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Chapter 16

Sustainable Waste Management: A Case Study of the Bangkok Metropolitan Authority

Watana Luanratana and C. Visvanathan

CONTENTS

Introduction

The metropolis of Bangkok has an area of 1,568 square kilometers with a population of about 10 million registered and nonregistered residents. In its 50 districts comprising 2,000 communities, Bangkok generated about 9,500 tons per day of solid waste in 2002. The entire municipal solid waste management (SWM) is under the jurisdiction of the Bangkok Metropolitan Administration (BMA), which arranges for primary collection, transport, and disposal. At an estimated annual increase of 2.25%, the waste generation for 2007 would be 10,600 tons per day, and the trend would accelerate with the expansion of the urban boundaries and growth of urban population with the increased standards of living (BMA, 2000a). The scenario for the year 2000 indicated that of the total waste generated and collected, more than 90% was disposed of at the two landfill sites. Currently, the BMA has a simple system of SWM: collection and storage of discharged waste into roadside bins or enclosures in institutions and business centers from which compaction trucks collect and haul to the transfer stations for onward transportation to the landfill sites. During the entire stream, waste picking and scavenging (material recovery for recycle and reuse) occurs, contributing to only 8% reduction of the total waste. This is done either by the BMA collection and transport workers or by the informal sector collectors called Salengs, who visit door to door with carts, or by the waste pickers who scavenge from the roadside bins, transfer station heaps, and landfills (Figure 16.1).

The trend shown in Figure 16.1 requires change for effective SWM as BMA has had to cope up with several problems related to its environmental, social, financial, managerial, and administrative aspects. Some of the technical problems encountered are the spills of waste, dust problems during transport, and malodor from transfer stations and landfill sites. As a result, the affected citizens have made complaints to the BMA. Illegal dumping and disposal have hindered 100% waste collection (BMA, 2000b). Waste collectors and scavengers work in an unhealthy environment.

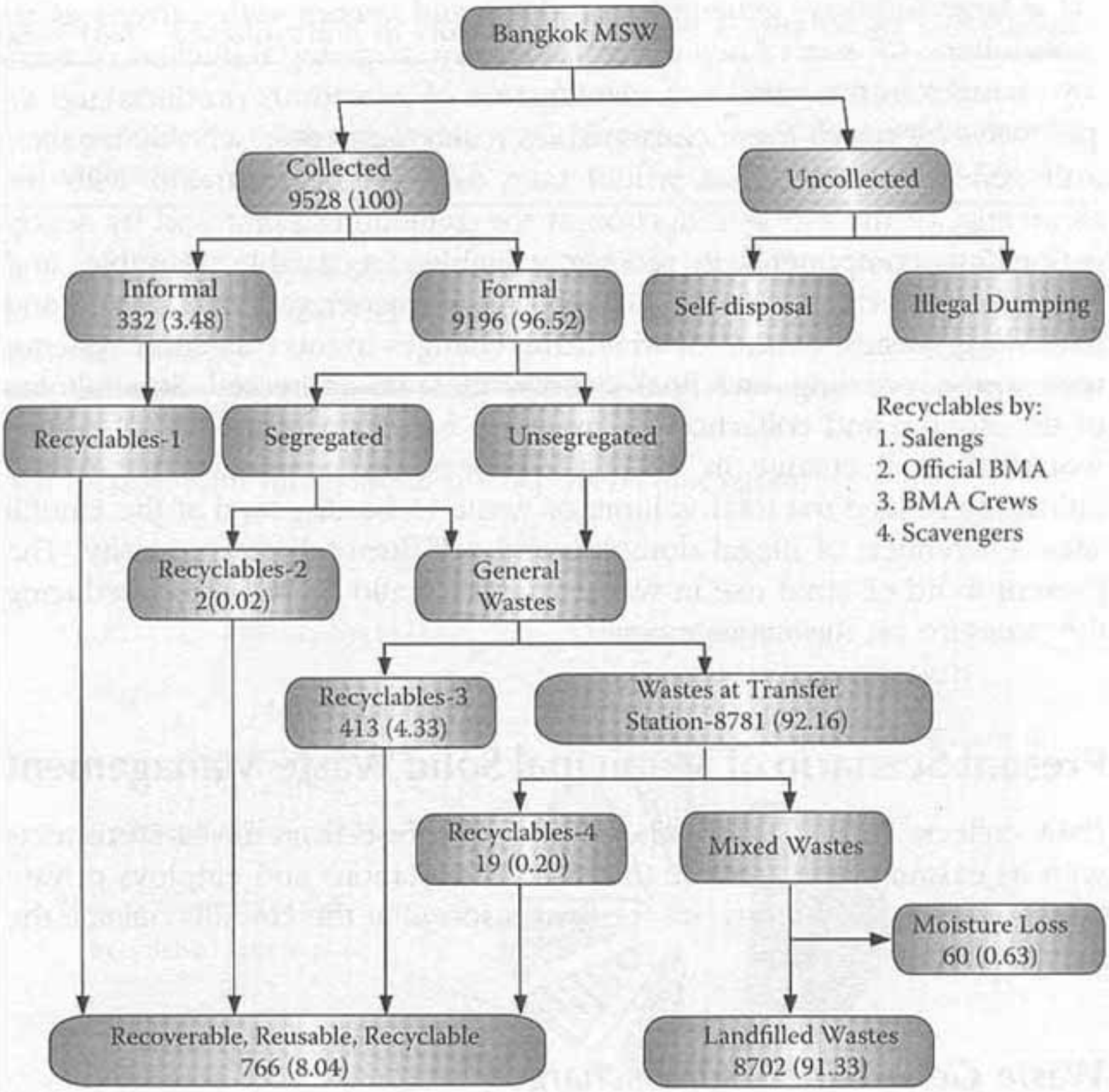

Figure 16.1 Municipal solid waste in Bangkok for 2000. Source: BMA (2000a).

