general, solid waste collection and disposal systems have little or no economies of scale, so that costs are not determined by the amount of refuse to be managed. Selection of technology is therefore not significantly affected by the size of the urban area and the amount of waste to be collected and disposed. In general, selection is based on optimization of the level of mechanization and intensity of labor. In cities where wage rates are relatively high compared to equipment unit costs, the number of persons in a given equipment unit's crew should be minimized. Where wage rates are very low, the more labor-intensive systems generally prove cost-effective. Mr. Flintoff has developed the following chart to illustrate this point: (1)

Chart 2: LABOR/MECHANIZATION OPTIMIZATION



For a low ratio of wage rate to vehicle cost, 1:10 the largest team achieves the lowest cost

For a high ratio of wage rate to vehicle cost, 1:2, a small team achieves the lowest cost

Source: "Management of Solid Wastes in Developing Countries"
By Frank Flintoff

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There should be a continuous planning activity within the solid waste management program. As long as it is designated as a discrete activity, planning may be arranged to be assigned to one or more individuals involved in operations; or a discrete planning unit may be created to perform this activity. There are pros and cons with both, and the institutional setup should conform to whatever system seems to work for the local government.

Planning activity required as a regular function of the solid waste service primarily deals with the recommendation of appropriate technology. One of the key issues in selection of appropriate technology is a determination of the optimum level of mechanization and labor involvement within a technological system. Various levels may be analyzed and comparatively assessed through life-cycle costing. As an example, five collection techniques of different levels are compared in Table 7 for Colombo, Sri Lanka. (2)

Appropriate technology selection does not always require choosing the lowest cost option. First, there are issues of worker health, safety and dignity to be considered; and the choices must be among those which are acceptable to the local population regarding these issues. Second, there may be employment objectives that favor labor-intensive solutions even where they are not the least-cost solutions. Third, limitations on foreign exchange and capital may lead to favoring systems with higher total costs. And fourth, bilateral aid or low-cost loans may bias selection toward capital-intensive solutions. Local social and cultural aspects of selecting specific systems may rely on qualitative judgment, but can be investigated by means of interviewing residents and pilot testing various options.

C. Create a Phased Action Plan

Based on specific objectives to provide acceptable solid waste management service, and on existing financial constraints, a phased action plan may have two basic elements. One element of the plan being the direct expenditures for equipment, facilities and personnel. Another element of the plan being provision of management incentives and disincentives, as well as the improvement of the financial and institutional base upon which the solid waste service relies.

The plan should try to readily incorporate those actions which may realize a major improvement without major capital investment. Therefore, initial emphasis may be placed on actions such as the following:

1. Optimize the ratio of supervisory personnel to direct labor and provide equipment and facilities to facilitate their work.

2. Optimize the ratio of inspection personnel to service area and provide equipment, facilities and enforcement mechanisms to facilitate their work.

3. Optimize the ratio of maintenance personnel to equipment, and provide the workshop tools and infrastructure needed for ease in making repairs.

4. Adopt a system of record keeping on equipment and maintenance supplies, so that an adequate supply of spare parts and materials is available at all times for typical maintenance needs--and so that an adequate lead time is given for ordering special parts for a pending repair need.

Table 7: <u>TYPICAL YEARLY COST COMPARISON OF AVAILABLE REFUSE COLLECTION EQUIPMENT PER VEHICLE</u>

<u>SCENARIO I</u>: 30 Minutes Round Trip Travel Time to Disposal Site

	NON-COMPACTION					COMPACTION		
	Tractor with Open Trailer		Tractor Shuttle System with Open Trailers		Side Loading Truck	Rear Loader with Bins		Rear Loader
	Tractor	Trailer	Tractor	Trailers		Rear Loader	Bins	
Purchase Price per Unit	Rs 100,000	Rs 35,000	Rs 100,000	Rs 35,000	Rs 300,000	Rs 700,000	Rs 13,750	700,000
Purchase Price per System	"	"	"	(10) 350,000	"	"	(72) 990,000	
Estimated Life	10 years	10 years	10 years	10 years	7 years	7 years	3 years	7 years
Annualized Capital Cost (Purchase Price @ 16% Interest over Estimated Life)	20,600	7,210	20,600	72,100	74,100	172,900	440,550	172,900
Labor, including 17% of Fringes: /a								
Driver (Rs 3,675)	(1) 4,300		(1) 4,300		(1) 4,300	(1) 4,300		(1) 4,300
Laborer (Rs 2,843)	(6) 19,958		(1) 3,326		(6) 19,958	(2) 6,652		(4) 13,304
Fuel: Gasoline (Rs 9/liter)	44,800		44,800					
Diesel (Rs 5/liter)					74,550	74,550		74,550
Vehicle Maintenance (20% of Purchase Price) /b	20,000		20,000		60,000	140,000		140,000
Trailer Maintenance (10% of Purchase Price)		3,500		35,000				
Bin Maintenance (Rs 500/year)							36,000	
Management and Administrative Overhead (10% of direct labor) /c	2,135		714		2,135	999		1,567
Miscellaneous (insurance, fees, etc.)	10,000	3,500	10,000	17,500	30,000	70,000	______	70,000
Total Annualized Cost	121,793	14,210	103,740	124,600	265,043	469,401	476,550	476,621
Total Annualized System Cost	Rs 136,003		Rs 228,340		Rs 265,043	Rs 945,951		Rs 476,621
Trips per Day /d	3		10		3	4		3
Metric tons per Load /e	1.3		1.3		3.8	4.4		4.4
Metric tons per Year (trips/day x 350 day/yr x metric tons/load)	1,365		4,550		3,990	6,160		4,620
Cost per metric ton	Rs 99.63/ton		Rs 50.18/ton		Rs 66.43/ton	Rs 153.56/ton		Rs 103.16/ton

Table 7 (cont'd) TYPICAL YEARLY COST COMPARISON OF AVAILABLE REFUSE COLLECTION EQUIPMENT PER VEHICLE

SCENARIO II: 80 Minutes Round Trip Travel Time to Disposal Site

	NON-COMPACTION					COMPACTION		
	Tractor with Open Trailer		Tractor Shuttle System with Open Trailers		Side Loading	Rear Loader with Bins		Rear
	Tractor	Trailer	Tractor	Trailers	Truck	Rear Loader	Bins	Loader
Purchase Price per Unit	Rs 100,000	Rs 35,000	Rs 100,000	Rs 35,000	Rs 300,000	Rs 700,000	Rs 13,750	Rs 700,000
Purchase Price per System	"	"	"	(4) 140,000	"	"	(52) 715,000	"
Estimated Life	10 years	10 years	10 years	10 years	7 years	7 years	3 years	7 years
Annualized Capital Cost (Purchase Price @ 16% Interest over Estimated Life)	20,600	7,210	20,600	28,840	74,100	172,900	318,175	172,900
Labor, including 17% of Fringes: /a								
Driver (Rs 3,675)	(1) 4,300		(1) 4,300		(1) 4,300	(1) 4,300		(1) 4,300
Laborer (Rs 2,843)	(6) 19,958		(1) 3,326		(6) 19,958	(2) 6,652		(4) 13,304
Fuel: Gasoline (Rs 9/liter)	44,800		44,800					
Diesel (Rs 5/liter)					74,550	74,550		74,550
Vehicle Maintenance (20% of Purchase Price) /b	20,000		20,000		60,000	140,000		140,000
Trailer Maintenance (10% of Purchase Price)		3,500		14,000				
Bin Maintenance (Rs 500/year)							27,000	
Management and Administrative Overhead (10% of direct labor) /c	2,135		714		2,135	999		1,567
Miscellaneous (insurance, fees, etc.)	10,000	___	10,000	7,000	30,000	70,000		70,000
Total Annualized Cost	121,793	14,210	103,740	49,840	265,043	469,401	345,175	476,621
Total Annualized System Cost	Rs 136,003		Rs 153,580		Rs 265,043	Rs 814,576		Rs 476,621
Trips per Day /d	2		4		2	3		2
Metric tons per Load /e	1.3		1.3		3.8	4.4		4.4
Metric tons per Year (trips/day x 350 day/yr x metric tons/load)	910		1,820		2,660	4,620		3,080
Cost per metric ton	Rs 149.45/ton		Rs 84.38/ton		Rs 99.64/ton	Rs 176.31/ton		Rs 154.75/ton
Cost per metric ton, Scenario I	Rs 99.63/ton		Rs 50.18/ton		Rs 66.43/ton	Rs 153.56/ton		Rs 103.16/ton

/a Fringe benefits expressed as percent of total cleansing labor costs. /b Equipment maintenance includes tires and oil for this example. However, every effort should be made to disaggregate this category as follows: Consumables: fuel, oil, tires, equipment maintenance. /c Management and administrative overhead expressed as percent of district supervision to laborers (an average for Districts I, IIA, IIB, IV, and V). /d Trips per day were derived from total feasible running and loading times based on time and motion studies in Colombo accounting for round trip travel time to proposed landfill facilities (for Scenarios I and II). /e Tons per load based on 250/kg/m^3 uncompacted and 400/kg/m^3 compacted relative to equipment capacity and average percentage filled.

Source: S. Cointreau, et al., SWMC, Ltd. Solid Waste Management Study for Colombo, Sri Lanka. National Water Supply and Drainage Board of Sri Lanka. March (final draft) 1982.

Note: Rs 20 roughly equal US$1 in 1982.

5. Clarify responsibilities by such actions as making specific collection crews responsible for specific routes or areas of service, and similarly assigning equipment to individual drivers or operators. Also, clearly designate the chain of communication and coordination for workers to utilize in reporting problems and issues in service provision, and for citizens to utilize in making complaints or commendations.

6. Establish city ordinances that spell out citizen participation in the solid waste management system, by outlining methods of household storage, placement of wastes for pickup, payment of charges, source separation of recyclables, and responsibilities for keeping their curbside property clean for pedestrian traffic. Also implement ordinances that outline acceptable dumping practices for wastes from sanitation systems, industry and commercial establishments.

After the non-structural actions are addressed in the action plan, activities which require capital investment may then be implemented. The first set of actions address primary facilities; for example:

1. Locate disposal facilities so that hauling time from the collection service area to the point of dumping is minimized.

2. Locate transfer facilities so that direct haul by collection vehicles is limited and actual time on the collection route is maximized, to the extent needed with respect to remote disposal sites.

3. Provide facilities for decentralized parking and daily maintenance for those refuse service districts that are not within a reasonable travel time from centralized facilities.

4. Equip all parking areas with enough fueling stations to minimize start-up delays at the beginning of each shift.

5. Establish a competent central workshop for major repairs and overhauls of refuse vehicles, and to the extent needed for provision of daily maintenance to some or all districts of refuse service.

Improvements of overall management and administration, followed by improvements of basic facilities serving the refuse fleet and crews, allow activities of existing equipment and personnel to be optimized. Thereafter, if there are needs for changes in the equipment or personnel, the foundation has been established to support those changes.

If specific institutional and financial arrangements are developed as necessary to properly manage the refuse system and provide the funding base for its improvement, they should probably be prerequisites or conditions to be implemented prior to capital investment, and would be implemented along with the non-structural proposals listed.

D. Arrange Institutions for Planning, Management and Service Delivery

Institutional arrangements should never be created in a vacuum. They are to be built upon the existing framework of institutions which have evolved in the refuse management sector over the history of the local goverment. Every effort should be made to keep intact those parts of the institutional setup that work, adjusting only for those parts of the setup that do not work.

In theory, it would be best if all refuse management functions, including maintenance, were placed under one roof and given status that is equitable with respect to other local government service agencies (i.e., public works, health, and education). Chart 3 provides an organizational framework recommended by the Bank for Onitsha, Nigeria, which is currently being implemented. The middle position of foremen provides an opportunity for upward mobility to the drivers and collectors. Inspectors provide a check on the work accomplished by the equipment crews and foremen, as well as an impartial party to whom citizens can register complaints or compliments.

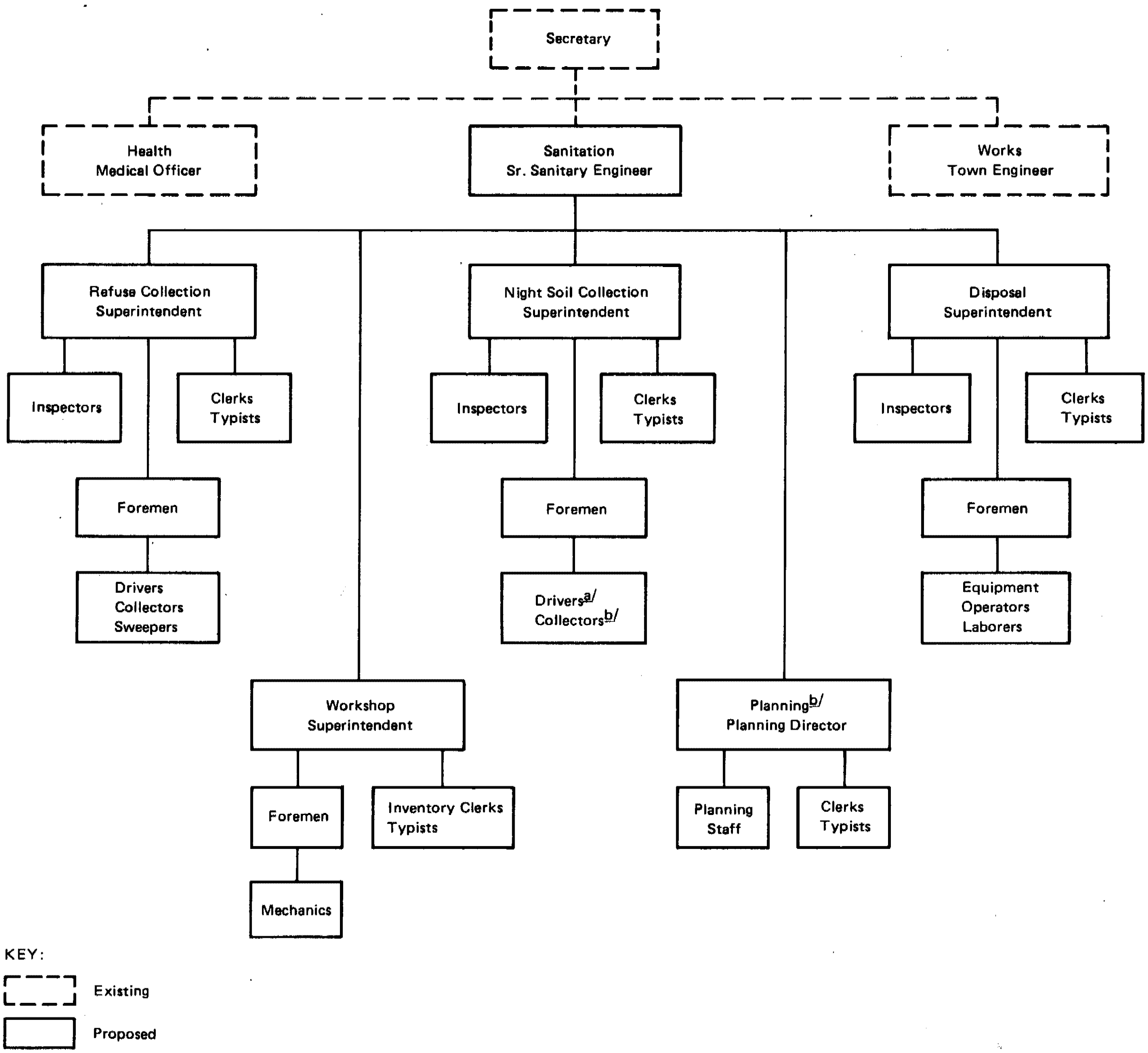
In practice, various functions in refuse management may be successfully split among a number of agencies. In any event, it is important that the designation of responsibility and authority be clear, and that the organizational structure be straightforward. Means of coordinating and communicating--both vertically and horizontally--in the refuse management system need to be clarified. As mentioned earlier, somewhere in the system the planning function needs to be assigned, and somewhere in the system accessibility to the decision-making process on budget allocations should be established.

