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Solid Waste Management: Issues and Challenges in Asia

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Report of the APO Survey on Solid-Waste Management 2004–05

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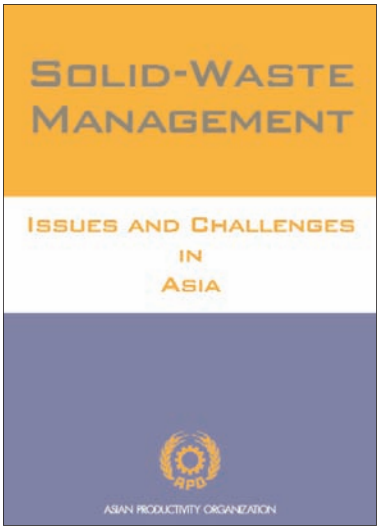

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Solid-Waste Management

Issues and Challenges in Asia

ASIAN PRODUCTIVITY ORGANIZATION

SOLID-WASTE MANAGEMENT

ISSUES AND CHALLENGES IN ASIA

2007
ASIAN PRODUCTIVITY ORGANIZATION
TOKYO

Report of the APO Survey on Solid-Waste Management 2004–05

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FOREWORD

One of the most obvious impacts of rapidly increasing urbanization and economic development can be witnessed in the form of heaps of municipal solid waste. Based on estimates, waste generation in Asia has reached 1 million tons per day. A World Bank study showed that urban areas in Asia spent USD25 million per year on solid-waste management, and this figure will increase to USD47 million per year. Despite the huge expenditures, urban areas in most APO member countries are still grappling with the challenge of preventing environmental degradation due to nonsystematic solid-waste management. Apart from the contamination of water resources and severe air pollution due to the open burning of solid waste, the health hazard is another key issue to be addressed. Solid-waste management has become an important issue in the Asia-Pacific region, and it needs to be resolved through an integrated community, private-sector, and policy-based approach.

Since recognizing the significance of solid-waste management, the APO has been organizing multicountry workshops, seminars, and conferences to discuss related issues and problems in member countries and devise solutions. A survey was conducted on solid-waste management in 11 APO member countries: Bangladesh, Republic of China, India, Islamic Republic of Iran, Malaysia, Nepal, Philippines, Singapore, Sri Lanka, Thailand, and Vietnam to assess current solid-waste management practices and to highlight issues, problems, and the initiatives undertaken to tackle them. This survey was also an attempt to create a consolidated database on solid waste that can be utilized for planning purposes at the national level and for strategy formulation for regional planning.

The APO has been promoting Green Productivity, i.e., the integration of productivity enhancement and environmental protection, as a method for sustainable socioeconomic development, which can help member countries adopt simple, down-to-earth measures for systematic solid-waste management. This survey also encompassed such endeavors and activities undertaken by the target countries.

This volume contains information collected during the survey on solid-waste management in the 11 countries, including waste-generation profiles, regulatory frameworks, solid-waste management governance, waste-collection and disposal mechanisms, Green Productivity activities, etc. I hope that this publication will be useful for policymakers, planners, and solid-waste-management professionals, giving them a better insight into the issues involved and developing a perspective for addressing them.

Shigeo Takenaka
Secretary-General

Tokyo
August 2007

Part I

Overview of Solid-Waste Management in Asian Countries

OVERVIEW OF SOLID-WASTE MANAGEMENT IN ASIAN COUNTRIES

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BACKGROUND

Solid-waste management is a major challenge in urban areas throughout the world. Without an effective and efficient solid-waste management program, the waste generated from various human activities, both industrial and domestic, can result in health hazards and have a negative impact on the environment. Understanding the waste generated, the availability of resources, and the environmental conditions of a particular society are important to developing an appropriate waste-management system.

Solid-waste management may be defined as the discipline associated with controlling the generation, storage, collection, transfer and transport, processing, and disposal of solid waste in a manner that is in accordance with the best principles of health, economics, engineering, conservation, aesthetics, and other environmental considerations, and that is also responsive to public attitudes. In its scope, solid-waste management includes all administrative, financial, legal, planning, and engineering functions involved in the solutions to all problems of solid waste. The solutions may involve complex interdisciplinary fields such as political science, city and regional planning, geography, economics, public health, sociology, demography, communications, and conservation, as well engineering and materials science.