Despite different acts, laws, and regulations for SWM, their implementation has been inadequate, with a lack of coordination and follow-up between the implemented schemes and the civic authority. Budget allocations have not been streamlined to suit all aspects of SWM; and collection of user fees covers only a minute fraction of the actual costs (BMA, 2000b). Lack of dissemination of public information hinders the overall management of the waste. There is large room for improvement in the SWM system, from upstream reduction in generation to downstream disposal. Incorporating the principles of cleaner production (CP) would allow an effective reduction of the waste generation as well as disposal in the landfills with a larger percentage of recovery of the valuables in the entire waste stream.

CP concepts would help minimize the problems and constraints faced by BMA for effective SWM in the metropolis. Bangkok can be considered

as a large industry, generating products and wastes with citizens as the consumers. CP would begin at the industry, targeting reduction of waste by changes in the pattern of manufacture of its various products and the pathways by which these consumables reach the people who utilize them and generate waste. That would take care of the upstream with the awareness of the refuse reduction at the generating point and by segregation into components to recover valuables (recyclable, reusable, and repairable objects), biowaste (kitchen organic matter and yard waste), and hazardous wastes. Further downstream, changes in the collection systems, transport, processing, and final disposal must be addressed. Streamlining of the storage and collection (segregation based on properties of waste) would allow a change in the waste-processing techniques that would ultimately reduce the total volume of waste to be disposed at the landfill sites. Prevention of illegal dumping and self-disposal is a necessity. The present trend of rapid rise in waste quantity could be stabilized, reducing the pressure on the management.

Present Scenario of Municipal Solid Waste Management

BMA collects and transports the municipal refuse from all its 50 districts with its existing infrastructure to the transfer stations and employs private transporters to haul the waste for final disposal at the landfills outside the metropolitan boundary.

Waste Generation and Discharge

To estimate the per capita waste generation, Bangkok households are classified on the basis of income group, namely, A, B, and C. Table 16.1 summarizes the result of a detailed survey conducted at the On-Nuch transfer station. It is interesting to note that the per capita solid waste generation did not differ significantly between high- and low-income groups, at 0.425 kg per capita per day, whereas Visvanathan and Tränkler (2003) have reported that India and China range between 0.3 to 0.65 kg and 0.2 to 1.7 kg, respectively.

Waste Composition

The overall waste composition sampled on a wet basis indicated that kitchen waste dominated the total quantity, at about 51%; nonrecyclable (plastic and foam and paper) was the second largest at more than 24%. Other recyclables (plastic, foam, paper, metals, bottles, and glass) as

Table 16.1 Classification of Households and per Capita Waste Generation

Household Classification	*Income Level (THB/month)*[a]	*Population (%)*	*Solid Waste Generation Rate (kg per capita per day)*
A	30,000 and above	24	0.490
B	13,000 – 29,999	38	0.440
C	Below 12,999	38	0.400
Weighted average			**0.437**

[a] THB40 = US$1.

Source: Japan Bank for International Cooperation [JBIC] (2001).