E. Arrange Financial Resources and Budget Planning Systems

This relates to the preceding section, where the need for continuous planning and for inclusion of the planning findings in the budgeting process is discussed. Refuse management typically comprises a sizable portion of the municipal budget. Good accounting procedures are essential to the regular maintenance and renewal, as well as expansion, of the system.

Financial arrangments for the refuse system should provide for a steady, reliable source of money for regular operation and maintenance. The source of money may be the municipal budget or it may be a user charge. Where competent water or electricity billing systems are established, a user charge for refuse management could be added. Joint billing would generally cost less than separate billings. Furthermore, since water and electrical services can be terminated for non-payment more readily than refuse management services, joint billing provides greater likelihood of cost recovery. The arrangements, together with the accounting procedures, should encourage adequate records be kept on equipment depreciation--coupled with the need for renewal and provision for payment of interest. Many cities procure all or a major portion of

CHART 3
ONITSHA LOCAL GOVERNMENT
Recommended Reorganization



a/ May be engaged through private contractor.
b/ Optional for near-term, with Superintendents performing planning function.

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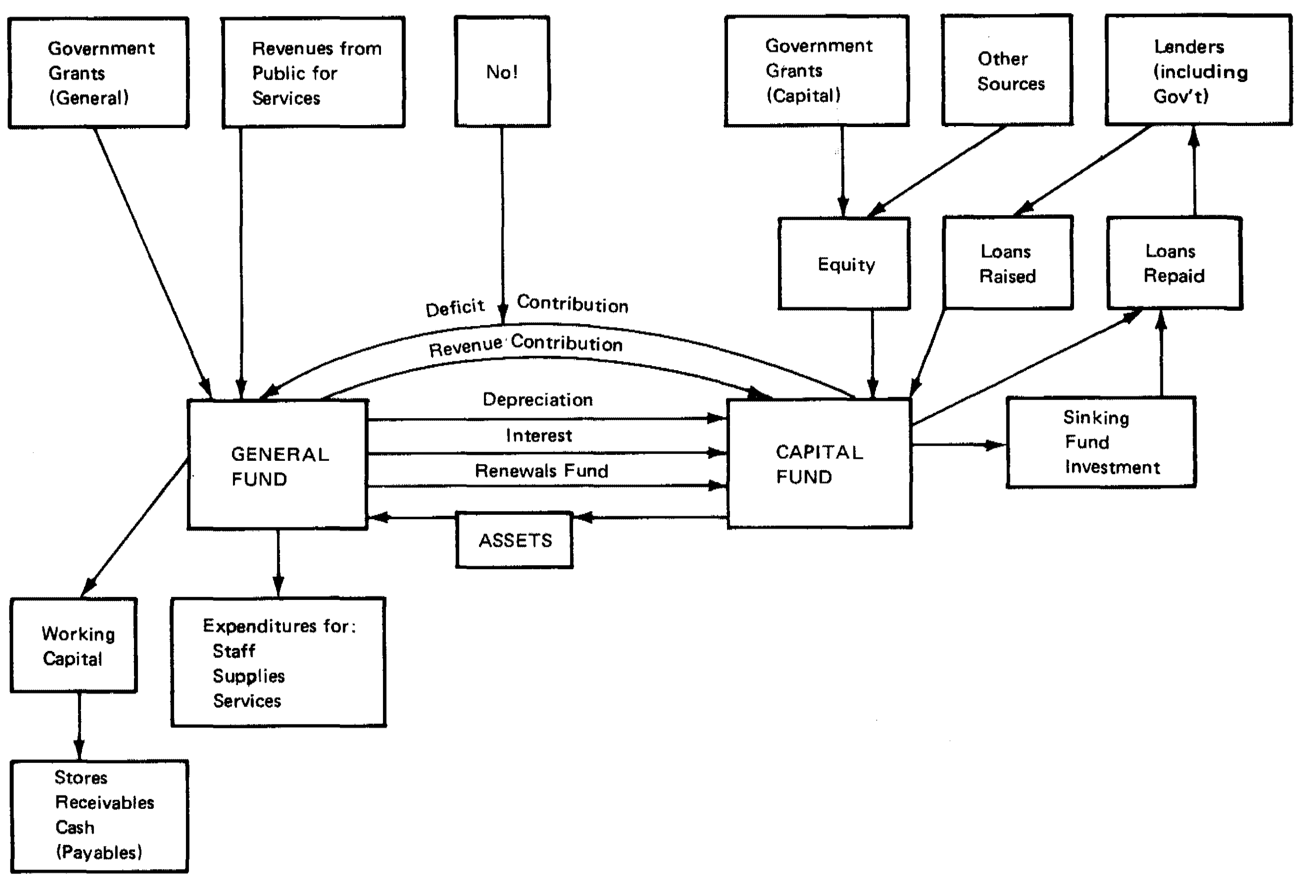
their collection equipment at one time. Rather than regularly replenish a fraction of the fleet, most cities will wait for most of the equipment to be beyond recommended retirement age and will then present a crisis situation to the local financing entity.

The following schematic by David Jones, financial adviser for urban development at the World Bank, illustrates the flows of money for which there should be provision within the accounting and budget planning arrangements of a municipality as a whole. A well managed solid waste system will be integrated within such a system.

As indicated in chapter IV, section D, government grants for the solid waste service are largely inappropriate and relatively unlikely compared with other services.

Chart 4: SCHEMATIC FINANCIAL RESOURCE AND BUDGET PLANNING SYSTEM



Source: David Jones, Urban Development Department, World Bank.

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F. Develop Regulatory and Enforcement Support Systems

Citizen participation in the refuse system is important. It is not effective to provide door-to-door collection service, and then have residents dump wastes in drains, on open lands, and along curbs. Generally, a system of combined incentives and disincentives is needed to obtain their cooperation.

One disincentive to poor cooperation from residents with the refuse management system is legislation. Laws, ordinances, regulations--coupled with inspection and enforcement are the chief deterrents to wide-spread littering, refusal to use a standardized dustbin, lack of cooperation with the timed schedule of collection, and illegal dumping.

Some cities have ordinances, but have so few inspectors or such cumbersome enforcement procedures, that the ordinances are virtually ineffective. If a specific rule is broken, an inspector's issue of a notice should be readily followed by implementation of the penalty. Should a fine be issued, collection procedures should be efficient and effective. In some cities this has involved creation of a special small claims court, so that minor offenses can be handled within a few days of a notice being issued.

Management of some wastes may require national policies and laws be developed and implemented. This is particularly true for potentially hazardous wastes, for which a country's government may even proceed to implement a national tracking or manifest system--so that the path of hazardous materials is known from the point of generation to the point of ultimate disposal.

In addition, laws on a national or regional (i.e., river basin) scale may require protection of specific resources. Air quality standards may have an impact on a city's choice of disposal options, and in some cases rule out incineration. Protection of groundwater resources of special significance may limit the acceptability of certain landfill sites, or may drive up the cost of landfill on such sites because of the necessary water pollution control steps which may be required.

National and regional laws and policies influence recycling practices and resource recovery. For example, the opening of Colombo, Sri Lanka, as a duty-free port led to stiff competition from foreign suppliers, apparently resulting in a decrease in local paper production and a major decline in the local private sector's recycling of used paper. New tariffs on selected paper grades are currently expected to rekindle the national paper industry and markedly encourage paper recycling. National subsidies of chemical fertilizers in Nigeria discourage conversion of refuse to compost. Mexican laws prohibiting urban shanty dwellers to raise cows, pigs and other animals for table consumption do little to stop the practice of animal raising, but do much to encourage the development of organized middlemen as buyers/agents/protectors.

G. Provide Public Education and Participation Programs

The refuse collection worker can be a prominent representative of a city. Appearance, courtesy, competence and consideration on the part of the refuse worker provide the first and foremost incentive (or disincentive) to citizen cooperation with the refuse system. Therefore, the initial step in upgrading the system so that it is a mutually beneficial cooperative effort between local government and urban residents is proper training and supervision of refuse workers.

There are a number of basic items of information to communicate to the public regarding its refuse service, and expenditures in this area prove cost-effective: schedule of collection pick up, requirements for storage container placement and removal for pick up, arrangements for special collection of bulky wastes or garden, methods for making complaints about service, and designation of special pick-ups for recyclables.

Publicity campaigns are valuable for specific events, such as seasonal clean-up campaigns--when residents are encouraged to clean their yard and storage spaces of litter and accumulated junk. Publicity campaigns are also invaluable to activities by the refuse service to sample and survey waste generation and characterization, or to pilot test new methods of collection. When a major upgrading of refuse management recently occurred in Riyadh, Saudi Arabia, billboards, small signs on sidewalks and 200,000 printed leaflets advertised the new sanitation system; and when the equipment arrived for the central cleansing facility the local government staged a parade of refuse vehicles through the streets of Riyadh to familiarize the residents with the new system and its fleet. (3)

A leaflet about the refuse management system may contain information such as: what services are provided, how many workers there are, the annual budget, what improvements are planned, organization of the system, how a resident can obtain information or provide comment on the system, what is expected of the resident as part of the cooperative effort, and the economic and health benefits of a cleaner city.

Violation notices can be considered a part of the education process. If a violation tag lists all the practices that are not allowed with a space for checking the specific violation, the resident learns not only which mistake has been made, but which mistakes to avoid. (4) The violation tag may even include some information on the reasons behind certain rules and regulations.

Word-of-mouth communication of an idea or comment will undoubtedly remain our most effective form of education. For this reason, pilot testing and demonstration of certain new methods of refuse management is particularly valuable. To some extent, the pilot test yields data and information useful to the extension of the method and allows for modifications to the method to be made before major expenditures are incurred. In addition, residents participating in the tested method become part of the documented evidence on whether the system works or does not work. The World Bank has sponsored a number of pilot projects for door-to-door collection by pushcarts in neighborhoods which are densely populated and inaccessible to trucks. One of the benefits of the pilot programs is that they are replicable examples of a refuse management improvement that can be toured, costed, discussed and thereafter extended in accordance with financial limits and public acceptance.

Pilot projects are particularly useful to innovative systems of resource recovery, and to the use of the recovered materials or energy. The World Bank sponsored pilot project for composting in Tunis, Tunisia, incorporates demonstration of differences in crop yield and fruit quality for plots of land receiving compost versus those not receiving compost as a soil amendment.

H. Incorporate Incentives and Disincentives to Aid Program Success

One fundamental incentive (or removal of a disincentive) which a city can provide to its refuse workers is a well managed and maintained equipment fleet. It is discouraging for a refuse worker to have to use equipment that is constantly breaking down. It is also discouraging to arrive promptly at work--only to wait in line for an hour to obtain fuel at the gas pump or get the day's assignment. Prompt start-up procedures and good equipment are necessary to optimizing productivity.

Another necessary item is selection of the most appropriate technology. If the worker constantly has to work against the technology rather than with it, motivation is difficult to maintain. Simple measures, such as putting rubber tires on pushcarts or lowering the loading height of a vehicle, go a long way in maintaining the workers' motivation.

Clear designation of responsibility and authority are important parts of the incentive system. For example, make individual collection workers responsible for serving a specific route. Give them the responsibility to deal with complaints from people within their service area. And establish rewards for crews with routes that are complaint free, overtime free, accident free and otherwise trouble free for an extended period. (5)

Another way of clarifying responsibility is to assign specific equipment units to individual operators or drivers. The person assigned an item of equipment should be accountable for it. Requirements for recording its daily maintenance needs as being met, and for noting potential repair needs, should be in the hands of the designated driver or operator. Disincentives for a poor safety record or unreasonable repair needs would normally complement the incentives provided.

Many cities in developing countries have specific cultural or religious groups providing refuse collection. These may be Zabbaleen in Cairo, the Tamils in Colombo, or the Harijan in Calcutta. Opportunities for upward mobility of these workers, because of their class, are virtually nil. One often used informal incentive is to assign the better workers to the wealthier neighborhoods, where the "picking" opportunities are better and year-end bonuses higher.

If a worker does not have complete authority or control over provision of good service, the chain of communication to people that are necessary to his service should be clear and simple. For example, a worker should have only one supervisor; and that supervisor should have access to persons higher in the organizational structure who can remove constraints or disincentives that may be inhibiting efficient and effective provision of service.

Pride in self-accomplishment is an integral part of attaining good work from refuse personnel. Training which provides the worker with some skills, such as vehicle operation, or teaches him or her about the need for refuse management should be designed to demonstrate the importance of the worker to the system. Provision of attractive and clean uniforms is another way of improving the worker's self-image. Another way is for the city to take the side of the worker on certain issues, and to do so publicly. One example of this was a notice distributed to residents of Tuscon, Arizona, U.S.A.:

> As a member of a City Garbage crew, I have been given very careful instructions not to bang your garbage cans, but to treat them with tender loving care. But in order for me to follow these instructions and still empty your garbage cans, your cooperation is needed. If you fill the cans and then stuff in some more trash and jump on it in order to get the lid on, the garbage won't fall out when I turn over your can to empty it.
> I am not allowed to reach in the can and pull garbage out with my hands. I can't tell when I will grab a broken bottle, old razor blades, jagged tin can lids or other dangerous things, and if I am hurt you have to pay for it... So please don't cram your garbage can full; get another one if you feel you often need more room. (6)

While money is generally a good motivator for getting a person to show up for work and put in the required time, it is not necessarily a good motivator for getting that person to provide efficient and effective service--especially if the person is salaried. One practice which works in many cities around the world is this: a specific area is served by a specific crew of workers who work as a team; effectiveness of their effort is monitored by inspectors and the complaint handling system; and productivity is under their control as they are allowed to leave work once their area has been serviced. As a result of this practice, there is usually considerable reduction in the travel time off the route, and considerable fuel savings are often apparent.

VII. THE PROJECT CYCLE

A. Project Identification

The first hurdle in project development is identification of the potential project. Identification is made by either the Bank staff or the borrowing government. The need for the project may have been identified by the Bank, the borrower, or by private enterprise (i.e., a resource recovery equipment vendor or a private cleansing service company). (1)

If a solid waste project is identified early, the steps for preparation and appraisal can proceed at a comfortable pace. Once identified, a project is incorporated into the Bank's multi-year lending program for the project country.

Country programs are used for scheduling and budgeting the Bank's operations. Without early identification, the Bank project officer has difficulty arranging adequate budget to prepare and appraise the project. Late identification of solid waste management needs has, thus far, been the main problem in project development for the solid waste sector.

There have been a number of urban development and water supply and drainage projects which have included a solid waste component just before the appraisal mission by the Bank. There are then very little monies available to engage a solid waste expert to perform the combination preparation and appraisal; and a number of projects have allocated less than two weeks of field time for this entire effort.

The main problem with this mode of project development is that there is no time to generate data. The solid waste expert must work with whatever is available in the field. Generally, there is little or no competent data defining the amount of waste being generated nor its density. As a result, it is nearly impossible to accurately state how much of the generated waste is being collected and how great is the need for more equipment capacity.

Another problem with late identification of a potential solid waste project is that single-time analysis (such as a one-time effort at the appraisal stage) could influence the solid waste specialist's recommendations differently than time-series analysis. (2)

It was outlined in Chapter I that the World Bank has had many different types of solid waste projects. Most of these have been components of larger projects, and one has been separately developed and implemented.