For instance, if waste is wet or has a low heating value, it would not be possible to incinerate it without adding supplemental fuel. If a portion of the waste stream consists of organics and can be easily separated from other waste materials, bioconversion of the waste may become a viable strategy. On the other hand, the waste generated by industrialized countries may be different from those generated by nonindustrialized countries. Nonindustrialized societies may have more organic waste than those generated by industrialized countries. If this is the case, composting or anaerobic digestion may be more suitable for organic waste management.

The activities associated with managing solid waste from the generation point to final disposal normally include generation, reduction, reuse, recycling, handling, collection, transfer and transport, transformation (e.g., recovery and treatment), and disposal. Depending on site-specific conditions, a sound waste-management program can be established by combining some of the necessary activities into integrated solid-waste management. On the other hand, legislative efforts and effective implementation are vital for the safe management and disposal of solid waste. Incentives may be provided for the development and practice of safe treatments, harmless manufacturing processes, and methods for converting solid waste into valuable resources by recycling and reuse. On the part of industry, industrial waste-management is also indispensable from the viewpoint of both the social responsibility of business corporations and ISO 14000, which will influence their survival in global markets.

Keeping the above background in view, the fact-finding survey has been conducted to study the current situation, major problems, and techno-managerial practices on solid-waste management in the member countries. It is the purpose of this APO project to gather solid-waste management information from member countries to develop a combination of processes and innovative approaches to manage and treat the solid-waste stream. Eleven APO member countries participated and completed the survey studies: Bangladesh, the Republic of China, India, the Islamic Republic of Iran, Malaysia, Nepal, Philippines, Singapore, Sri Lanka, Thailand, and Vietnam. This paper presents the findings of the survey study on solid-waste management in these 11 member countries.

OBJECTIVES

The objectives of the survey study are:

1. To study the current situation and major problems in member countries in the generation, reduction, reuse, recycling, handling, collection, transfer and transport, transformation (e.g., recovery and treatment), and disposal of solid waste;
2. To gain information on the prevailing technologies and practices of solid-waste management collection, transformation, and disposal;
3. To study ways and means to manage solid waste for reduction, reuse, recycling, and recovery; and
4. To explore policy measures and industrial actions to minimize the undesirable impacts generated by solid waste.

SOLID-WASTE MANAGEMENT POLICY AND LEGISLATION

The 11 participating member countries in this project have established legislation for environmental protection. Most of these countries have also set up different ministries to handle the environmental issues. The legislation for water- and air-pollution control are comprehensive and well established, but not for solid-waste management. Solid-waste management is still very much a municipal government responsibility. A long-term strategy on solid-waste management is still lacking in the developing Asian countries.

Like many other developing countries in the world, concerns in the region are growing in both the governmental and public sectors for an effective and economic management of solid waste. The lack of awareness, technical knowledge, legislation, policies, and long-term strategy are major issues for solid-waste management in Asian developing countries.

SOURCES AND QUANTITIES OF SOLID-WASTE MANAGEMENT

In the purview of management and legal aspects, solid waste in Asian countries can be broadly defined as waste other than liquid or gaseous waste. The sources and quantities of solid waste depend on various factors such as economics, culture, heritage, industrialization, and season. The sources of solid waste include: domestic waste, commercial waste, hospital waste, and hazardous waste.

The amount of solid waste generated in the cities is much higher than in rural areas. The generation rate in rural areas can be as low as 0.15 kg/cap/day, while in the urban areas the

Table 1.1: Solid-Waste Generation Rates of Major Asian Cities

City	Country	Generation rate (kg/cap/day)
Delhi	India	0.47
Dhaka	Bangladesh	0.50
Urban	Islamic Republic of Iran	0.80
Penang	Malaysia	0.98
Katmandu	Nepal	0.30
Manila	Philippines	0.66
Singapore	Singapore	0.94
Colombo	Sri Lanka	0.62
Taipei	Republic of China	0.95
Bangkok	Thailand	0.88
Hanoi	Vietnam	0.63

rate can be above 1.0 kg/cap/day. The generation rates of major cities reported by the participating member countries are listed in Table 1.1.