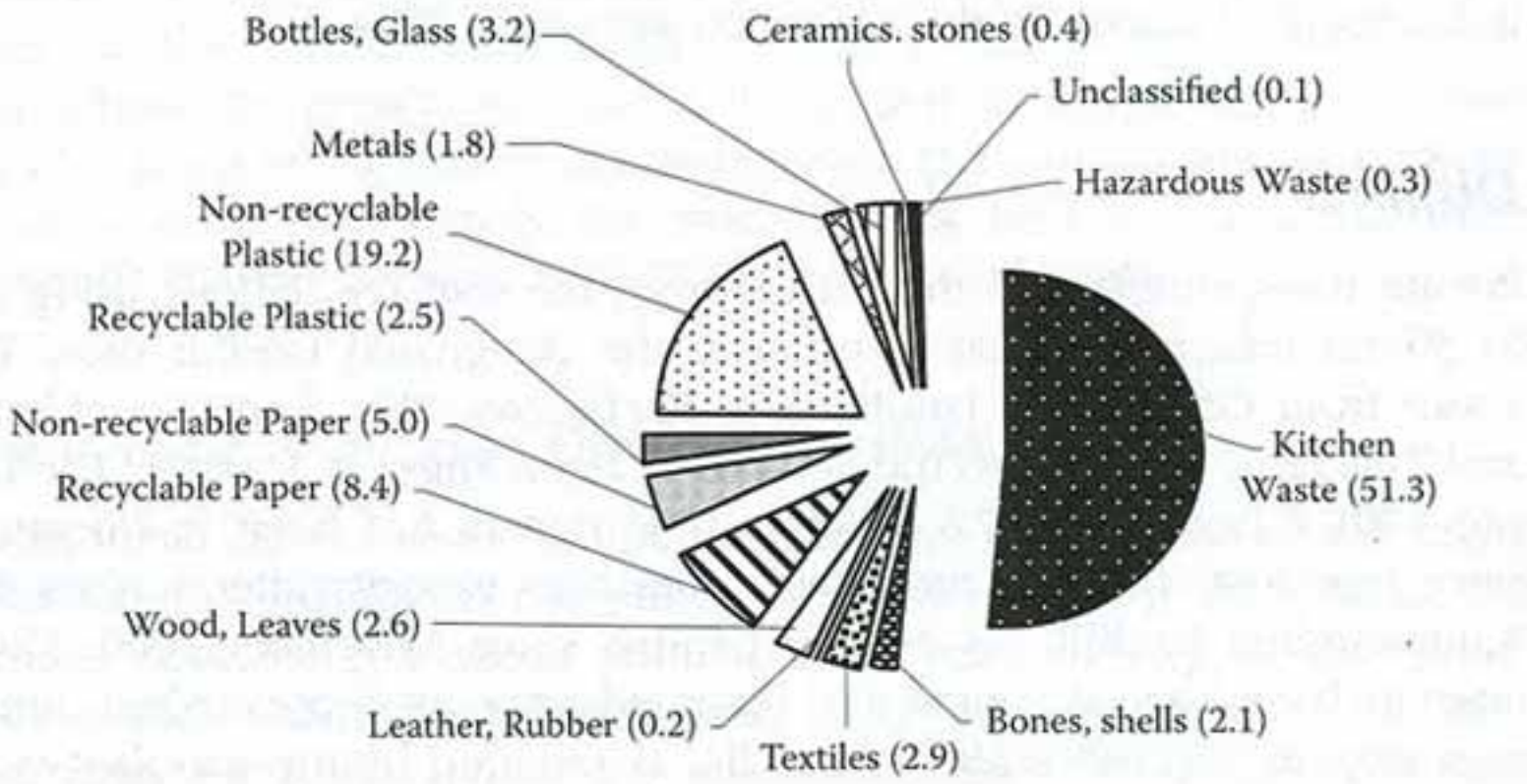

Figure 16.2 Physical composition of solid waste of Bangkok (in percentage wet basis).

indicated constituted almost 16%. The rest of the components were textiles, leather, wood, leaves, rubber, ceramic, and stones with a small percentage of recyclables (Figure 16.2). This clearly indicated a larger fraction of combustible waste, which under the existing circumstances could not be considered for incineration because of the higher moisture content in the kitchen waste and reduced calorific value. Meanwhile, a higher fraction of biodegradable waste indicates the attractiveness of the composition for adoption of composting techniques, but before selecting this treatment technology, proper upstream waste segregation schemes need to be chosen.

Collection and Transport

The responsibility of waste collection and transportation lies directly with the BMA. Currently there are 1,306 collection vehicles and a total crew of around 7,000 who make 1,780 daily collection trips to residential and commercial areas. These collection vehicles are used for hauling 9,500 tons of waste to the transfer stations. Each of these transfer stations, located at On-Nuch, Tharaeng, and Nongkhaem, handles about 3,500, 2,300, and 2,800 tons, respectively. In general, the transfer stations are overloaded; overloading leads to unsanitary conditions, which are due to stockpiling of excess waste despite continuous hauling to the landfills.

With the continuous increase in waste generation in BMA, it is important to investigate the collection system and crew efficiency. For example, in Kuala Lumpur municipality in Malaysia, 7,660 tons per day of waste is hauled with a fleet of 565 collection trucks (Levine, 1995); this figure indicates the lacunae in the collection system of BMA.

Disposal

Private transporters haul the wastes from the transfer stations using 20- to 30-ton trailers for final disposal at the designated landfill sites. The waste from On-Nuch is landfilled at Rachthewa; that from Nongkhaem and Tharaeng is hauled to the landfills at Kampangsaen 1 and 2. The first site with a capacity of 7.5 million cubic meters has been in operation since July 2000 and was projected to reach its capacity after 4 years; the Kampangsaen landfill has been expanded since November 2000. These landfills have been designed and operated more as impoverished dump-sites than as secured sanitary landfills, as required by the national waste disposal regulations.

Waste Processing

Waste processing and pretreatment become essential parts of the waste stream before the final disposal. At BMA, there exist no formal processing and treatment facilities, though there are potentials for a higher degree of processing based on the waste composition. The techniques used by BMA are material recovery at various stages and a pilot project for separate collection in some target waste generation units to allow recycling.

Recycling

Recycling of the waste reduces the waste quantity if it is practiced widely. There are two forms of recycling systems in operation, which can be

considered as formal and informal sector operations. In the formal sector, the BMA transport crews collect all the valuables they can find in the waste stream and sell them to the waste shops during the regular waste collection shifts to obtain additional income. The Pollution Control Department (PCD) has estimated that such collections total about 413 tons per day, accounting for more than 50% recovery of the recyclable waste in the stream (BMA, 2002). The formal system uses 10 target groups (educational institutes, hospitals, department stores, hotels, religious centers, high-rise buildings, condominiums, housing estates, markets, and commercial centers) that have been initiated to practice source segregation.

In the informal sector, the most prominent recovery of recyclables is by Salengs, who make locality visits with their tricycles and collect materials from the households. About 2,100 Salengs operate in Bangkok and collect a total of about 332 tons of recyclables, which accounts for more than 40% of the recovered materials (JBIC, 2001). In addition, the scavengers at the transfer stations collect about 2% to 3% of the recyclables. As a whole, the present scenario indicates that the recycling rate is about 8% (766 tons) of the total waste stream with the participation of both the formal and informal sectors. The system saves the BMA about Thai baht (THB) 97 million per year at THB 350 per ton of waste.