A solid waste management project may include any one of the following, or any combination of the following:

(a) Terms of reference and technical assistance financing for a solid waste management study--to equal preparation of a project for potential Bank financing or other financing.

(b) City-wide recommendations to address solid waste management needs, including upgraded maintenance and disposal facilities, for the immediate future.

(c) Area-targeted recommendations to address solid waste management needs in specific neighborhoods or refuse service districts--particularly to address the urban poor.

(d) City-wide recommendations to address solid waste management needs, including improved institutional and financial arrangements, for the long term.

In some of the above steps, the World Bank is working to build up the management capability of the urban administration handling refuse: an effort to build institutions and financial resources for the long term. In other steps, the World Bank is attempting to mitigate some serious immediate problems or inequities of refuse service. Any and all of the above are acceptable project concepts for implementation.

While it is acceptable to do some "fire-fighting" on a solid waste project, it is not recommendable that a project entirely be comprised of addressing immediate needs. In general, Bank staff who have experience with the solid waste sector agree that it is necessary to look at the city-wide system and its long-term needs. (3)

In addition to identifying needs at this first stage of project development, it is necessary to identify pressures. For a number of the Bank's projects, pressures from a private contractor or international aid agency supporting specific equipment recommendations have led the borrower to request the World Bank's assistance. Typically, the project officer responded to this request by provision of a solid waste expert to make a quick assessment of the situation and recommend either: (i) proceed with the concept assessed; or (ii) hold the fort for additional review and analysis as a part of potential project preparation.

Seldom would the solid waste expert, who has been hired to respond to external pressures discussed above, propose that no action be taken. Normally, external pressures do not build up and lead to Bank assistance unless a basic need exists. The question for the expert to address is whether the solution being proposed is appropriate, and if not: what would be appropriate?

Annex C provides data collection guidance for use in the project identification stage of a potential solid waste component. This effort would normally be accomplished by Bank staff who are not specialized in the solid waste sector. A short questionnaire is provided in Annex D and is to be used with the local government to obtain some basic indicators on the adequacy of refuse service.

In some cases, the refuse management service delivery may be very good. The overall city may appear clean and disposal practices may be conducted in a sanitary manner. Even so, there may be some need for review of the solid waste sector. Solid waste management generally comprises such a large fraction of a municipal budget--often the largest portion of the budget goes toward meeting collection needs--that there may be ways to improve its efficiency while maintaining its effectiveness. If revenue sources in a city are limited and expenditure for solid waste is high, it may be possible to reduce the costs of the system and free monies for other urban needs.

The following activities should be accomplished at the identification stage of project development for the solid waste sector:

- determine whether the service provided in the solid waste sector is adequate;
- determine whether the service provided is efficient;
- review whether there are local institutions that could participate in project preparation, and perhaps provide continuous support during subsequent stages of appraisal and implementation; and
- develop a rough outline of project elements that appear to address the city's needs, and sketch out a budget line item for project programming purposes.

B. Project Preparation

Normally the project preparation stage takes one to two years. Assuming that a solid waste project has been identified early in the project development cycle, at the identification stage along with other parts of an overall project being investigated, this provides a reasonable amount of time for preparation.

The borrower is responsible for project preparation, and the Bank works closely with the borrower throughout this stage. Since solid waste management is typically the responsibility of local government agencies, and because expertise for planning is generally limited, technical assistance is normally needed.

In most urban areas where the Bank has developed solid waste projects, the Bank has never before dealt with the agency providing solid waste service. Therefore, the Bank staff must help local officials to understand the role of the Bank, and its requirements and standards for project development. If Bank staff are not going to be directly involved with local officials at this stage because they have engaged solid waste experts to participate in the preparation missions, they should make sure that the consultants are carefully briefed and have materials to hand out concerning Bank procedures for contracting.

The most important item of information to be generated at this stage of project development is quantification of existing and projected waste weights and volumes, as collected. Additional information is useful on the character and composition of various types of solid waste. This information is then used to assess the adequacy of the existing fleet of collection and disposal equipment, as well as the supportive infrastructure.

Annex A provides Terms of Reference for use in engaging a solid waste expert consultant or contractor to help prepare the project. These tools are provided to enable Bank staff to assist the local government. Thereafter, it is primarily the responsibility of local government and its consultants to generate data, analyze data and perform feasibility studies that compare alternative designs of technical and institutional/financial arrangements for costs and benefits. Annex D provides guidance on data collection for use in preparation of a solid waste project.

Based on the feasibility studies accomplished, the local government selects or ranks the solid waste management options. The local government should recommend the various equipment, facility and other improvements for which it would need investment financing.

In summary, the activities which should be accomplished at the preparation stage of solid waste management project development are:

- review the population, income, housing and health statistics for the project area and determine disparities in collection service levels among neighborhoods;

- perform sampling and surveys as needed to determine the quantity and character of solid wastes being generated in various source categories,

- collect data to fully define the existing technical and institutional/financial system of refuse management;

- determine whether there are opportunities for enhanced recycling or resource recovery, and explore whether there is sufficient market demand for recovered materials or energy potential;

- perform feasibility studies on various technical and institutional/financial arrangements, and comparatively array their costs and benefits;
- recommend a system for implementing solid waste improvements which includes equipment, civil works and technical assistance which the Bank could finance, breaking down each item into its foreign exchange and local cost components;
- determine whether there are opportunities for pilot testing and demonstration of new systems;
- assess the need for technical assistance and/or training to complement the potential project and assure competent implementation; and
- throughout the preparation stage, assist the responsible agencies in the project area in understanding and following the World Bank procedures for project preparation.

C. Project Appraisal

This stage of project development should normally follow extensive project preparation efforts conducted by the borrower. However, if project identification was not made early for the solid waste sector vis-a-vis the rest of the project, it may be necessary to compress project preparation into a few short weeks during preappraisal and appraisal stages. This would normally mean reliance on a single solid waste expert's recommendations, based on fieldwork with preappraisal and appraisal missions.

The above practice is not recommended. If, however, it appears necessary, the same Terms of Reference and Data Collection Workbook developed for project preparation and provided in Annexes C and D would be applicable. Of course, the level of detail of the results would be lower and would have to rely on utilization of existing and readily available information.

Under normal conditions, project appraisal is the culmination of project preparatory work. Appraisal is the Bank's responsibility. It is conducted by Bank staff and, as needed, by their consultants in solid waste management. If a good job of preparation has been accomplished, it may be possible to perform a competent solid waste management appraisal in two weeks of field time (with another two weeks of back-to-office time). As this is generally not the case, the person appraising solid waste should be allocated three to four weeks of field time, and a corresponding amount of back-to-office time.

The appraisal should accomplish the following:

- provide specific recommendations on equipment, facilities, and personnel needed for solid waste management improvement;
- estimate the benefits to accrue from the recommended solid waste management plan;
- provide detailed costs for each item requiring capital investment, and break-down costs into local and foreign exchange components;
- provide costs for operation and maintenance of the improved solid waste system, and develop total annual costs for investment, operation and maintenance to assess affordability of the proposed plan;
- recommend institutional and financial arrangements which are necessary or even conditional to implement the proposed plan; and
- recommend management incentives and disincentives that would encourage improved worker efficiency and effectiveness, as well as citizen cooperation with the upgraded system.

Major aspects to be included in an appraisal of any Bank project are discussed in some detail in The Project Cycle by Warren C. Baum. (4) In his discussion, four aspects of project appraisal are included: (a) technical; (b) institutional; (c) economic; and (d) financial. As he notes, not only must the project be appraised as a self-contained entity, but the economic analysis should aim at assessing the contribution of the project toward the development objectives of the country.

D. Project Negotiation

At this stage, communication and coordination between the Bank and the borrower determine the final project elements to be implemented. As needed, conditions or measures necessary to project success are established. These may include specific institutional and financial changes to implemented prior to implementation of equipment procurement or civil works construction.

Once negotiations are completed, the appraisal report is amended to address the conditions or measures agreed by both parties. The appraisal report is also amended to finalize the recommended project technical components. This amended report is then presented, along with the President's report and the loan agreements, to the Executive Directors of the Bank. Upon their acceptance of the project, the loan may be signed.

E. Project Implementation and Supervision

While implementation is the responsibility of the borrower, the Bank usually plays an important role in the process. If conditions developed during the project negotiation stage require institutional changes, for example, it may be necessary to give new personnel a complete briefing on the project's conception and design. Often the project financed by the Bank includes technical assistance for the implementation process. There is, for example, a full time solid waste expert assigned to the Indonesian solid waste projects for a period of several years and financed within the project.

The Bank staff must generally provide assistance to the solid waste agency in charge of implementation, regarding Bank procedures for procurement, land acquisition, civil works contracting, etc. As mentioned before, the agency in charge of solid waste has generally not had any contact with the World Bank prior to this project. Key officials responsible for the project implementation should be "walked through" the appraisal report and the loan agreement. Copies of materials that specify Bank procedures should be carefully explained. The role of the Bank in the implementation process should be made clear, so that the responsible agency can proceed readily on its own--knowing which are the critical checkpoints for Bank staff involvement.

Throughout project implementation, supervision missions of Bank staff and consultants, as needed, work in the field to review the planned versus actual schedule of events and their costs. Often during these supervision missions, the reasons for delays are identified. In many cases, delays are attributable to inadequate communication and coordination among parties within the project area. Bank staff typically act as facilitators during these missions, and bridge the gap between agencies so that project delays can be mitigated.

An important aspect of project implementation and supervision efforts is accumulating experience. This is particularly true for the solid waste management sector, for which the Bank currently has limited project experience. Pilot projects in Calcutta, India; Manila, Philippines; Jakarta and Surabaya, Indonesia; and Tunis, Tunisia; are expected to realize important feedback on what works and what does not work in project design. These projects are also expected to increase our data base on waste generation, collection and landfill costs, and resource recovery feasibility. For determining the needs of solid waste improvement programs in other cities, it would be valuable to obtain health statistics from before and after project implementation. A system of monitoring and evaluation, together with the technical assistance monies to support it, should be incorporated into the appraisal so that our ability to learn from each project is optimized.

A big hurdle in project implementation is the writing of procurement specifications. Refuse equipment comes in many forms. Decisions must be made on whether to have diesel engines or gasoline engines, air starters or electric starters, compaction equipment or open containers, hydraulic or mechanical tipping devices, tube tires or tubeless tires, and so on. Inadequate attention to the development of good procurement specifications is probably the biggest mistake a solid waste agency can make.

At a minimum, each potential supplier should be visited. The standard local stores of spare parts applicable to the equipment considered for procurement should be assessed, as well as the available local service and training programs. With each prospective supplier, the city maintenance records for existing equipment should be reviewed to determine particular stress areas (such as rear axles or tires) experiencing most frequent breakdown. The supplier's opinion on appropriate equipment options to avoid present problems should then be recorded and assessed. A city would be wise to invest the time of one of its key mechanical engineers or maintenance supervisors in such a city-wide review of available suppliers, prior to finalization of bid specifications.

There is no good reference available that clearly describes how to write equipment specifications, and how to decide among the various options available. There is no replacement for experience and expertise. If the solid waste project includes equipment with which the local refuse management agency is unfamiliar, assistance from the Bank is advised. Bank assistance by either arranging participation of a solid waste expert on supervision missions or providing a list of sources from which the local government can obtain assistance may be needed.

It is anticipated that this project guide will eventually be augmented by an annex providing information to facilitate writing performance specifications. In the meantime, the reader may refer to Users Manual for Development of Performance Specifications for Residential Refuse Collection Vehicles, for guidance on certain types of collection equipment; (5) and Caterpillar Tractor's guidance manual on writing specifications for earth moving equipment.

F. Project Evaluation

Bank projects, once completed, are subject to audit by the Operations Evaluation Department. The audit basically investigates the project expenditures against what equipment and facilities, as well as service contracts, have been realized.

Prior to the audit report, project staff prepare a completion report at the end of the disbursement period. The completion report gives the staff assessment of project successes and failures at the end of the disbursement period. At this time, the Bank does not have a "next step" for evaluation of project successes or failures after an extended period beyond the disbursement period's closure.

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Environmental Management of Urban Solid Wastes in Developing Countries

A Project Guide

SAMPLE TERMS OF REFERENCE

(for Solid Waste Specialist)

Sample Terms of Reference for Preparation and Appraisal Stages of Solid Waste Management Projects:

Every project for solid waste improvement is unique. In some cases, there is an expressed need for refuse collection vehicles. In other cases, there is a keen interest in a resource recovery system. In all cases, it is recommendable that the entire system of people, equipment, facilities, and organizations involved in the collection, transfer and disposal of refuse be reviewed. Special attention may be given to one particular aspect or the system; but only after the system is at least broadly assessed.

The Terms of Reference provided here are fairly comprehensive. There has been no differentiation made for Terms of Reference used in preparation versus appraisal. Certainly, the level of effort should be markedly different in the two stages of project development. However, the basic aspects of the refuse system needing to be studied, remain the same.

The level of effort required of a solid waste specialist in the conduct of a preparation or appraisal study is also site-specific. Generally, the smaller the city, the less time is required to review its needs. Furthermore, the amount of work required would depend on the competence of the local government officials responsible for refuse management and their ability to provide reliable adequate data readily.

Task 1:

The consultant will review existing reports pertinent to the development of baseline planning conditions for the study area of refuse management improvement. This will include available reports containing information on population, income distribution, land use, municipal institutional organization, municipal financial arrangements and revenue sources, commercial activity, industrial activity, land and water resources, climate and geography. Plans for future development, water supply and sanitation infrastructure, and institutional/financial arrangements would be reviewed.

This information is used to determine the quantity, character and distribution of solid wastes being generated. It is also used in determining the setting for disposal alternatives, and the management systems that govern the administration and financing of the refuse handling system.

Task 2:

The consultant will collect data on refuse generation rates, refuse composition, and refuse density. (During a preparation effort, this should include sampling and surveying of households, institutions and commercial establishments.) (During an appraisal effort, this should if possible include weighing of handcarts and trucks before and after loading to capacity.) Cooperation of the local government is essential to the performance of this task. Where citizens are involved in sampling and surveying, a social worker and a representative of the refuse management agency should provide preliminary briefings and obtain full cooperation. In addition, sanitation workers would be needed to provide manpower in collecting and sorting the samples.

Task 3:

The consultant will examine the existing sociocultural baseline of the project area to determine whether there are informal sectors of collection and recycling which might be encouraged to extend or upgrade their services, whether there are unique constraints to household storage of refuse, whether there are existing practices of using or recycling wastes at the household level which may affect projections of waste quantitites, and whether the existing practices of discarding wastes require special modifications or public education efforts.

Task 4:

The consultant will examine the existing collection and transfer of refuse in light of road and traffic conditions, access to various neighborhoods (especially to urban poverty groups), design of dwelling and communal refuse storage containers, frequency of pick-up, time-and-motion of various types of collection methods, supervision of workers, inspection of service areas, size and productivity of collection crews, efficiency of collection and transfer routing, and citizen participation in the overall system.

Task 5:

The consultant will examine existing disposal facilities with respect to location and capacity of landfill sites; environmental issues of gas and leachate migration, fires, scavengers and vectors; and the need for land reclamation through engineered landfill practices. Proximity of landfill sites to shallow drinking water supply wells, to future public water supply development aquifers, recreational surface waters, etc., should be clearly noted with respect to hydraulic gradients and groundwater/surface runoff flow paths.

Task 6:

The consultant will assess the potential for resource recovery in view of existing and prominently pending markets for recovered materials or energy. The type of resource recovery methods viable for the study area should be related to the compositional nature of the refuse. The level of mechanization viable for the study area should be related to conditions of labor and capital costs, with various levels of mechanization assessed economically.

Potential cost recovery of resource recovery practices and systems with respect to existing and projected supply and demand of competitive products should be reviewed in the overall assessment of economic feasibility of the options. Mappings of refuse sources, potential plant locations, major transport routes and markets should be presented as part of the overall assessment of cost-effectiveness of resource recovery.

Task 7:

The consultant will review existing maintenance equipment and facilities, the skill level and length of service of mechanics and supervisors, and the stores of supplies and spare parts with respect to the needs of existing and pending refuse management equipment.

Travel times to and from the maintenance area should be reviewed relative to locations of refuse service areas. Assess the need for decentralized workshops to render services of daily maintenance and minor repairs, coupled with centralized facilities for major repairs and overhauls.

Task 8:

The consultant will provide specific recommendations for equipment and facilities for collection, transfer and disposal; staffing to administer, operate and maintain the upgraded system; and regulatory, educational and enforcement procedures to accommodate the system. To the extent possible, the recommendations should build on existing systems which are working effectively and to which existing municipal employees and citizens have become accustomed.

Task 9:

Investment, operating and maintenance costs for all recommendations in the plan for upgrading refuse management will be provided. Local and foreign exchange costs for the capital requirements will be identified. Unit costs and salary grade assumptions should be given, so that negotiation efforts or project updates may modify the costs, as needed.

A phased program of investments will be recommended in light of financial resources of the urban administration and cost recovery opportunities. The phased program should consider initial investment in those project elements that particularly address the needs of the urban poor and the opportunities for positive environmental impacts.

Task 10:

The consultant will provide basic management recommendations regarding the institutional and financial arrangements for refuse collection and disposal. Special attention to any disincentives attributed to decentralization of activities of sweeping, hauling, maintenance, etc., should be given. Overall organizational status of various institutional entities involved in refuse management should be assessed with respect to ability to plan improvements to the system and ability to obtain financial resources to carry out such plans.

If there is an informal private sector involved in collection, disposal or resource recovery, the consultant will review the obstructions or incentives provided by the existing institutional and financial arrangements regarding the encouragement of that sector to provide good service.

Task 11:

The consultant will provide a field memorandum at the end of the work period for presentation to the local government officials responsible for refuse management. The field memorandum should highlight the basic data and provide a description of the existing system. Problems and issues in refuse management should be outlined, together with basic recommendations for improvement, and an estimated budget line item for the anticipated improvement program.

Task 12:

The consultant will provide a report, which fully addresses all of the above items of the Terms of Reference, to the level of detail commensurate with the work effort performed in the study area and the information generated and provided by others.

Environmental Management of Urban Solid Wastes in Developing Countries

A Project Guide

HAZARDOUS WASTES FROM NONSPECIFIC AND SPECIFIC SOURCES

HAZARDOUS WASTES FROM NONSPECIFIC AND SPECIFIC SOURCES

Hazardous Wastes from Nonspecific Sources (Generic Wastes)

Generic:	Hazard Code
The spent halogenated solvents used in degreasing, tetrachloroethylene, trichloroethylene, methylene chloride, 1,1,1-trichloroethane, carbon tetrachloride, and the chlorinated fluorocarbons; and sludges from the recovery of these solvents in degreasing operations.	(T)
The spent halogenated solvents, tetrachloroethylene, methylene chloride, trichloroethylene, 1,1,1-trichloroethane, chlorobenzene, 1,1,2-trichloro-1,2,2-trifluoroethane, o-dichlorobenzene, trichlorofluoromethane and the still bottoms from the recovery of these solvents.	(T)
The spent non-halogenated solvents, xylene, acetone, ethyl acetate, ethyl benzene, ethyl ether, n-butyl alcohol, cyclohexanone, and the still bottoms from the recovery of these solvents.	(I)
The spent non-halogenated solvents, cresols and cresylic acid, nitrobenzene, and the still bottoms from the recovery of these solvents.	(T)
The spent non-halogenated solvents, methanol, toluene, methyl ethyl ketone, methyl isobutyl ketone, carbon disulfide, isobutanol, pyridine and the still bottoms from the recovery of these solvents.	(I,T)
Wastewater treatment sludges from electroplating operations	(T)
Spent plating bath solutions from electroplating operations	(R,T)
Plating bath sludges from the bottom of plating baths from electroplating operations	(R,T)
Spent stripping and cleaning bath solutions from electroplating operations	(R,T)
Quenching bath sludge from oil baths from metal heat treating operations	(R,T)
Spent solutions from salt bath pot cleaning from metal heat treating operations	(R,T)
Quenching wastewater treatment sludges from metal heat treating operations	(T)
Flotation tailings from selective flotation from mineral metals recovery operations	(T)
Cyanidation wastewater treatment tailing pond sediment from mineral metals recovery operations	(T)
Spent cyanide bath solutions from mineral metals recovery operations	(R,T)
Dewatered air pollution control scrubber sludges from coke ovens and blast furnaces	(T)

Hazardous Waste from Specific Sources

Wood Preservation:	Hazard Code
Bottom sediment sludge from the treatment of wastewaters from wood preserving processes that use creosote and/or pentachlorophenol	(T)

Inorganic Pigments:	
Wastewater treatment sludge from the production of chrome yellow and orange pigments	(T)
Wastewater treatment sludge from the production of molybdate orange pigments	(T)
Wastewater treatment sludge from the production of zinc yellow pigments	(T)
Wastewater treatment sludge from the production of chrome green pigments	(T)
Wastewater treatment sludge from the production of chrome oxide green pigments (anhydrous and hydrated)	(T)
Wastewater treatment sludge from the production of iron blue pigments	(T)
Oven residue from the production of chrome oxide green pigments	(T)

Organic Chemicals	
Distillation bottoms from the production of acetaldehyde from ethylene	(T)
Distillation side cuts from the production of acetaldehyde from ethylene	(T)
Bottom stream from the wastewater stripper in the production of acrylonitrile	(R,T)
Still bottoms from the final purification of acrylonitrile in the production of acrylonitrile	(T)
Bottom stream from the acetonitrile column in the production of acrylonitrile	(R,T)
Bottoms from the acetronitrile purification column in the production of acrylonitrile	(T)
Still bottoms from the distillation of benzyl chloride	(T)
Heavy ends or distillation residues from the production of carbon tetrachloride	(T)
Heavy ends (still bottoms) from the purification column in the production of epichlorohydrin	(T)
Heavy ends from fractionation in ethyl chloride production	(T)
Heavy ends from the distillation of ethylene dichloride in ethylene dichloride production	(T)

	Hazard Code Code
Heavy ends from the distillation of vinyl chloride in vinyl chloride monomer production	(T)
Aqueous spent antimony catalyst waste from fluoromethanes production	(T)
Distillation bottom tars from the production of phenol/acetone from cumene	(T)
Distillation light ends from the production of phthallic anhydride from naphthalene	(T)
Distillation bottoms from the production of phthalic anhydride from naphthalene	(T)
Distillation bottoms from the production of nitrobenzene by the nitration of benzene	(T)
Stripping still tails from the production of methyl ethyl pyridines	(T)
Centrifuge residue from toluene diisocyanate production	(R,T)
Spent catalyst from the hydrochlorinator reactor in the production of 1,1,1-trichloroethane	(T)
Column bottoms or heavy ends from the combined production of trichloroethylene and perchloroethylene	(T)
Waste from the product stream stripper in the production of 1,1,1,-trichloroethane	(T)
<u>Pesticides</u>	
By-products salts generated in the production of MSMA and cacodylic acid	(T)
Wastewater treatment sludge from the production of chlordane	(T)
Wastewater and scrub water from the chlorination of cyclopentadiene in the production of chlordane	(T)
Filter solids from the filtration of hexachlorocyclopentadiene in the production of chlordane	(T)
Wastewater treatment sludges generated in the production of creosote	(T)
Still bottoms from toluene reclamation distillation in the production of disulfoton	(T)
Wastewater treatment sludges from the production of disulfoton	(T)
Wastewater from the washing and stripping of phorate production	(T)
Filter cake from the filtration of diethylphosphorodithoric acid in the production of phorate	(T)
Wastewater treatment sludge from the production of phorate	(T)
Wastewater treatment sludge from the production of toxaphene	(T)
Heavy ends or distillation residues from the distillation of tetrachlorobenzene in the production of 2,4,5-T	(T)
2,6-Dichlorophenol waste from the production of 2,4-D	(T)

Explosives

	Hazard Code
Wastewater treatment sludges from the manufacturing and processing of explosives	(R)
Spent carbon from the treatment of wastewater containing explosives	(R)
Wastewater treatment sludges from the manufacturing, formulation and loading of lead-based initiating compounds	(T)
Pink/red water from TNT operations	(R)

Petroleum Refining

	Hazard Code
Dissolved air flotation (DAF) float from the petroleum refining indistry	(T)
Slop oil emulsion solids from the petroleum refining industry	(T)
Heat exchanger bundle cleaning sludge from the petroleum refining industry	(T)
API separator sludge from the petroleum refining industry	(T)
Tank bottoms (leaded) from the petroleum refining industry	(T)

Leather Tanning Finishing

	Hazard Code
Chrome (blue) trimmings generated by the following subcategories of the leather tanning and finishing industry: hair pulp/chrome tan/retan/wet finish; hair save/chrome tan/retan/wet finish; retan/wet finish; no beamhouse; through-the-blue; and shearling.	(T)
Chrome (blue) shavings generated by the following subcategories of the leather tanning and finishing industry: hair pulp/chrome tan/retan/wet finish; hair save/chrome tan/retan/wet finish; retan/wet finish; no beamhouse; through-the-blue; and shearling.	(T)
Buffing dust generated by the following subcategories of the leather tanning and finishing industry: hair pulp/chrome tan/retan/wet finish; hair save/chrome tan/retan/wet finish; retan/wet finish; no beamhouse; and through-the-blue.	(T)
Sewer screenings generated the following subcategories of the leather tanning and finishing industry: hair pulp/chrome tan/retan/wet finish; hair save/chrome tan/retan/wet finish; retan/wet finish; no beamhouse; through-the-blue; and shearling.	(T)
Wastewater treatment sludges generated by the following subcategories of the leather tanning and finishing industry: hair pulp/chrome tan/retan/wet finish; hair save/chrome tan/retan/wet finish; retan/wet finish; no beamhouse; through-the-blue; and shearling.	(T)

	Hazard Code
Wastewater treatment sludges generated by the following subcategories of the leather tanning and finishing industry: hair pulp/chrome tan/retan/wet finish; hair save/ chrome tan/retan/wet finish; and through-the-blue.	(R,T)
Wastewater treatment sludges generated by the following subcategory of the leather tanning and finishing industry: hair save/non-chrome tan/retan/wet finish.	(R)
Iron and Steel	
Ammonia still lime sludge from cooking operations	(T)
Emission control dust/sludge from the electric furnace production of steel	(T)
Spent pickle liquor from steel finishing operations	(C,T)
Sludge from lime treatment of spent pickle liquor from steel finishing operations	(T)
Primary Copper	
Acid plant blowdown slurry/sludge resulting from the thickening of blowdown slurry from primary copper production	(T)
Primary Lead	
Surface impoundment solids contained in and dredged from surface impoundments at primary lead smelting facilities	(T)
Primary Zinc	
Sludge from treatment of process wastewater and/or acid plant blowdown from primary zinc production	(T)
Electrolytic anode slimes/sludges from primary zinc production	(T)
Cadmium plant leach residue (iron oxide) from primary zinc production	(T)
Secondary Lead	
Emission control/sludge from secondary lead smelting	(T)

Source: USA Federal Register, vol. 5, no. 98, May 19, 1980, pp. 33123-24.

Key : (R) reactive
(T) toxic
(I) ignitable
(C) Corrosive

Environmental Management of Urban Solid Wastes in Developing Countries

A Project Guide

DATA COLLECTION WORK BOOK

(For Project Identification, to be used World Bank Project Officers)

Data Collection Workbook:

Annex C provides data collection guidance for use by The World Bank staff in project identification.

Annex D provides data collection guidance for use by the local government in project preparation. It may also be used to augment the preparation efforts of the local government, during the period of project appraisal by The World Bank staff and its consultants.

To the extent possible, Annexes D and E should be used to encourage local participation in the planning and design of a solid waste management project. Once completed, they should remain on record as a snapshot in time of the basis for project conception. If, during project implementation, the project design is questioned, persons involved in implementation would be able to check the current validity of certain design decisions and adjust them accordingly.

Section 1: Project Identification:

If a project officer of the World Bank has either an urban development project or a water supply and drainage project, he or she should be aware of the potential for a solid waste management component. The need for the component may be apparent for one or more reasons:

- It may be necessary to improve collection of solid waste so that it does not clog drains expected to carry increased water flows attributed to the project.

- It may be necessary to provide collection as visible evidence of upgrading poverty neighborhoods and to encourage residents participating in a self-help manner in the upgradation.

- Removal and proper disposal of refuse is an adjunct to health benefits of an improved water supply study.

- Efficient urban management of solid wastes may be necessary to the municipality's ability to reallocate available financial resources to other services needed by the project, such as road maintenance and street lighting.

- There may be a revenue generating opportunity in the recovery of material or energy resources from solid waste which would cover a part of the cost of disposal, and perhaps create secondary sources of income.

- Addressing the local government's institutional and financial system through a solid waste component provides a vehicle for spin-off benefits to be realized in other local government services, especially if the local government's revenue generating, appropriation and accounting procedures are improved.

During project identification, three steps establish whether there is justification for developing a solid waste component. First, visual inspection of the urban area provides obvious evidence of solid waste management problems. Second, discussions with local government leaders highlight urban priorities, problems in the solid waste sector, and opportunities for resource recovery. Third, a written request for data supplied on the solid waste system provides the basic numbers useful for a first-cut analysis of the system.

During the visual inspection, the World Bank staff conducting the project identification effort should look for these signs of solid waste management problems:

- refuse accumulations in drains and floating debris in open canals;
- uncollected refuse along roadways and in open areas;
- refuse disposal by open dumping within the urban area;
- unconfined refuse at open markets and motor parks;
- maintenance workshops with little activity, that appear to serve primarily as parking lots for broken down vehicles;
- communal containers that have refuse scattered around them rather than placed within;
- refuse collection crews that are relatively idle;
- transfer stations that are heaped with waste because the haulage system is not keeping pace with the collection system; and
- general evidence of significant litter in some or all parts of the urban area.

During discussions with local leaders, such as mayors or permanent secretaries of local governments, priorities and needs of the urban area may be discerned. Views which may be brought out:

- certain parts of the city are dirty, the residents are not clean, and it is impossible to change their bad habits;
- there is a big market for compost--if we could build a plant to convert our garbage to compost, we would make a lot of money;
- there is no space for disposal by landfill, as the city grows we must go further and further with our collection trucks, and for that reason we need a resource recovery plant in the city;
- our canals are filled with garbage, the pumps won't work because they keep getting filled with garbage, and during the rainy season garbage is carried all over some areas of the city;
- these donkey carts that the garbage collectors use are too slow, they cause big traffic jams, we need new trucks;

- the (collection) workers are all corrupt, they spend all their time picking through the waste and taking detours to their buyers in order to sell the recyclables, instead of driving straight to the dump;

- the scavengers are a nuisance, they get in the way of the unloading operation at the dump, they spread refuse all around the communal containers and do not put it back, they live in these awful shacks at the dump, they are thieves and leave the dump at night to go around the neighborhood and rob people, they are unsightly and spread disease in their wake;

- we have trouble getting spare parts for our equipment, sometimes a machine or truck sits in the workshop for three months waiting a special part to be imported;

- our fleet is very old, all of the trucks are about 9 years old and are falling apart all the time;

- we do not have enough equipment, we have to run two shifts in order to service the city; and

- traffic is terrible, we can only run our collection system during the early morning and the mid-afternoon, in order to avoid heavy traffic...otherwise it takes more than one hour to drive to the disposal site.