The Recycle Promotion Drive by the BMA

As an initial step of reducing the total amount of solid waste generated, BMA focused mainly on the policy of waste recycling. In spite of the original target of 20% waste reduction through recycling by 2001, only 8% recycling was achieved even with the concerted efforts of the PCD and active local educational and media campaigns by nongovernmental organizations (NGOs) (Thailand Environment Monitor, 2003). The reduction of waste was aimed at adherence to the rule of 4 Rs—reduce, reuse, repair, and recycle. To allow such a system, source separation has been promoted with the use of separate colored bins: green for food wastes and other biodegradables; yellow for recyclable waste (bottles, plastic, glass, paper, aluminum cans, and other metals), and gray for the hazardous category of wastes (lightbulbs, dry cells, batteries, etc.) especially in commercial centers. The source separation activities are designed such that they are carried out by the BMA collection crews or Salengs, rather than by household owners. Though these recycle activities carried out by the BMA workers assist their monthly incomes, their working efficiency is significantly reduced in terms of garbage collection rate. Currently, the BMA is considering drafting a policy whether to prohibit or make this system of source separation official as an initiative to promote recycling (BMA, 2002).

Present Problems and Constraints

BMA is faced with increasing SWM problems that can be broadly categorized as waste-related environmental issues, management issues, and financial aspects issues. These issues are discussed in detail in the following sections.

Waste-Related Environmental Issues

The waste discharge rate has been increasing by about 2.25% annually mainly because of the population growth and the increase in urbanization and BMA's waste handling capacity has not kept pace with the trend (BMA, 2002). It does not collect 100% of the total generated waste, and illegal dumping and disposal are still practiced. The capacity of transfer stations is found to be inadequate to handle the incoming waste; the result is stockpiling, which creates significant environmental problems. The waste pickers and scavengers as well the BMA workers are at environmental health risks while handling the waste. The transport for final disposal at the landfill sites has been a cause of air pollution in terms of dust, odor, noise, fumes, and emission of landfill gases. These problems are due to the lack of institutional capacity in the sphere of technical management that would be able to remedy them. Another issue is the leakage of wastewater from the collection trucks and transfer stations. Leachate generated at the disposal sites leads to groundwater pollution for which treatment facilities are required.

Management Issues

Despite efforts by BMA to formalize the recycle system with source segregation by using several pilot projects, the SWM system is not fully integrated. BMA workers sort the recyclables during waste collection trips; that activity reduces their efficiency as they barely collect 5.33 tons per trip. However, their role is not formalized; nor is that of the Salengs who operate individually without any input from the civic authority. The existing regulations governing collection of waste and levying of fees and user charges are not well coordinated; therefore, strengthening of the management issues would be necessary. The actual SWM cost far exceeds the realization from the users, as seen in Table 16.2. For effective management, the participation of the private sector, NGOs, and community-based organizations (CBOs) would be necessary. The role of PCD for direction of municipal solid waste (MSW) activities should go hand in hand with the objectives of BMA to foster effective monitoring of the waste collection, transport, processing, and disposal. Further, publication by the

Table 16.2 Comparison of Expenditure and Collection of User Fees with Percentages for Years 1995–2000

	Collection Costs[a]		*Disposal Costs*[a]		*Total Costs*[a]		*Collection Fees*[a]		*Deficit*[a]	
Year	THB/ Ton	%	THB/ Ton	%	THB/ Ton	%	THB/ Ton	%	THB/ Ton	%
1995	416.02	68.59	190.48	31.41	606.50	100	25.78	4.25	580.72	95.75
1996	418.86	70.37	176.36	29.63	595.22	100	20.55	3.45	574.69	96.55
1997	419.94	74.23	145.82	25.77	565.76	100	20.45	3.61	546.31	96.56
1998	452.99	71.69	178.84	28.31	631.83	100	17.83	2.82	614.01	97.18
1999	553.84	77.24	163.17	22.76	717.01	100	17.67	2.46	699.34	97.54
2000	477.87	72.75	178.97	27.25	656.84	100	22.47	3.42	634.37	96.58

[a] THB40 = US$1.

From Bangkok Metropolitan Administration, 2002.

Department of Public Cleansing (DPC) of public information must be directed to more target groups to allow a reduction of the waste upstream rather than provide the downstream solution. BMA requires adequate professional and technical competency for effective management.

Financial Aspects

Another issue of concern for management are the budget allocations for the various activities related to SWM. Compared to that for the other municipal services, the financial allocation for SWM is in the range of 20% to 25%. Of this amount, 65% to 75% is spent on the collection and transportation activities, the remaining 25% to 35% is used for the final processing and disposal. This clearly indicates the processing and disposal sectors have received inadequate attention, lacunae in the overall management of these aspects of the waste stream are the result.