This is just a sampling of the type of comment which one might hear. In general, such statements indicate inadequate management (in the form of enforcement of local ordinances and the supervision of workers), inadequate planning (in terms of equipment and facilities design and operation), and inadequate institutional/financial arrangements (in terms of proper planning for and obtainment of sufficient budget for procurement, operation and maintenance). They may also indicate the presence of a third party offer of low-cost loans or subsidies for intensive mechanized collection equipment or resource recovery facilities.

On the following pages is a questionnaire which should be filled in with help of the person(s) in charge of solid waste collection, transfer, disposal and maintenance. It is designed to provide overall indications of the level of collection service provided, productivity and cost-effectiveness of collection service, and adequacy of disposal systems.

In reviewing the results of the questionnaire, there are "rule-of-thumb" numbers provided within the text of the project guide. If a solid waste specialist is not engaged to participate in the identification mission, his or her review of the response to the questionnaire would be advisable before a decision is reached on the need for a project.

Project Identification Questionnaire:

How big is your refuse collection service area: ____________________

How many permanent residents live in this area: ____________________

How many transient residents live in this area: ____________________

Do you know how much waste is generated daily by these residents and their activities, for which the local government is responsible:

if yes, how much: ____

What percentage of the waste generated daily do you estimate is collected and subsequently removed from the source of generation: ___________ %

What type of equipment do you use for collection and haul of refuse:

____

____

How old is most of your fleet: _________________________ years.

How many shifts a day do you use your vehicles: _____________________

How many workers are engaged in the collection and transfer of refuse:

____

How much waste is collected and transferred daily: _________________

How many days a week is this amount handled: ________________________

How much money is spent each year by the local government on refuse management:

_______________________________ (note monetary units used)

What percentage of the municipal budget does this represent: ________ %

Approximately what percent of the city's average per capita income must be collected in taxes to cover this cost:

____________________ %

Do you dispose of wastes by open dumping, sanitary landfill or other methods:

____

Are there large accumulations of uncollected refuse in your city, if so, where:

____

On a typical work day, what percentage of the usable fleet is down

(in other words, awaiting maintenance or repairs): ________ %

How long is a vehicle typically out of service:

for minor repairs: ________________; for major repairs: ______________

What is the round trip travel time from most collection routes to their respective disposal site:

____

What is the typical round trip distance that this travel time represents:

____

Are there any particular types of waste which are problematic to collect or dispose of? If so, what types are these:

____

Please describe the major difficulties you are having to perform this work:

____

____

____

What opportunities for recycling and for resource recovery do you feel have technical and economic feasibility in your area:

____

Person filling out this form:

Name ________________________

Title ________________________

Address ______________________

____

____

For project area: ____

Date: ____

PHOTO REQUIREMENTS

Photos needed of the following:

- ___ each type of household container and storage
- ___ each type of communal bin
- ___ each type of market bin
- ___ representative market scene at central markets and local markets
- ___ condition of drainage systems
- ___ neighborhood conditions with respect to refuse collection
- ___ each type of vehicle for hauling containers
- ___ each type of refuse collection vehicle
- ___ each type of sweeper cart
- ___ each landfill
- ___ neighborhood housing types representative of each district
- ___ representative commercial areas
- ___ parking and maintenance facilities for refuse equipment
- ___ landfill equipment

It is useful to keep a photo log, writing down the number of the photo and the location of the photo being taken. Be sure to get correct spellings of names of places and people.

Environmental Management of Urban Solid Wastes in Developing Countries

A Project Guide

DATA COLLECTION WORK BOOK

(For Project Preparation, to be used by Solid Waste Management Specialists)

Section 2: Project Preparation:

Once the need for solid waste improvements has been identified, preparation of the project is performed. This activity is largely the responsibility of the local government and its consultants. This workbook is not designed for use by a novice to solid waste management planning.

Solid waste management specialists involved in project preparation are encouraged to augment this workbook with information which they believe is germane to their study area. If the format is not suited to the way in which their information is available and recorded, it should be changed or augmented.

Furthermore, there are data collection items presented here which may prove too difficult or time-consuming to fulfill, relative to the need for and usefulness of the specific items. This workbook provides a checklist of questions to ask. However, the final analysis would necessarily depend on data that are either readily available or can be developed within the allocated level of effort and time-frame of the planning effort.

There are two critical items of information to be developed during the preparation stage of project development. The first is the volume of waste to be handled by the collection and transfer system. The second is the baseline capacity, appropriateness, and reliability of existing equipment and facilities including information on manpower effectiveness and productivity within the collection and transfer system, basic maintenance systems, overall urban administrative, and financial practices in managing solid waste.

Project Preparation Questionnaire

Date: ____________

Urban area: ______________________________

Please note the names and titles of persons filling out this form, with regard to:

Sweeping and collection ______________________________

Transfer and haul ______________________________

Equipment maintenance ______________________________

Disposal ______________________________

Please enter the name and address of the person responsible for this questionnaire, and to whom questions could be addressed:

____

____

____

Provide a map of the refuse service area, indicating the following:

- Municipal boundaries
- Refuse service districts or zones
- Central workshop facilities for refuse equipment
- Central parking facilities for refuse equipment
- Central administrative offices and zonal office
- Transfer stations
- Land disposal sites (existing and prominently pending)
- Resource recovery, practices, and facilities

Provide a land use map, indicating the following:

- Residential areas
- Cantonments
- Commercial areas
- Markets and motor pools
- Institutions of large scale
- Industrial areas (existing and prominently pending)

Briefly, describe the solid waste management organization for your urban area. Provide a schematic of the organizational hierarchy, and indicate the number of full-time employees at each level. Also enhance the description by filling out Data Collection Guide #1. A sample schematic is provided on the following page; it is based on the Kanpur, India system existing in 1981.

____

____

____

____

____

____

Do you have information on waste generation rates for: combined municipal refuse (___yes, ___no), individual residential refuse (___yes, ___no), commercial establishments (___yes, ___no), institutions (___yes, ___no), markets (___yes, ___no), nightsoil and sewage sludges (___yes, ___no), street sweepings (___yes, ___no), industrial establishments (___yes, ___no).

If yes, how was this information developed: through sampling? through surveying? through measurements of wastes collected?

____

____

____

____

Provide information of waste generation rates on Data Collection Guide #2.

KANPUR REFUSE MANAGEMENT STAFF
(within the Kanpur Municipal Authority)

Collection	Within the Public Health Department	Within the Mechanical Engineering Department	Transportation & Disposal

Public Health Officer (1)

- Zonal Health Officer (3)
- Chief Sanitary Inspector (12)
  - Sanitary Inspector (42)
- Sanitary Supervisor (160)
  - Sweeper (5,000)

Chief Engineer (1)

Assistant Engineer (Workshop) (1)

- Foreman (6)
- Mechanic (17)
- Fitter (58)
- Cleaner (39)
- Carpenter (8)
- Blacksmith (4)
- Cleaner (5)
- Road Roller (18)
- Store Keeper:
  - auto (1)
  - petrol (1)

Sales Officer (1)

Assistant Engineer (Garbage) (1)

- Asst. Transport Officer (1)
- Rubbish Inspector (1)
- Driver (95)
- Sweeper at Dumping (82)
- Sweeper (480)

Assistant Engineer (Compost) (1)

- Junior Engineer
- Supervisor (1)
- Driver (12)
- Sweeper (42)

Note: Information provided by the Department of Mechanical Engineering. Parentheses indicate number of employees in each position.

How many residents are there within the boundaries of the local government's refuse collection service area: ___________. Are there additional transient residents: ___________.

Using a municipal waste generation rate derived from Data Collection Guide #2, or using a range of 500 to 800 grams/capita/day, estimate the quantity of municipal refuse being generated daily in your service area:

__________________________ to ____________________ kilograms/day

Using a waste density, as collected, derived from Data Collection Guide 3. or using a range of 200 to 500 kilograms/cubic meter, estimate the volume of municipal refuse requiring collection service in your service area:

__________________________ to ____________________ cubic meters/day

Based on the vehicle fleet capacity regularly engaged to haul refuse from the area of collection service to the disposal site, estimate the level of city-wide service provided:

__________________________ to ____________________ % collected

If there is a shortfall between the amount of refuse generated, and the amount of refuse regularly collected, where is this waste accumulating:

/_/ drains, /_/ poor neighborhoods, /_/ market areas, /_/ illegal dumps,

/_/ other ____________________________________.

Can you rank the reasons for any shortfall which may exist:

Worker productivity ____

Shortage of equipment ____

Inappropriate methods of collection ______________________________

Poor maintenance of equipment, frequent breakdowns ________________

Inadequate access to certain neighborhoods with equipment available ____

Lack of citizen cooperation with the collection system ____________

Other ____

____

Has there been any research performed to determine the density (__ yes, ___ no), moisture content (__ yes, __ no), particle size (__ yes, __ no) or compositional nature (__ yes, __ no) of various types of solid waste in your area?

If so, who performed this research, when was it done, and what methods were used? Please explain:

____

____

____

____

____

For the types of refuse which may have been described by the above research, provide information on the waste character on Data Collection Guide # 3.

Please describe your basic refuse collection system, with respect to:

Household or dwelling storage ________________________________

Discharge of wastes ____

Direct and indirect collection methods __________________________

____

____

____

Transfer points and hauling methods ____________________________

____

____

Provide a schematic of your basic system, as has been done on the following page showing the system in Kano, Nigeria.

Discharge of household refuse to wheel barrow
for transfer to collection point

Municipal
drain cleaner

Discharge of municipal refuse at
curbside collection point

Municipal sweepers cleaning
refuse along curbs and
within inaccessible areas

Payloader clearing open collection point and
loading open tipper truck

Manual loading of side loader tipping truck
often employed at masonry collection paints

Refuse Collection Systems——Kano, Nigeria

Are there special systems for collection of the following:

Bulky or garden wastes ______________

Market or motor pool wastes ______________

Institutional wastes ______________

Construction/demolition debris ______________

Commercial and light industrial wastes ______________

Industrial wastes ______________

Other ______________

____

Provide schematics accordingly as you have for your basic system.

On Data Collection Guide #4, provide information about your refuse collection and transfer (haul) equipment.

Based on the number and utilized capacity of vehicles employed in hauling refuse from the collection service area to the disposal area, and on the average number of trips per day, estimate the amount of refuse collected per day:

Vehicle type 1 ___ vehicles x ___ capacity x ___ % full x ___ trips = ___

Vehicle type 2 ___ vehicles x ___ capacity x ___ % full x ___ trips = ___

Vehicle type 3 ___ vehicles x ___ capacity x ___ % full x ___ trips = ___

Vehicle type 4 ___ vehicles x ___ capacity x ___ % full x ___ trips = ___

Vehicle type 5 ___ vehicles x ___ capacity x ___ % full x ___ trips = ___

Total daily haul of fleet = ______

Total daily haul of ___ x number of days of collection service per

week ______ ÷ number of days in a week ___ = average amount of

refuse collected daily ___ in cubic meters /_/ or yards /_/.

What are the problems and issues you perceive regarding productivity of the various types of equipment (i.e. access to the waste source, delays in traffic, long travel times off the collection route, breakdowns while on route, slow loading and unloading systems:

____

____

____

What are the problems and issues you perceive regarding productivity of workers (i.e. union conditions, time spent on picking or scavenging, laziness, procedures are slow, lost time in travel to the disposal site, lack of supervision):

____

____

____

Observe the time and motion of the principal methods of collection in the study area, and record data on Data Collection Guide #5.

If there seems to be a discrepancy in the productivity of workers or equipment among districts, perform the time and motion studies in those districts exhibiting large differences, and record the findings on Data Collection Guide #5.

Relative to productivity, are there existing organizational arrangements or financial arrangements that act as disincentives to improvement of the system? Are there social or cultural constraints to improvement of the system's productivity?

____

____

____

Are there special incentives to improve productivity? ____________________

____

____

____

Is maintenance of equipment a serious problem in your study area?

____

If equipment is managed at a central facility for all municipal equipment, list the priority sequency followed to service equipment (i.e. (i) fire; (ii) ambulance; (iii) refuse collection; (iv) public works). ______________

____

____

____

Is there good planning and procurement of supplies and basic spare parts, or are major delays incurred in order to await these items? ______________

____

What type of daily maintenance program is conducted? ____________________

____

Please provide additional data on maintenance on Data Collection Guide #6.

What type of disposal systems do you have? ______________________

____

Are these options available for your continued use for: 5 years ________,

10 years _____, 15 years ______, more? ____________________________

For land disposal sites, please fill out Data Collection Guide #7: one form for each site.

Do you feel that resource recovery is technically or economically feasible in your area? ____

What type of system would you consider appropriate (i.e. biogas, methane recovery from landfills, composting, incineration):

____

____

If you feel composting is feasible for your area, please address questions on its application to various crops, Data Collection Guide #8.

Is there scavenging:

From door to door /_/ At the communal bins /_/ At transfer depots /_/

At the disposal sites /_/

Is scavenging organized by middlemen, is it operated as a collective or community, or is each scavenger an independent entrepreneur?

____

____

Is scavenging a life-long work, an entry employment for migrants, or the traditional territory of certain religious or cultural groups?

____

____

Approximately how many people are engaged in scavenging:

In direct picking and sorting ____________________

As middlemen organizers or buyers ____________________

As users of recycled materials ____________________

Are municipal workers involved in the scavenging activities? __________
If so, do they cooperate in some way with the private scavengers?

____

____

Does the local government rely on scavenging to provide a part of their refuse collection or disposal service?

____

____

Is this a cooperative effort in refuse management, or do the private and public systems clash at certain intervals, explain:

____

____

Please provide information to the extent possible (and as needed) on Data Collection Guide #9, concerning the economic viability of scavenging.

By using Data Collection Guide 10, determine the costs of refuse management for vehicle depreciation, labor, operation and maintenance. Based on this cost information, estimate the cost per metric ton and per capita.

For each type of equipment (including manual carts, trucks, and loaders) multiply the number of equipment units by the investment cost and divide by the estimated life, then multiply by the portion of time that the equipment unit is allocated to refuse management...to get the average annual cost of all units of each equipment type. Then total these costs to get the total vehicle depreciation amount.

For each labor category (including overhead categories) multiply the number of persons in each category by the average annual salary (including an average amount of overhead wage), then add a percentage of this amount to account for fringe benefits...to get the average annual cost of all persons in each labor category. Then total these costs to get the total cost for salaries.

From the basic budget, obtain operating and maintenance costs for supplies, utilities, etc. These are generally not broken down by equipment and labor units for which operation and maintenance costs are incurred.

Add up the entire cost of vehicle depreciation, salaries and fringe benefits, operation and maintenance.

Divide this number by the estimated amount of refuse collected and transported to disposal sites, to get a cost per metric ton.

Divide this same number by the population served, to get a cost per capita.

If there is refuse management service by the private as well as the public sector, or in lieu of the public sector, indicate the set of Data Collection Guide #10 being completed for the private sector.