Table 16.2 indicates that the absence of budgetary provisions for processing and the levy on the users are far too highly subsidized (hardly 2.5% to 3%) with an annual fluctuation that could contribute to the ineffectiveness of the management, as well as cause deficit in the budget. More than 95% of the SWM costs are borne by BMA, at a total of more than THB 2 billion. The cost of disposal has been between 20% and 31% of the total management cost, indicative of a disproportionate expenditure for the collection. For effective management of the solid waste, the collection, processing, and disposal must be streamlined in the budgetary provisions. The user fees should be able to cover a larger fraction of the budget than the present one by applying the "Polluter Pays Principle," which would reduce the waste generated. It has been seen from practices in India and Sri Lanka that the involvement of the private sector in collection and transport has greatly increased the efficiency of the MSW system (Asian Institute of Technology [AIT], 2004). Another example of increased efficiency with the involvement of the private sector was reported in Kuala Lumpur, Malaysia, where the collection by the private sector was 8.5 tons per vehicle trip, whereas that by the public sector was only 5.7 tons per vehicle trip (Levine, 1995).

Sustainable Waste Management Strategies for BMA

The sustainable waste management approach of BMA should incorporate the basic principle of waste reduction, reuse, and recycling at the source to allow an upstream approach to the overall strategy for waste reduction. The fundamental approach would be to consider Bangkok as a large industry whose citizens are consumers to apply the CP principles that

would dictate the production and supply of goods and services with environment-friendly norms. This strategy would minimize the waste at the producer's end rather than at the consumer's end with a stepwise follow-up on the downstream. In creating the strategy, the factors influencing the generation play an important role in the waste minimization plan that could be achieved by using legal and economic instruments, suasion, and appropriate collection, treatment, and disposal technologies.

Factors Controlling Waste

The primary factors that control the waste amount are the population and the income level of the citizens. The forecast for the waste amount is based on these two factors, though various other factors contribute to its precision. In terms of the factors considered later, the forecast for waste discharge and collection amount is given in Figure 16.3, which indicates a steady rise with nearly 15,000 tons per day by 2019.

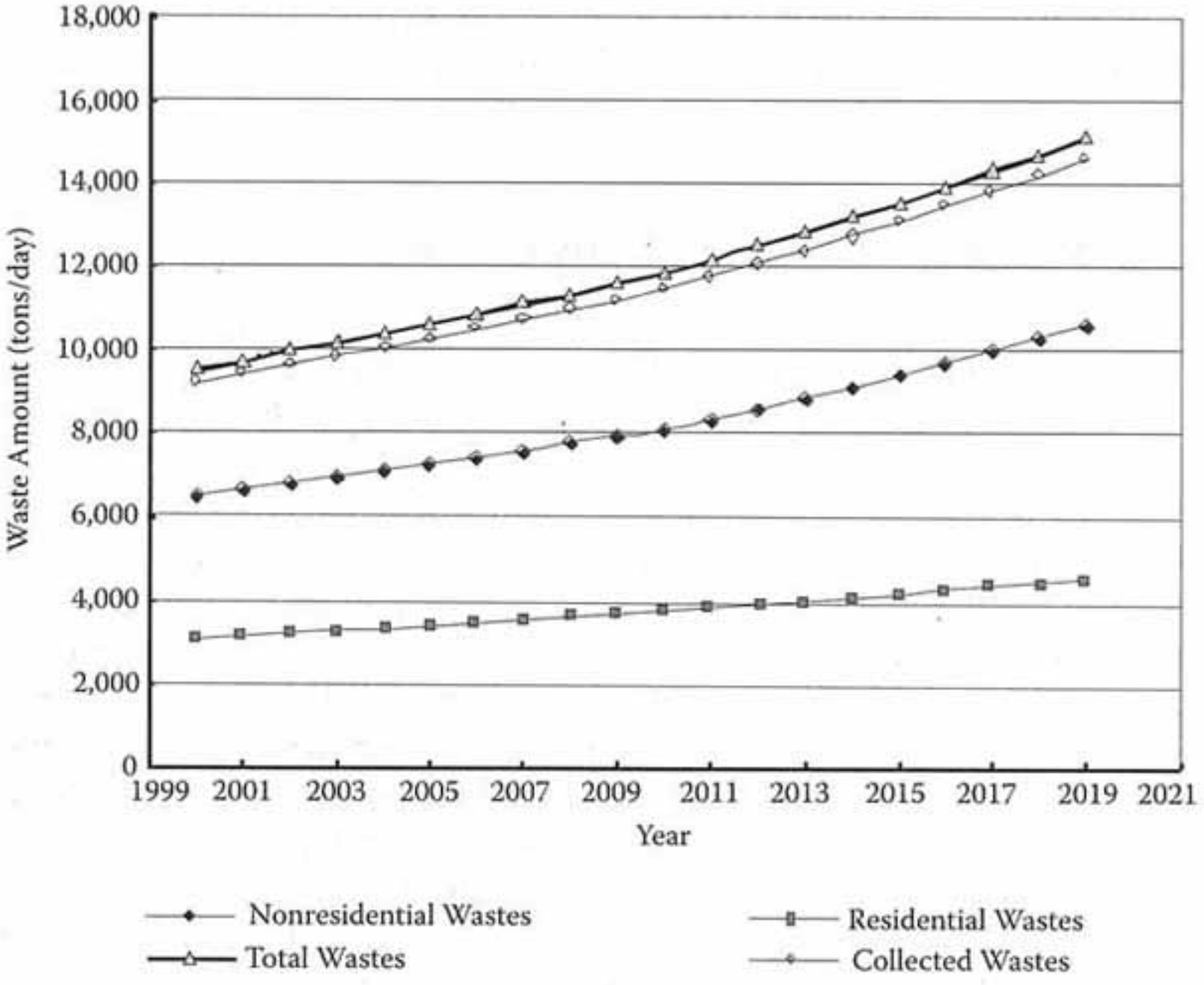

Figure 16.3 Forecast of waste generation and collection amount.