What percent of the local government budget does the above estimate of refuse management costs comprise? ________________ %

What is the average annual income per capita in the project area? ____________________ What percent of income is required for refuse management? _________________________

Depending on the time and information available, it may be possible to generate information on the cost per metric ton and cost per worker of various collection equipment units existing in the project area. This exercise is also possible for various equipment types being considered for the future.

To this end, Data Collection Guide 11 is provided. Based on the annualized investment cost, operation and maintenance, and wage cost; the typical amount of waste hauled coupled with the number of trips per day; and the number of collection service days per year...a cost per unit volume is determinable. Using an as-transported density based on weighing the equipment full and empty, a cost per metric ton can be estimated.

Data Collection Guides #12 through #19 are provided to assess the unique needs of specific collection service districts or neighborhoods.

Completing these data guides may indicate inequities of service among districts attributable to allocation of equipment and labor, road and access conditions, poverty groups, presence of substantial market activity or commercial activity, etc.

Unique baseline conditions in specific areas may require equally unique methods of refuse management.

In the event that data are not available on the quantity nor character of wastes generated in various categories of activies (household, commercial, institutional, market, etc.), Data Collection Guide #20 is provided as an example of how information may be recorded from a survey and sampling effort of homes.

In Frank Flintoff's manual, entitled Management of Solid Wastes in Developing Countries (WHO Regional Publications, South-East Asia Series No. 1, published in 1976), Chapter 2 is devoted to explaining how a sampling program should be performed. This standard procedure is recommendable for purposes of project preparation discussed here.

RECORD OF DATA COLLECTION ASSISTANCE, PEOPLE AND SOURCES

Guides:

Parking and maintenance facilities ____________________

Markets ____________________

Residential Collection ____________________

Land disposal facilities ____________________

Other disposal facilities ____________________

Other ____________________

____

Name of driver(s) ____________________

Sources of Information:

Data Collection Guide #1 ____________________

Data Collection Guide #2 ____________________

Data Collection Guide #3 ____________________

Data Collection Guide #4 ____________________

Data Collection Guide #5 ____________________

Data Collection Guide #6 ____________________

Data Collection Guide #7 ____________________

Data Collection Guide #8 ____________________

Data Collection Guide #9 ____________________

Data Collection Guide #10 ____________________

Data Collection Guide #11 ____________________

Data Collection Guide #12 ____________________

Data Collection Guide #13 ____________________

Data Collection Guide #14 ____________________

Data Collection Guide #15 ____________________

Data Collection Guide #16 ______________________________

Data Collection Guide #17 ______________________________

Data Collection Guide #18 ______________________________

Data Collection Guide #19 ______________________________

Data Collection Guide #20 ______________________________

Other sources of information:

People:

Published and Unpublished Reports:

PHOTO REQUIREMENTS

Photos needed of the following:

- ___ each type of household container and storage
- ___ each type of communal bin
- ___ each type of market bin
- ___ representative market scene at central markets and local markets
- ___ condition of drainage systems
- ___ neighborhood conditions with respect to refuse collection
- ___ each type of vehicle for hauling containers
- ___ each type of refuse collection vehicle
- ___ each type of sweeper cart
- ___ each landfill
- ___ neighborhood housing types representative of each District
- ___ representative commercial areas
- ___ parking and maintenance facilities for refuse equipment
- ___ landfill equipment

It is necessary to keep a photo log, writing down the number of the photo and the location of the photo being taken. Be sure to get correct spellings of names of places and people.

PHOTO LOG -- ROLL No. ______________

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________
8. ______________________________
9. ______________________________
10. ______________________________
11. ______________________________
12. ______________________________
13. ______________________________
14. ______________________________
15. ______________________________
16. ______________________________
17. ______________________________
18. ______________________________
19. ______________________________
20. ______________________________
21. ______________________________
22. ______________________________
23. ______________________________
24. ______________________________
25. ______________________________

PHOTO LOG -- ROLL NO. ______________

26. ____________________

27. ____________________

28. ____________________

29. ____________________

30. ____________________

31. ____________________

32. ____________________

33. ____________________

34. ____________________

35. ____________________

36. ____________________

37. ____________________

38. ____________________

39. ____________________

40. ____________________

DATA COLLECTION GUIDE #1

Organization of Solid Waste Management Responsibilities

Which organization develops:

National environmental policy ______________________

National solid waste management policy ______________________

Municipal solid waste collection ordinances ______________________

Municipal solid waste disposal ordinances ______________________

Municipal solid waste plans ______________________

Which organization provides:

Enforcement of national policy ______________________

Enforcement of municipal ordinances ______________________

Direction of plan implementation ______________________

Which organization performs or manages:

Street sweeping ______________________

Minor drain cleaning ______________________

Major drain cleaning ______________________

Direct collection of municipal refuse ______________________

Indirect collection of municipal refuse ______________________

Transfer and haul of municipal refuse ______________________

Disposal of solid wastes ______________________

Resource recovery ______________________

Marketing of recovered byproducts ______________________

For new civil works, i.e. garages and transfer depots, who would perform:

Procurement of equipment ______________________

Acquisition of land ______________________

Construction of facilities ______________________

Management of contractors ______________________

DATA COLLECTION GUIDE #1 (continued)

What are the methods of communication and coordination among agencies performing various steps in refuse management or formulating policy and regulations:

What are the methods of communication and coordination within agencies performing various steps in refuse management:

How are priorities established:

For maintenance of refuse vehicles

For allocation of equipment to districts

For allocation of municipal budget

For other activities

DATA COLLECTION GUIDE #2

Waste Generation Rates

What is the residential per capita waste generation rate for:

Low-income neigborhoods ____________________

Medium-income neighborhoods ________________

High-income neighborhoods __________________

Mixed residential neighborhoods ____________

What is the commercial waste generation rate for:

Food service establishments ______________________

Grocery stores ______________________________

Apparel stores ______________________________

Office service establishments ____________________

General retail stores ___________________________

Other ____________________________________

(Indicate above whether the commercial rate is: per employee, per unit of floor space, per unit of sale, or has been allocated to a per capita basis.)

What is the institutional waste generation rate for:

Hospitals ____________________________________

Schools _____________________________________

Barracks _____________________________________

Government offices ______________________________

Other _______________________________________

(Indicate above whether the institutional rate is: per bed, per unit of floor space, per employee, or per capita.)

DATA COLLECTION GUIDE 2 (continued)

What is the market and motor park waste generation rate for:

Markets ______________________________

Motor pools ______________________________

(Indicate whether the rate is by stall, motor transport unit, surface area of the trade and parking space; is the combined rate for all the city's markets; or has been allocated to a per capita basis.)

If construction and demolition debris is separately collected, how much of it is there on a daily basis?

____

____

Is there any estimate on the amount of street dust and dirt, and drain cleaning, requiring collection on a daily basis?

____

Are yard wastes or bulky wastes collected separately? ______________

What is the estimated quantity of these wastes? ______________

List the main industries in your area. Indicate the number of employees, floor space areas, or production values within each category; and provide waste generation data, if available:

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________
8. ______________________________
9. ______________________________

DATA COLLECTION GUIDE #2 (continued)

If only a combined municipal waste generation rate has been estimated, please provide it, and indicate which categories of refuse are included in it:

City-wide rate ____________________ grams/capita/day

Mixed residential rate ______________ grams/capita/day

Other ______________________________ grams/capita/day

Includes: /_7 residential /_7 commercial /_7 institutional /_7 market

/_7 street sweepings /_7 construction/demolition debris /_7 yard wastes

/_7 light industrial /_7 heavy industrial /_7 other

For categories of refuse which might be handled by the municipality, indicate which are directly collected, indirectly collected, and permitted to be disposed within the municipal dump:

	Directly Collected	Indirectly Collected	Municipal dump
Residential	_____	_____	_____
Commercial	_____	_____	_____
Institutional	_____	_____	_____
Market, motor pool	_____	_____	_____
Street sweepings, drain cleanings	_____	_____	_____
Construction, demolition debris	_____	_____	_____
Light industrial	_____	_____	_____
Heavy industrial	_____	_____	_____
Other	_____	_____	_____

DATA COLLECTION GUIDE # 3

Waste Character

% by weight
(___wet weight basis, or ___ dry basis)

Waste Category	1	2	3	4	5	6	7
Constituent:							
Vegetable/putrescible							
above 50 mm							
10 mm-50 mm							
below 10 mm							
Total							
Paper							
Metals							
ferrous							
aluminum							
Total							
Glass							
colored							
clear							
Total							
Textiles							
Plastics							
Polyethylene							
Other							
Rubber							
Tires							
Other							
Bones, wood, straw, shells							
Miscellaneous							
combustible							
non-combustible							
Inerts below 10 mm							
Moisture content							

DATA COLLECTION GUIDE # 3 (continued)

For the waste categories whose waste character was defined on the preceding page--where was the source of the sample and when was it taken:

Waste Category	1	2	3	4	5	6	7
Source of Sample							
Household bin	/_/	/_/	/_/	/_/	/_/	/_/	/_/
Closed portable bin	/_/	/_/	/_/	/_/	/_/	/_/	/_/
Open masonary communal bin	/_/	/_/	/_/	/_/	/_/	/_/	/_/
Open collection point	/_/	/_/	/_/	/_/	/_/	/_/	/_/
Manual cart	/_/	/_/	/_/	/_/	/_/	/_/	/_/
Vehicle	/_/	/_/	/_/	/_/	/_/	/_/	/_/
Season							
Nov-Feb	/_/	/_/	/_/	/_/	/_/	/_/	/_/
Mar-May	/_/	/_/	/_/	/_/	/_/	/_/	/_/
June-Aug	/_/	/_/	/_/	/_/	/_/	/_/	/_/
Sept-Oct	/_/	/_/	/_/	/_/	/_/	/_/	/_/
Year	____	____	____	____	____	____	____

DATA COLLECTION # 4

Existing Waste Collection and Haul Capacity

Type of Equipment	Number	Capacity	Number Trips/Day	Number Days/Week
Manual (i.e. wheelbarrows, donkey carts, dollies with baskets):				
1.				
2.				
3.				
Direct collection and haul vehicles (from dwelling to disposal site):				
1.				
2.				
3.				
4.				
Transfer vehicles (from collection rendevous with sweepers or transfer depot to disposal site):				
1.				
2.				
3.				
4.				
Portable communal containers and hauling equipment (i.e. tractor w/trailer):				
1.				
2.				
3.				
Other:				
1.				
2.				
3.				

Note: Capacity expressed in cubic meters_____; or cubic yards _____?

DATA COLLECTION GUIDE #5 Equipment Type: ___________

Times for Calculation of Payload Capacity and Study of Productivity
(to be done for each type of equipment used in collection)

Start-up time, for sign-in, refueling, getting out of parking area: __________

Loading time per stop: ________________

Number of stops on first route: ________________

Number of stops on second route: _______________ other routes: _______________

Travel time on first route: _____________________

Travel time on second route: ________________ other routes: _______________

Time for morning break: ______________________

Time for lunch break: ________________________

Time for afternoon break: ______________________

Haul distance from first route to dump site: __________ haul time: ____________

Haul distance from second route to dump site: _________ haul time: ____________

Travel times to scavengers, buyers, other diversions: _________________________

Time spent at scavengers, buyers, other diversions: ___________________________

Dumping time: _________________________

Traffic delays at dump site: ________________________

Travel distance from parking to first route: __________ travel time: __________

Travel distance from dump site to parking: _________ travel time: _____________

Hours of regular working time: ______ to ____________

Hours of overtime each day: _________ to ____________

Hours of overtime on weekends: _______ to ______________

Amount of waste collected on first route: ________________

Amount of waste collected on second route: _______________

on other routes: _______________

Note: duplicate for each type of equipment.

DATA COLLECTION GUIDE 5 (continued)

District ____ Vehicle # _____ Crew Size _______ Street __________

Direction of Travel ___________ Time of Day ____________

Type of Service _____________ (i.e. curbside, door-to-door)

Stop-to-Stop Times			Loading Times		
1.	9.	17	1.	9.	17.
2.	10.	18	2.	10.	18.
3.	11.	19.	3.	11.	19.
4.	12.	20.	4.	12.	20.
5.	13.	21.	5.	13.	21.
6.	14.	22.	6.	14.	22.
7.	15.	23.	7.	15.	23.
8.	16.	24.	8.	16.	24.

Total travel time on route: ________________________

Total volume collected on route: ______________________

% Dustbins (regulation) % Dustbins (nonregulation) % Crates, etc.

__________________ % ___________________ % __________________ %

Uncontained % ___________________________

Loading Volumes (as observed at each stop where timing was performed above):

1.	9.	17.
2.	10.	18.
3.	11.	19.
4.	12.	20.
5.	13.	21.
6.	14.	22
7.	15.	23.
8.	16.	24.

Note: duplicate for each type of equipment.

DATA COLLECTION GUIDE # 5 (continued)

District: ______________________________

Equipment type(s): ______________________________

____

Are there any incentives (i.e. bonuses, early release from work, recognition awards) for workers to provide more effective and/or productive collection efforts:

____

____

____

Is each crew assigned to a specific service area, where citizens know who is responsible for their collection service, and where a rapport may develop between the crew and the residents:

____

____

What type of "upward mobility" opportunities are available to collection workers? For example, can they be advanced to become drivers, foremen, supervisors?

____

____

If so, is there any training or are there any tests that are regularly scheduled to enable and encourage upward mobility?

____

____

How do unions affect worker effectiveness and productivity?

____

____

DATA COLLECTION GUIDE # 6

Maintenance Information

Area size of main garage(s): ________________ ea. how many: ________________

Area size of local garages(s): ________________ ea. how many: ________________

Location and time required for major overhaul: ________________ per vehicle

Location and time required for bodywork: ________________________________

Location and time required for repairs: ________________________________

Location and time required for daily service: ____________________________

% of usable truck fleet usually down: ________________

% of usable tractor fleet usually down: ______________

% of usable landfill equipment usually down: __________

mechanics per usable equipment items: ______________ # assistant mechanics per usable equipment items ________________ (i.e., 1 mechanic per 10 trucks)

Availability of spare parts: ____

Discuss availability and condition of maintenance equipment:

Lifts or pits for access to underneath parts of vehicles ________

____

Engine lifts and stands ____

Tool sets ____

Air compressor for tools ______________________________________

Parts cleaning and solvents recovery __________________________

Heavy duty jacks ____

Steam cleaner ____

Tire machine ____

Machine making equipment _____________________________________

Body work equipment ____

Other equipment ____

DATA COLLECTION GUIDE # 6 (continued)

Vehicle Type	Date of Purchase	Mileage	% Down Time	Major Repair Issues
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				

DATA COLLECTION GUIDE # 6 (continued)

Is refuse equipment assigned to one operator or driver, or is it generally available to various users as part of an equipment pool? ____________________

____

If there are two or more shifts of equipment use per day, how is the assignment of equipment arranged?

____

____

Does each driver or operator have a checklist of daily maintenance activities to perform? ____________________

If so, does a supervisor ensure this activity is performed? ____________________

____

Do drivers and operators receive any training on equipment operation and maintenance? ____________________

If so, are there refresher training programs? ____________________

____

Are there any incentives for good operation and maintenance of equipment, or for good safety records? ____________________

____

What is the system for drivers and operators to report and/or record maintenance needs: ____________________

____

DATA COLLECTION GUIDE # 7

Disposal Area: ____________________

Location: ____________________

How long has this site been used? ____________________

Surface Area Available: ____________________

Topographical Character: ____________________

Presence of Surface Waters: ____________________

Soil Type(s): ____________________

Surrounding Land Use: ____________________

Initial Land Cost/Value: __________ Land Cost Value Upon Completion __________

Distance to Nearest Dwelling with Well: ____________________

Distance to Nearest Dwelling without Well: ____________________

Presence of Scavengers: ____________________

Condition of Access Road: ____________________

Length of Access Road from Main Road: ____________________

Width of Access Road: ____________________

Equipment Available on Site: ____________________

Facilities Available on Site (i.e. water, sanitation, fire-fighting): __________

____

Method of Landfill: ____________________

Existence of an Operational Plan: ____________________

Availability and Cost of Daily Cover: ____________________

Hours of Daily Operation: __________ Days of Operation: __________

Estimated Cost of Disposal: __________ Depth to Groundwater: __________

Environmental Issues: ____________________

____

Note: Duplicate form for use regarding each major disposal site.

DATA COLLECTION GUIDE # 8

Existence of composting experience in the area ______________________

____

Crops which may use compost ______________________________

____

Availability of competitive products:

Cow manure ______________________ cost ______________

Chicken manure ____________________ cost ______________

Chemical fertilizer _________________ cost ______________

subsidized? ________________________________

Application rates of current organic amendments with fertilizing capability:

Crop 1 ____________________

Crop 2 ____________________

Crop 3 ____________________

Crop 4 ____________________

Crop 5 ____________________

Crop 6 ____________________

Acreage of crops which may use compost:

Crop 1 ____________________ Distance from Service Area ________

Crop 2 ____________________ ________

Crop 3 ____________________ ________

Crop 4 ____________________ ________

Crop 5 ____________________ ________

Crop 6 ____________________ ________

Availability of sites for compost facilities ______________________

____

Main access routes to compost facilities ________________________

____

DATA COLLECTION GUIDE # 9

	Buyer 1	Buyer 2	Buyer 3	Buyer 4
Describe facilities for transport, handling & storage of scavenged items				
Number of employees engaged in scavenging				
Average income per employee				

	Buyer 1			Buyer 2			Buyer 3			Buyer 4		
	Quantity/kg/day	Price paid/kg	Resale price/kg	Quantity kg/day	Price paid/kg	Resale price/kg	Quantity/kg/day	Price paid/kg	Resale price/kg	Quantity kg/day	Price paid/kg	Resale price/kg
Paper--total 1. Corrugated 2. Kraft 3. Cardboard 4. Newspring 5. Other												
Ferrous metal												
Aluminum												
Copper												
Other metal												
Plastics												
Bottles--total 1. Clean 2. Dirty												

DATA COLLECTION GUIDE # 10

ANNEX D
Page 38

Equipment depreciation costs

Equipment type	Investment Cost	Life Expectancy/ Average Age	% life used for refuse
1.		/	
2.		/	
3.		/	
4.		/	
5.		/	
6.		/	
7.		/	
8.		/	
9.		/	
10.		/	
11.		/	
12.		/	

DATA COLLECTION GUIDE # 10 (continued)

Type of Labor	Required Weekly Hours	Average Weekly Overtime	Regular Salary	Overtime Salary
Supervisors				
Foremen				
Inspectors				
Mechanics				
Mechanic Aids				
Drivers				
Vehicle Crew				
Sweepers				
Drain Cleaners				
Landfill Equipment				
Landfill Labor				
Administration				

Other ______________________________

For Municipal Employees: No. of sick days_____ No. holidays _____ No. of vacation days _____

Fringe Benefits: Retirement fund _______ health insurance _______ life insurance _______ unemployment compensation _______ disability _______ uniforms _______ bonuses _______ longevity benefits _______ safety equipment _______

Approximate % of salary added to costs for fringe benefits _______

Turnover ______________________________

DATA COLLECTION GUIDE # 10 (continued)

Salaries of Personnel:

Number of Employees	Position	Average Annual Salary	Total
________	Directors	________	________
________	District Supervisors	________	________
________	Foremen	________	________
________	Inspectors	________	________
________	Mechanics	________	________
________	Mechanics Aids	________	________
________	Drivers	________	________
________	Loaders/Collectors	________	________
________	Sweepers	________	________
________	Drain Cleaners	________	________
________	Landfill Equip.	________	________
________	Landfill Labor	________	________
________	Administrative	________	________
________	Other	________	________
________	Other	________	________
________	Other	________	________
		TOTAL	________

(TOTAL x expenditure for fringe benefits as a % of

TOTAL) x (TOTAL) = ________________

Overhead salaries for local government leader, comptroller, attorney, personnel advisors, etc. plus fringe benefits ________________

____

DATA COLLECTION GUIDE # 10 (continued)

Operation and Maintenance Expenses

Equipment operations and maintenance (fill in annual cost attributable to refuse management):

Tires ______________________

Fuel ______________________

Oil ______________________

Lubrication ______________________

Spare parts ______________________

Other supplies ______________________

Utilities, etc., ______________________

Total ______________________

Administrative expenses (fill in annual cost attributable to refuse management):

Telephone ______________________

Office supplies ______________________

Rent, utilities ______________________

Radio communication ______________________

Mail, billing ______________________

Public education materials ______________________

Other ______________________

Total ______________________

Insurance and taxes:

Vehicles ______________________

Personnel ______________________

Property ______________________

Damage, liability ______________________

Total ______________________

Interest:

Equipment ______________________

Facilities ______________________

Total ______________________

DATA COLLECTION GUIDE # 11

Equipment Type	Capacity (cubic ?)	Investment Cost (monetary units ?)	Annualized Investment Cost	O&M Cost per year	# trips/day: % full to capacity
1.					:
2.					:
3.					:
4.					:
5.					:
6.					:
7.					:
8.					:
9.					:
10.					:
11.					:
12.					:
13.					:

DATA COLLECTION GUIDE # 11 (continued)

Equipment Type	Crew Size (includes driver)	Description of Crew	Average Cost of Crew per year	Cost per Metric Ton
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				

DATA COLLECTION GUIDE # 12

District	Population	Area	Density	No. of Floors in Residential Dwellings
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				
16.				
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				
Total				

DATA COLLECTION GUIDE # 13

District	Residential:Commercial:Institutional:Industrial Land Use Mix (ratio by area)
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	
9.	
10.	
11.	
12.	
13.	
14.	
15.	
16.	
17.	
18.	
19.	
20.	
21.	
22.	
23.	
24.	
Total	

DATA COLLECTION GUIDE # 14

District	Average Income per capita	Population Below Urban Poverty	Comment on Income Status of Residents
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
13.			
14.			
15.			
16.			
17.			
18.			
19.			
20.			
21.			
22.			
23.			
24.			
Total			

DATA COLLECTION GUIDE # 15

District	Km of Paved Road	Km of Truck Route	Type of Service on Paved Road (i.e. door-to-door curbside)
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
13.			
14.			
15.			
16.			
17.			
18.			
19.			
20.			
21.			
22.			
23.			
24.			
Total			

DATA COLLECTION GUIDE # 15 (continued)

Describe condition of paved roads:

Width of one-way roads ______________________________

Width of two-way roads ______________________________

% of road encroached upon by stalls and refuse ____________

__________ and parking ______________________________

Average speed of vehicles ______________________________

% of slow-moving traffic versus motorized traffic __________

Days of heavy traffic ______________________________

Times of heavy traffic ______________________________

Upkeep of road surface ______________________________

Lights at night on any roads ______________________________

Extent of hilly terrain, degree slope ____________________

Discuss issues of refuse collection which are obstacles or constraints to effective, efficient collection:

____

____

____

____

____

____

____

____

DATA COLLECTION GUIDE # 16

Communal Bins

District	No. of Bins Type 1 ____ m^3	No. of Bins Type 2 ____ m^3	No. of Bins Type 3 ____ m^3	Frequency of Service 1	2	3
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						
11.						
12.						
13.						
14.						
15.						
16.						
17.						
18.						
19.						
20.						
21.						
22.						
23.						
24.						
Total						

DATA COLLECTION GUIDE # 16 (continued)

Communal Bins:

Describe Type 1 Bin:

Construction material, size, number of sides ______________________

____

Method of loading ______________________

Loading by who? age? ______________________

Method of unloading ______________________

Time for unloading ______________________

Scavenging activity ______________________

____

Describe Type 2 Bin:

Construction material, size, number of sides ______________________

____

Method of loading ______________________

Loading by who? age? ______________________

Method of unloading ______________________

Time for unloading ______________________

Scavenging activity ______________________

____

Describe Type 3 Bin:

Construction material, size, number of sides ______________________

____

Method of loading ______________________

Loading by who? age? ______________________

Method of unloading ______________________

Time for unloading ______________________

Scavenging activity ______________________

____

DATA COLLECTION GUIDE # 17

District	No. of Markets per capita	No. of Stalls	Stalls Ratio Produce:Food Service: Apparel: Appliance: Other	Frequency of Service
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				
16.				
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				
Total				

DATA COLLECTION GUIDE # 17 (continued)

Describe the condition of the central markets:

What are the market days? ______________________

When are goods delivered? ______________________

What are the water supply, drainage and sanitation facilities? __________

____

Are there bins at each stall? with lids? ______________________

Are there communal bins? with lids? portable? ______________________

Method of loading and unloading communal bins? ______________________

____

Discuss access and traffic conditions for collection service __________

____

Describe overall cleanliness of sites ______________________

Describe the condition of the local markets:

What are the market days? ______________________

When are goods delivered? ______________________

What are the water supply, drainage and sanitation facilities? __________

____

Are there bins at each stall? with lids? ______________________

Are there communal bins? with lids? portable? ______________________

Method of loading and unloading communal bins? ______________________

____

Discuss access and traffic conditions for collection service __________

____

Describe overall cleanliness of sites ______________________

DATA COLLECTION GUIDE # 17 (continued)

Market Name	District/Location	Bin Size m^3	Quantity Waste/Day m^3
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
13.			
14.			
15.			
16.			
17.			
18.			
19.			
20.			
21.			
22.			
23.			
24.			
Total			

DATA COLLECTION GUIDE # 18

District	Km Length of Commercial Establishments	No. of Establishments	Type of Service (Door-to-Door or Curbside)
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
13.			
14.			
15.			
16.			
17.			
18.			
19.			
20.			
21.			
22.			
23.			
24.			
Total			

DATA COLLECTION GUIDE #18 (continued)

District	Mix of Commercial Activity (ratio of food service: grocery: apparel: appliance: office services: other)	Gross Sales or Floor Area
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		
16.		
17.		
18.		
19.		
20.		
21.		
22.		
23.		
24.		
Total		

DATA COLLECTION GUIDE # 18(continued)

District	Type of Bins for Commercial Establishments	Type of Communal Bins and size m^3	Quantity Waste/Day m^3	Frequency of Service
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				
16.				
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				
Total				

DATA COLLECTION GUIDE # 19 Type ____________

District	Travel Time to Parking	Travel Time to Maintenance	Travel Time to Disposal Area #1	Travel Time to Disposal Area #2
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				
16.				
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				
Average				

DATA COLLECTION GUIDE #19 (continued)

District	Vehicle Type _____ Owned / In Use	Vehicle Type _____ Owned / In Use	Vehicle Type _____ Owned / In Use
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
13.			
14.			
15.			
16.			
17.			
18.			
19.			
20.			
21.			
22.			
23.			
24.			
Total			

DATA COLLECTION GUIDE #19 (continued)

District	No. Supervisors	No. Foremen	No. Inspectors	No. Mechanics & Aids
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				
16.				
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				
Total				

DATA COLLECTION GUIDE #19 (continued)

District	No. Drivers	No. Truck Crew	No. Sweepers	No. Drain Cleaners
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				
16.				
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				
Total				

DATA COLLECTION GUIDE # 20

Describe each Household: location, condition of dwelling, neighborhood type, income level of family(ies), monthly cost of rent or mortgage, floor space:

Household 1. ____________________

____

____

Household 2. ____________________

____

____

Household 3. ____________________

____

____

Household 4. ____________________

____

____

Household 5. ____________________

____

____

Household 6. ____________________

____

____

Household 7. ____________________

____

____

Household 8. ____________________

____

____

Household 9. ____________________

____

DATA COLLECTION GUIDE # 20 (continued)

Household 10. ____________________

____

____

Household 11. ____________________

____

____

Household 12. ____________________

____

____

Household 13. ____________________

____

____

Household 14. ____________________

____

____

Note: The basic description requested above will probably require the judgment of the surveyer. Other information for the following forms will probably be more readily provided by the residents living in the household.

DATA COLLECTION GUIDE # 20 (continued)

	Number of People	Head of House/ Occupation	# of Animals	Kitchen	# of Bedrooms	# of Baths
Household 1.						
Household 2.						
Household 3.						
Household 4.						
Household 5.						
Household 6.						
Household 7.						
Household 8.						
Household 9.						
Household 10.						
Household 11.						
Household 12.						
Household 13.						
Household 14.						

Remarks: ____

DATA COLLECTION GUIDE # 20 (continued)

	No. of Toilets	Electricity	Water Connection	Sewer Connection	Owned or Rented	Cooking Method	Yard or Garden
1.							
2.							
3.							
4.							
5.							
6.							
7.							
8.							
9.							
10.							
11.							
12.							
13.							
14.							

Remarks:____

DATA COLLECTION GUIDE # 20 (continued

Weight of household samples in ____________

Day	1	2	3	4	5	6	7	8	9
Household 1.									
Household 2.									
Household 3.									
Household 4.									
Household 5.									
Household 6.									
Household 7.									
Household 8.									
Household 9.									
Household 10.									
Household 11.									
Household 12.									
Household 13.									
Household 14.									

Remarks: ____

DATA COLLECTION GUIDE # 20 (continued)

	Diet	Religion	Cultural Information	Recycling Activities
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				

Remarks: ____

____

____

DATA COLLECTION GUIDE # 20 (continued)

Constituent	Weight in Kg Sample Number	Sample Number	Sample Number	% by Weight Maximum %	Minimum %	Average %
Vegetable/Putrescible						
above 50 mm						
10 mm-50 mm						
below 10 mm						
Total						
Paper						
Metals						
ferrous						
aluminum						
other						
Glass						
colored						
other						
Textiles						
Plastics & Rubber						
Bones						
Miscellaneous						
combustible						
non-combustible						
Inert matter below 10 mm						
Total						
Moisture Content (%)						
Source of Sample						

Environmental Management of Urban Solid Wastes in Developing Countries

A Project Guide

WORKSHEETS FOR FINANCIAL ANALYSIS OF A SOLID WASTE PROJECT

(For Project Appraisal, to be used by a Municipal Financial Analyst in concert with a Solid Waste Management Specialist)

Financial Analysis

The 89 steps in this series of tables take the solid waste management specialist and the municipal financial analyst through a process of itemizing equipment and facility requirements, their capital costs, operating costs, and the projection of revenues required to support these expenditures.

Completing these tables involves estimating projected replacement plus expansion requirements for selected planning target years. The effort should be accomplished at the appraisal stage, to determine whether the municipality can afford to sustain the standard of service and level of technology proposed. Input from country economists is required to determine realistic interest and inflation rates.