The present population estimate of Bangkok is based on the 1990 census, and the proposed waste management plan has forecasted an annual growth of registered and nonregistered residents by 1.53% until 2019; the growth of commuters has been assumed to be 1.47% (BMA, 2000b). On this basis, the forecast for waste discharge can be determined together with the income growth. Waste generation and collection up to 2019 show a smaller growth in the domestic waste component but a substantial growth in the nonresidential (industrial and commercial) waste sector. It has been found that the increase in per capita daily residential waste has been 0.4 to 0.425 kg, whereas the per capita nonresidential waste increase is from 0.467 to 0.902 kg, thus increasing the share of the latter sector from 54% to 68% within the period 1989 to 2000 (BMA, 2000b). This factor requires stabilization at the current level to allow a consolidated decrease in the otherwise uncontrolled growth of MSW in the metropolis.

The growth in income of an individual increases her or his consumption pattern and is related to the growth in gross domestic product (GDP). The present trend in Thailand indicates a rise by 2.5% for the period from 2000 to 2010 and by 3.4% for 2011 to 2020. The waste discharge is expected to grow by 2.25% for the first decade and 3.06% for the second decade (JBIC, 2001).

Waste Minimization by Legal Instruments

Waste minimization can only be achieved with the incorporation of CP options that target the upstream of waste generation. Keeping the factors controlling waste generation fixed on the one hand, minimization efforts should bring about a control in the waste generation with a down-the-line follow-up on the waste stream. Control can be facilitated by legal and economic instruments. BMA has a number of laws and regulations governing environmental management, but their implementation is centralized and enforcement by legal authorities is difficult. The power vested in the police for enforcement with fines and permits is limited by their lack of institutional arrangements and technical expertise. Public comprehension of the rules and regulations is lacking, without regular updates that could be achieved with effective multimedia campaigns. The present system of command and control (CAC) has limited enforcement. BMA has inadequate professional capacity with technical competency for the enforcement of the law, which causes complexities of implementation of environmentally sound practices.

Economic Instruments

Besides the legal aspects, economic incentives play a vital role. The legal instruments can only be effective with the provision of economic instruments in the form of municipal taxes and service charges for handling the waste. Another factor to control waste generation would be to levy taxes or duties on goods that generate waste, restrict use of excessive packaging material, and provide a deposit refund system for recyclables and reusables (plastic, glass, rubber, or metal containers and household appliances once out of service). Further, the production process of consumables may be monitored for environmentally friendly practices and provide market-based incentives (MBIs) of loans, tax relief, and grants to the producers for adherence to sound environmental practices. Strictures and fines for violating these norms and regulations would deter the producers from environmentally unethical practices.

Suasion

Sustainable management of the urban MSW would not be complete with only a legal approach and application of economic instruments without voluntary public participation and awareness among the polluters. The willingness to promote a sound environment goes a long way in the reduction of the waste, for which education of the masses through multimedia campaigns would be necessary to make the public realize its importance. Hence, public willingness to participate in the programs and projects initiated by BMA would enhance effective management and coordination of the activities. Changing of consumer habits and patterns from the existing ones would be difficult using only CAC and economic instruments but would be simplified if the public were persuaded to change, thereby paving the way for the reduction of generated waste.

Appropriate Technologies

The applicable technology is related to both upstream (generation, source segregation, collection, transport) to downstream (processing/treatment and final disposal) MSW. Generation of waste depends on the technological approach in the various sources of waste—the consumer goods. An integrated approach by the producer of such goods to reduce packaging would decrease the waste at the user's end. This in effect would be a CP technique. Source segregation when systematized to separate different categories of waste promotes recycling and reuse of valuables in the waste stream.

The kitchen and the yard wastes that constitute biodegradable waste can be segregated and processed as compost either in the backyard or by large-scale composting units or plants specifically functioning under the BMA umbrella and can provide useful products for agricultural use as soil conditioners or biofertilizers. Once the biodegradable and recyclable wastes are separated, the volume to be processed further would be reduced by more than half and could easily be handled using the existing infrastructure for processing—compaction at the transfer stations and disposal in landfills.

Introduction of incineration facilities by BMA would require further segregation of waste into combustibles and noncombustibles. The calorific value of BMA MSW has been found to be about 4600 kJ per kg (JBIC, 2001), which is much lower than the minimal value required for sustainable combustion (5024 to 5861 kJ per kg) (AIT, 2004). The removal of the biowaste component from the waste stream would drastically reduce the moisture content and increase the calorific value of the waste, allowing a self-sustaining combustion in the incinerator that would generate electricity as a useful by-product. Such a technical strategy would help in the reduction of the waste volume for landfills and minimize problems arising out of transport of waste, malodor, leachate, and landfill gases.

Waste Generation Control and Reduction Plan

The significant growth in waste discharge as forecasted (Figure 16.3) had made BMA set targets for waste reduction with control at the source by implementing the legal, economic, and technical instruments vis-à-vis CP options as indicated. The waste stream has two components, residential wastes and nonresidential wastes, of which the former quantity could be stabilized but could not be reduced drastically with the options cited. People's participation with an effective campaign for reduction of waste generation would help control the per capita waste generation.

However, this would not significantly reduce the total waste generation, as the population of the metropolis would be on the increase. The present 0.468 kg per capita per day domestic waste generation could be maintained at the same level by 2019, but in effect, the total volume of domestic waste would increase significantly with the population growth. This value is lower than the per capita generation in cities of most developing Asian countries (Visvanathan and Trankler, 2003). Hence, the priority focus for waste reduction should be in the nonresidential sector.

BMA has proposed a reduction target for waste discharge by 2019 from its nonresidential waste stream estimated at 1.157 kg per capita per day, which could effectively be reduced to 0.632 kg per capita per day by applying CP principles with stringent measures to control large waste

discharges. Eventually, the measures could be expanded to include the medium- and small-scale waste discharges. Another step would be the recycle rule for the products that generate recyclable waste (household appliances, computers, mobile phones, electrical accessories), which should be routed back to the producers once the useful life is finished. Other waste products resulting from canning and packaging (cans, bottles and plastic trays) would have to be sent to the producers for recycling or reuse or to a recycling agency. Specific proposed scenarios for the waste reduction scheme are as follows:

- Charges to be levied on large-volume business or corporate waste based on the quantity per unit discharged
- Reduction in discharge by application of the reduction and recycle rule
- Institutional arrangements for the promotion of reduction and recycling

On the basis of BMA's proposed waste management plan, a recycle and reuse proposal for 15% of refuse has been put forward; the rest of the waste would be processed by composting, incineration, and disposal in sanitary landfills by 2019. Figure 16.4 indicates the various scenarios for the plan for integrated SWM in which waste is segregated from the generating source, residential and nonresidential sectors, into three categories (recyclables and reusables, biodegradable and nonbiodegradable), and for each category the processing and disposal criteria are outlined. The recyclables and reusables and the biodegradables would be removed from the waste stream at the beginning as a result of source segregation. The volume to be landfilled would be the processed household hazardous wastes, the incinerated residue, and the other nonbiodegradable wastes.

Sustainable Measures of Solid Waste Management

The efforts of BMA to incorporate CP through its proposed waste management plan would require additional sustainable measures based on the legal, financial, and technical instruments and motivation. These would exert control in the waste generation, a sound collection system, a market for recycling and reuse, dissemination of information and environmental education, and a monitoring system for the proposed activities and pilot projects.

The metropolitan management with certain regulations to control waste should require all large- and medium-scale generators to submit plans for waste reduction and reduce fancy packaging. It should promote recycling and resale of used goods, subsidize backyard or home composting, and