MUNICIPAL REFUSE MANAGEMENT

Table 1: PHYSICAL INDICATORS

	Measure	Actual		Estimated				
		FY79-80	FY80-81	FY81-82	FY82-83	FY83-84	FY84-85	FY85-86
General								
1. Population to be served [a]	Units							
2. Per capita production of solid waste per day [b]	Weight/ person/ day							
Measure of Collection								
3. Number of days per week of refuse management service	Work days/ week							
4. Total solid waste to be collected per work day [c] (1)x(2)x(seven days)÷ (3)	Weight/ work day							
5. Percent of production actually collected per day	%							
6. Actual reasonable collection per day	Weight/ work day							
Direct Haul								
7. Distribution of collection equipment which collects refuse and also directly hauls to the intermediate processing and/or disposal point [d]	Total load weight/means/ work day							

	Measure	Actual		Estimated				
		FY79-80	FY80-81	FY81-82	FY82-83	FY83-84	FY84-85	FY85-86
(a) /e	Total load weight/means/ work day							
(b)								
(c)								
( )	"							
(n)	"							
8. Subtotal								
Collection								
9. Distribution of collection equipment which traverses only the collection service route by various means /d	Total load weight/means/ work day							
(a) /e	"							
(b)	"							
(c)	"							
( )	"							
(n)	"							
10. Subtotal								
Transportation								
11. Distribution of transport equipment which hauls from a transfer point to the intermediate processing and/or disposal point /d	Total load weight/means/ work day							
(a) /e	"							
(b)	"							
(c)	"							
( )	"							
(n)	"							
12. Subtotal								

	Measure	Actual FY79-80	Actual FY80-81	Estimated FY81-82	Estimated FY82-83	Estimated FY83-84	Estimated FY84-85	Estimated FY85-86
Disposal								
13. Amount input to redemption center or intermediate processing point (8) + (12) /f	Total weight/ work day							
14. Amount recovered from recycling or intermediate processing	"							
15. Amount for final disposal (13) - (14)	"							

/a Increase population to be served reflecting net growth rate increase and additional area to be served, if any.

/b Per capita production of solid waste is likely to increase with economic development.

/c Percent collected should improve with time and reasonable estimates should be made for future years.

/d Based on actual weights for each equipment type, averaged over the year, and percentage of service to be provided by each mean. Densities of refuse vary for each stage of collection and haul, and each type of equipment.

/e Equipment for collection, transportation or direct haul would include: handcarts, basket-laden donkeys, tractors with trailers, roll-on container trucks, side loaders, open tippers and compaction vehicles. Include any special loading equipment, such as front-end loaders, used in collection.

/f It assumes that everything being transported goes for either intermediate processing or ultimate disposal.

MUNICIPAL REFUSE MANAGEMENT

Table 2: EQUIPMENT REQUIREMENTS

	Measure	Actual		Estimated				
		FY79-80	FY80-81	FY81-82	FY82-83	FY83-84	FY84-85	FY85-86
Direct Haul								
16. Capacity of each means	Load weight/ unit/trip							
(a) /a	"							
(b)	"							
(c)	"							
( )	"							
(n)	"							
17. Average number of daily trips of each means	Trips/unit/ work day							
(a)	"							
(b)	"							
(c)	"							
( )	"							
(n)	"							
18. Equipment Requirements	Number of units							
(a) (7a) ÷ [(16a)x(17a)]	"							
(b) (7b) ÷ [(16b)x(17b)]	"							
(c)	"							
( )	"							
(n) (7n) ÷ [(16n)x(17n)]	"							
Collection								

	Measure	Actual FY79-80	FY80-81	Estimated FY81-82	FY82-83	FY83-84	FY84-85	FY85-86
19. Capacity of each means	Load weight/ unit/trip							
(a) /a	"							
(b)	"							
(c)	"							
( )	"							
(n)	"							
20. Average number of daily trips of each means	Trips/unit/ workday							
(a)	"							
(b)	"							
(c)	"							
( )	"							
(n)	"							
21. Equipment Requirements	Number of units							
(a) (9a) ÷ [(19a)x(20a)]	"							
(b) (9b) ÷ [(19b)x(20b)]	"							
(c)								
( )								
(n) (9n) ÷ [(19n)x(20n)]	"							
<u>Transportation</u>								
22. Capacity of each means	Load weight/ unit/trip							
(a) /a	"							
(b)	"							
(c)	"							
( )	"							
(n)	"							

	Measure	Actual		Estimated				
		FY 79-80	FY80-81	FY81-82	FY82-83	FY83-84	FY84-85	FY85-86
23. Average number of trips/ day of each means	Trips/ unit/workday							
(a)	"							
(b)	"							
(c)	"							
( )	"							
(n)	"							
24. Equipment requirements	Number of units							
(a) (11a) ÷ [(22a)x(23a)]	"							
(b) (11b) ÷ [(22b)x(23b)]	"							
(c)	"							
( )	"							
(n) (11n) ÷ [(22n)x(23n)]	"							
Disposal								
25. Capacity of intermediate processing units	Weight/unit/ work day							
26. Number of intermediate processing units required (13) ÷ (25)	Units							
27. Capacity of earthmoving equipment for final disposal	Weight/ unit/ work day							
28. Number of equipment units required for final disposal (15) ÷ (27)								

/a Equipment for collection, transportation and direct haul would include: handcarts, basket-laden donkeys, tractors with trailers, roll-on container trucks, side loaders, open tippers and compaction vehicles. Include any special loading equipment, such as front-end loaders, used in collection.

MUNICIPAL REFUSE MANAGEMENT

Table 3: MANPOWER REQUIREMENTS

	Measure	Actual		Estimated				
		FY79-80	FY80-81	FY81-82	FY82-83	FY83-84	FY84-85	FY85-86
Direct Haul								
29. Manning requirement by means	Persons/ unit/work day							
(a)	"							
(b)	"							
(c)	"							
( )	"							
(n)	"							
30. Labor requirements /a	Persons							
(a) (18a)x(29a)	"							
(b)	"							
(c)	"							
( )	"							
(n) (18n)x(29n)	"							
31. Subtotal								
Collection								
32. Manning requirement by means	Persons/ unit/ work day							
(a)	"							
(b)	"							
(c)	"							
( )	"							
(n)	"							

	Measure	Actual FY79-80	FY80-81	Estimated FY81-82	FY82-83	FY83-84	FY84-85	FY85-86
33. Labor requirements /a	Persons							
(a) (21a)x(32a)	"							
(b)	"							
(c)	"							
( )	"							
(n) (21n)x(32n)	"							
34. Subtotal								
Transportation								
35. Manning Requirements by means	Persons/ unit/ work day							
(a)	"							
(b)	"							
(c)	"							
( )	"							
(n)	"							
36. Labor Requirements /a	Persons							
(a) (23a)x(35a)	"							
(b)	"							
(c)	"							
( )	"							
(n) (23n)x(35n)	"							
37. Subtotal								
Disposal								
38. Manning requirement per unit of intermediate processing (if publically employed)	Persons/ unit/ work day							

	Measure	Actual FY79-80	Actual FY80-81	Estimated FY81-82	Estimated FY82-83	Estimated FY83-84	Estimated FY84-85	Estimated FY85-86
39. Total labor required for intermediate processing (if publically employed) /b (26)x(38)	Persons							
40. Manning requirement per equipment unit for final disposal	Persons/ unit/ work day							
41. Total labor required for final disposal (28)x(40) /b	Persons							
42. Subtotal (39) + (41)	"							

/a Includes drivers and crews for vehicles, and sweepers for carts.
/b Includes equipment operators, hand sorters, and laborers.

Table 4: CAPITAL COST ANALYSIS

	Measure	Actual		Estimated				
		FY79-80	FY80-81	FY81-82	FY82-83	FY83-84	FY84-85	FY85-86
Direct Haul								
43. Additional No. of units of equipment required /a	Units							
(a)	"							
(b)	"							
(c)	"							
( )	"							
(n)	"							
44. Yearly replacement requirements for wear and tear /b	Units							
(a)	"							
(b)	"							
(c)	"							
( )	"							
(n)	"							
45. Total no. of units (net required each year)	Units							
(a) (43a) + (44a)	"							
(b)	"							
(c)	"							
( )	"							
(n) (43n) + (44n)	"							

	Measure	Actual FY79-80	Actual FY80-81	Estimated FY81-82	Estimated FY82-83	Estimated FY83-84	Estimated FY84-85	Estimated FY85-86
46. Average cost per unit /c	Cost/unit							
(a)	"							
(b)	"							
(c)	"							
( )	"							
(n)	"							
47. Total incremental capital cost per year	Cost							
(a) (45a)x(46a)	"							
(b) (45b)x(46b)	"							
(c)	"							
( )	"							
(n) (45n)x(46n)	"							
48. Direct Haul Subtotal	Cost							
Collection								
49. Additional no. of units required /a	Units							
(a)	"							
(b)	"							
(c)	"							
( )	"							
(n)	"							

	Measure	Actual FY79-80	Actual FY80-81	Estimated FY81-82	Estimated FY82-83	Estimated FY83-84	Estimated FY84-85	Estimated FY85-86
50. Yearly replacement requirements for wear and tear /b	Units							
(a)	"							
(b)	"							
(c)	"							
( )	"							
(n)	"							
51. Total no. of units (net required each year)	Units							
(a) (49a) + (50a)	"							
(b)	"							
(c)	"							
( )	"							
(n) (49n) + (50n)	"							
52. Average cost per unit /c	Cost/unit							
(a)	"							
(b)	"							
(c)	"							
( )	"							
(n)	"							
53. Total incremental capital cost per year	Cost							
(a) (51a)x(52a)	"							
(b)	"							
(c)	"							
( )	"							
(n) (51n)x(51n)	"							
54. <u>Collection Subtotal</u>	Cost							

		Actual		Estimated				
	Measure	FY79-80	FY80-81	FY81-82	FY82-83	FY83-84	FY84-85	FY85-86
Transportation								
55. Additional no. of units required /a	Units							
(a)	"							
(b)	"							
(c)	"							
( )	"							
(n)	"							
56. Yearly replacement requirements for wear and tear /b	Units							
(a)	"							
(b)	"							
(c)	"							
( )	"							
(n)	"							
57. Total number of units (net required each year)	Units							
(a) (55a) + (56a)	"							
(b)	"							
(c)	"							
( )	"							
(n) (55n) + (56n)	"							

	Measure	Actual FY79-80	Actual FY80-81	Estimated FY81-82	Estimated FY82-83	Estimated FY83-84	Estimated FY84-85	Estimated FY85-86
58. Average cost per unit /c	Cost/ unit							
(a)	"							
(b)	"							
(c)	"							
( )	"							
(n)	"							
59. Total incremental capital cost per year	Cost							
(a) (57a)x(58a)	"							
(b)	"							
(c)	"							
( )	"							
(n) (57n)x(58n)	"							
60. <u>Transportation Subtotal</u>	Cost							
<u>Disposal</u>								
61. Redemption or intermediate processing								
(a) No. of incremental units required/year /a and /b	Units							
(b) Avg. cost per unit /c	Cost/unit							
(c) Total cost (61a)x(61b)	Cost							

	Measure	Actual		Estimated				
		FY79-80	FY80-81	FY81-82	FY82-83	FY83-84	FY84-85	FY85-86
62. Final disposal								
(a) No. of incremental units required/ year /a and /b	Units							
(b) Avg. cost per unit /c	Cost/unit							
(c) Total cost (62a)x(62b)	Cost							
63. Estimated Civil Works, if any	Cost							
64. <u>Disposal Subtotal</u>	Cost							
<u>Supervision</u>								
65. Vehicles for super- intendents	Cost							
66. Motorscooters for super- visors	Cost							
67. Radio communication systems	Cost							
68. <u>Supervision Subtotal</u>	Cost							
<u>Mustering and Maintenance</u>								
69. Equipment	Cost							
70. Civil Works	Cost							
71. <u>Mustering and Maintenance Subtotal</u>								

	Measure	Actual		Estimated				
		FY79-80	FY80-81	FY81-82	FY82-83	FY83-84	FY84-85	FY85-86
<u>Summary of Capital Cost Subtotals</u>								
(a) Direct Haul	Cost							
(b) Collection	"							
(c) Transportation	"							
(d) Disposal	"							
(e) Supervision	"							
(f) Mustering and Maintenance	"							
72. <u>Total</u>	Cost							

/a Subtract previous year requirement from current year requirement to get additional current year need to meet population growth and per capita waste generation rate increases.

/b Estimate no. of units to be replaced each year from old stock due to usage.

/c Avg. cost per unit should reflect increase due to price level increase each year.

SOLID WASTE

Table 5: OPERATING COSTS ANALYSIS

	Measure	Actual		Estimated				
		FY79-80	FY80-81	FY81-82	FY82-83	FY83-84	FY84-85	FY85-86
73. Salaries /a	Cost/ year							
74. Fringe benefits /b	"							
75. Fuel /c	"							
76. Supplies /d	"							
77. Repairs and Maintenance /e	"							
78. Utilities /f	"							
79. Administration /g	"							
80. Overhead Allocation /h	"							
81. Depreciation /i	"							

	Measure	Actual FY79-80	FY80-81	Estimated FY81-82	FY82-83	FY83-84	FY84-85	FY85-86
82. Debt Service (Interest only) /j	Cost/ year							
83. Others /k	"							
84. Total Operating Costs	"							

/a Refer to Table 3 Manpower requirement by function and then estimate salary costs based on estimated wage scale per year. Wage rate should increase to reflect inflation. For each collection and transport equipment type, assume one field supervisor for every 5 to 7 equipment units, or one person for every square mile area. For disposal facilities, assume at least 2 supervisors per site.

/b Fringe benefits are usually a direct % of salaries. The factor is based on historical experience.

/c Fuel costs should relate to consumption pattern of collection and transport vehicles, and other equipment requirements indicated in Table 2, and location of transfer and disposal facilities. Unit fuel costs should reflect estimated increase in oil price in future year.

/d Supplies should relate to volume of solid waste handled per year. As needed, assume carrying one year's requirements of foreign spare parts per motorized equipment item.

/e Repairs and maintenance should relate to the equipment categories and should include both labor and materials. Accurate estimates would require one to do a historical analysis.

/f Utilities such as water and electricity costs should be estimated based on volume of solid waste handled/ year and estimated increase in rate of these services.

/g Administration and supervision costs are usually expressed as a % of direct salaries and range from 3% to 7% (usually) of direct salaries.

/h Overhead allocation is usually expressed as a % of direct salaries and varies from institution to institution. In order to estimate this %, one must do a historical analysis.

/i Depreciation should be calculated based on (acquisition cost of each category on hand + incremental capital cost each category) ÷ (estimated useful life of each category). See Table 4 for capital cost analysis. If no information on the economic life of each category is available, assume: pushcart economic life of 2 years, collection and transport vehicle life of 7 years, landfill equipment life of 10 years, and civil works and resource recovery facility life of 20 years.

/j Debt service includes only interest on any borrowed funds attributable to this service.

/k Other unclassified expenses, such as training programs and public education.

MUNICIPAL REFUSE MANAGEMENT

Table 6: REVENUE REQUIREMENT AND RATE STRUCTURE

	Measure	Actual		Estimated				
		FY79-80	FY80-81	FY81-82	FY82-83	FY83-84	FY84-85	FY85-86
85. Total operating costs to be recovered /a	Cost/ year							
86. Revenues needed to meet operating costs from /b :	Revenues/ year							
(a) public tariff	"							
(b) government grants	"							
(c) other	"							
87. Subtotal /c								
88. Total population served (1) /d								
89. Per capita charge from public (86a) ÷ (81) /e	Cost/yr/ capita							

/a See Table 5.

/b The institution needs to estimate the mix of sources of revenues likely to be achieved each year; i.e. government grants may go down in future years. Public tariff should approximate, at least, all operating expenses less depreciation.

/c This analysis assumes a break even situation, i.e., all operating costs are being met and no deficits or surpluses occur.

/d See Table 1.

/e This figure should provide the basis for a required tariff structure for solid waste management. The means by which the charge is to be levied is a matter of local conditions and feasibility.

The World Bank is executing a UNDP global research, development and demonstration project on integrated resource recovery and recycling. Work on the project started mid-1981. If you would like to add your name to the mailing list to receive progress reports on the project, please contact:

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