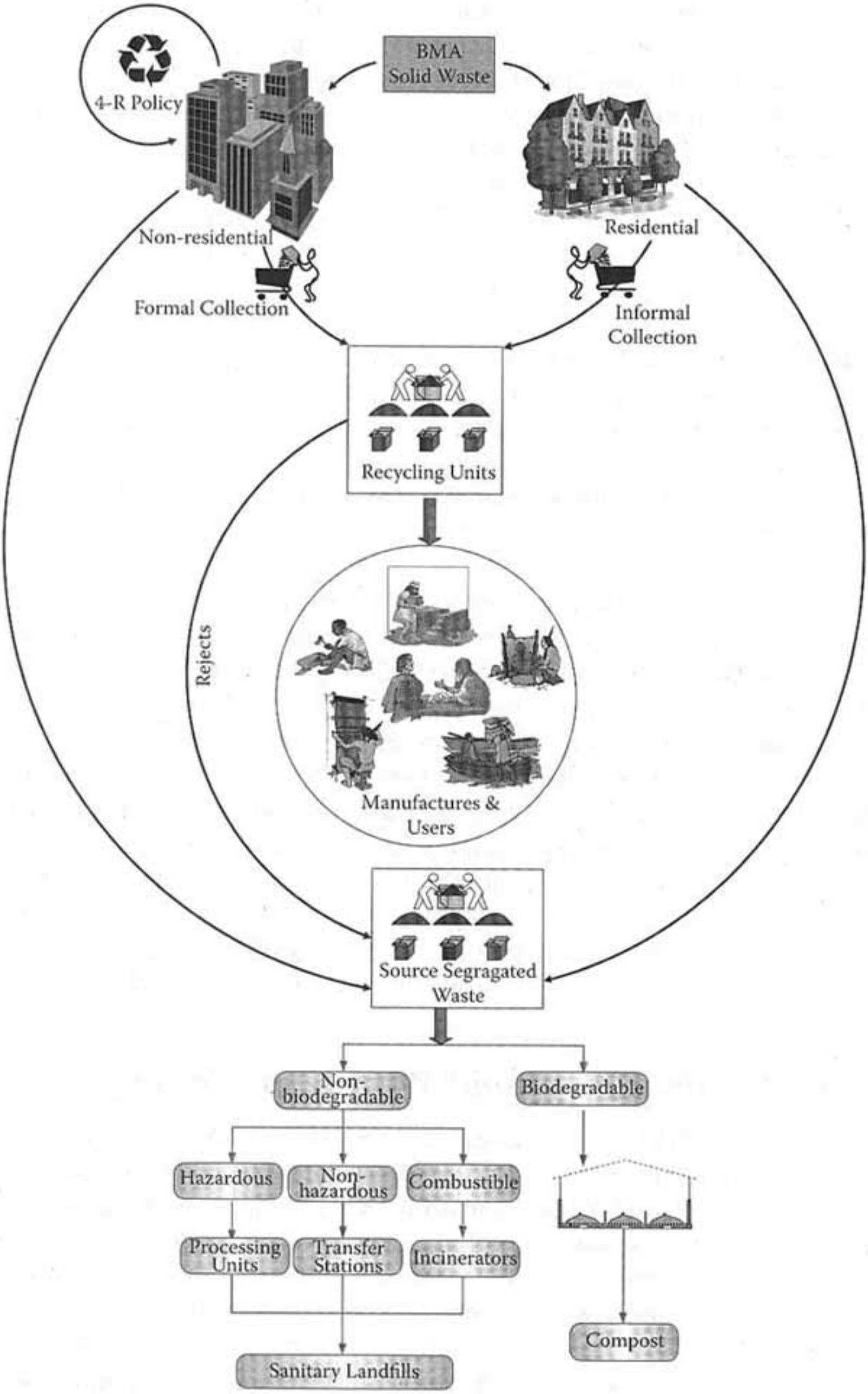

Figure 16.4 Integrated municipal solid waste management plan for Bangkok.

implement waste segregation at the source. Separation of large-scale organic wastes from such generation sources as hotels, restaurants, fast-food joints, and cottage food-processing units would provide resources for composting and hence reduce biowaste from the main stream.

Once the system is streamlined to that effect, an effective collection system would induce the polluters to segregate the waste. In addition, the informal sector waste collectors such as Salengs and scavengers should be registered under the BMA and the collection work by BMA crews should be formalized. At the same time, an awareness campaign on the benefits of source separation among the citizens would assist the collection system. The solid waste of Bangkok is the property of the BMA, and once the right to the ownership is given to the private sector with infrastructure support, its entry would make a difference in the SWM system, as indicated previously. The valuables in the waste stream would be attractive for private sector involvement that would make possible the establishment of recycling and resource recovery plants. This would significantly assist the SWM system for BMA as well as increase efficiency.

To begin recycling various types of waste a market would be necessary and BMA would be required to create it for the sustainability of the recycling units. Further, it should be able to provide certain subsidies in the form of collection, storage, and transport of the recyclables as well as land for establishing such units. A media campaign to encourage use of recycled goods and repair facilities would pave the way for reduction of waste that would otherwise accumulate in the main stream.

One of the keys to successful waste management is citizens' awareness of the environmental issues related to the garbage disposal. That could be achieved by disseminating information regarding the CP concepts of waste reduction, source segregation, recycling and composting technologies among the citizens along with the understanding of the adverse effects of the waste on human health, aesthetics, and the general environment.

All efforts to implement waste reduction strategies backed up by legal, economic, and technical measures would only partially fulfill the objectives or could even create a chaotic system without the effective monitoring of the waste stream. This system would not only collect statistics but also locate any lacunae in the SWM, which could be immediately remedied.

Conclusion

Municipal refuse is closely related to citizens' urban life: the industrial, corporate, and business activities of a city. The present scenario in Bangkok indicates the lacunae in the system of SWM by the metropolitan authority which are due to problems and constraints that limit 100%

collection and to lack of technologically sound methods for segregation, transport, and disposal.

Recognizing the facts and the loopholes within the system, BMA's policymaking body has proposed certain effective measures that incorporate principles of CP to reduce significantly the generation of refuse in the metropolis by targeting the sources, mainly the nonresidential sector, which includes the burgeoning industry, institutions, business centers, and corporate sector. These measures include reduction in the waste generation at the source with lesser consumption of packaging materials, stringent methods of resource utilization, and regulations governing the discharge of waste by large- medium- and small-scale dischargers.

The levy and collection of appropriate fees and discharge taxes should encompass all dischargers. Having more target groups for source segregation would allow a source-separated waste for further downstream processing. Inclusion of the small- and large-scale private sector participation, community participation, and involvement of the local NGOs would definitely prove a boon for BMA, providing for integrated SWM as shown in Figure 16.4.

The objectives of reducing total waste generation and increasing its processing by promoting recycling and composting would decrease quantities of trash at different stages in the waste stream. BMA has to secure active cooperation and understanding of its citizens while promulgating its plans for the desired objectives. Sharing of responsibilities by citizens, corporations, and administrative bodies would allow the establishment of an effective system that would cater to the urgent needs of sustainable development of the metropolis.

An analysis of the approaches to be adopted in the future with an understanding of the present scenario reflects BMA's people-oriented approach, which would encourage greater public participation through voluntary groups who could help with promotional materials and dissemination of information. The implementation of the proposed plan with its various approaches for CP concepts would achieve by 2019 a total per capita refuse discharge of 1.1 kg per capita per day (residential 0.468 kg and nonresidential 0.632 kg) by significantly reducing the nonresidential waste from the projected value of 1.625 kg per capita per day (without a plan). Bangkok would be generating a daily waste volume of 10,562 tons with CP options instead of 15,065 tons without the changed strategy (a reduction by 30% of the total discharge).

A recycling of 15% waste and composting of another 20% would further decrease the waste disposal amount to 6,865 tons (without incineration), ensuring longer life for the landfills. Introduction of incineration facilities would further decrease the landfilled waste by 20% to 25%. This objective could only be achieved by using the CP options in the upstream of waste

collection, which begin with reduction among the population in consumption patterns and source segregation for reuse, recycling, and composting, instead of downstream reduction, as presently practiced. To achieve the objective, strengthening of the BMA infrastructure and its institutional capacity would required for sustainable development within the framework of the principles of CP for well-coordinated urban refuse management.

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