The composition of solid waste varies significantly in the different cities in the region. Even within a city the composition varies with location and time. In general, the solid waste contains more organic components than other materials. The average percentages of organic matter in the solid waste in major cities in Asian countries ranged from 50% to 70%.

STORAGE, COLLECTION/TRANSPORTATION, TREATMENT, AND DISPOSAL

Since dumping waste on the roadside or in other public places is a common practice in Asian developing countries, street sweeping is one of the important activities in the waste-management system. The municipalities employ sweepers to sweep the city streets and public areas by using simple tools and facilities. Major streets are generally swept on a daily basis, sometimes more than once a day, while other streets are swept less frequently. The wealthier cities in Asia use fully automatic sweeping machines.

Sweeping-waste, together with other household waste, is commonly placed in plastic bags or other containers and stored at the collection centers. Community containers are placed at the roadsides to be collected by vehicles or hand-operated carts. Generally, Asian cities collect their household waste once a day. The frequency can be lower in some certain cities because of budget constraints. The lowest collection frequency is twice weekly. However, the collection area coverage in a city can be as low as 50%. The frequency and area coverage for solid-waste collection are limited by the municipal budget. The frequency can range from twice a day for the wealthy neighborhoods to twice a week for the poor neighborhoods—the wealthy neighborhoods are provided with adequate collection systems, but poor neighborhoods do not enjoy the same treatment. Once collected, domestic solid waste is transported to disposal sites by open trucks and/or compactor trucks. As for industrial solid waste, most major cities in Asian countries contract out to private sectors for the collection and transportation to the appropriate disposal sites.

INFRASTRUCTURES FOR SOLID-WASTE MANAGEMENT

The main disposal methods for municipal solid waste in Asian developing countries are open dumping and sanitary landfill. Overall the environmental condition of the uncontrolled dumpsites is extremely vulnerable, with severe environmental pollution. On open dumping grounds, foul odors and air pollution are dangerously affecting the surroundings. Rodents are spreading pathogens in the surrounding areas and the workers are highly exposed to disease and hazardous waste. Some cities dispose of their waste in sanitary landfills. The landfills are generally well operated and maintained. However, leachate treatment may not be commonly practiced in some cities due to resource constraints. Leachate from open dumping or sanitary landfill may cause serious water pollution if no proper treatment is provided.

Financially-capable cities with land scarcity have opted for incineration for municipal solid-waste disposal. Extensive air-pollution-control facilities are installed in the incinerators. The issue of dioxin, however, is not handled adequately. After incineration about 10% of the residue has to be disposed of in a secure landfill.

GREEN PRODUCTIVITY PRACTICES FOR SOLID-WASTE MANAGEMENT

Asian countries are concerned with the ever increasing amount of solid waste in their municipalities. The increase of solid waste in every Asian city is mainly attributed to population increase, industrialization, and the improvement of living standards. The governments have realized that Green Productivity (GP) measures such as reduction, recycling, reuse, and recovery are essential elements in solid-waste management as a form of checking the rapid growth rate of waste in the cities. National awareness campaigns on GP measures are held regularly to promote recycling activities.

Waste segregation is the initial stage for GP practices. Residents are encouraged to separate their waste and bring it to the appropriate locations for collection. Paper, scrap metal, glass, and plastic are the common items segregated and collected by the waste pickers. Waste pickers play a significant role in recycling activities. They—individuals or groups—collect saleable items from the waste-collection bins, households, and dumpsites. Organic waste is converted into compost in several cities as a part of their recycling activities. However, the rate of recycling in Asian developing countries is far from satisfactory. The low recycling rate can be attributed to poor strategic planning and to the implementation and enforcement of the policies. Lack of good incentives can also be a main factor in the poor waste recycling rate.

GP measures for solid-waste management not only reduce waste, but recover useful resources as well. Some Asian cities have long-term plans for zero-waste generation. Even though it may be a difficult task to achieve in the near future, measures and policies are being developed to move toward the target of zero-waste generation.

SUMMARY

Solid-waste management is a major challenge in Asian cities. Significant amounts of the municipal operating budgets are allocated for solid-waste management in every city. The amount of solid-waste generated in Asian cities has increased tremendously in the last decade, mainly due to the improvement of living standards, rapid economic growth, and industrialization in the cities. Resources in urbanized cities cannot meet the ever increasing quantity of waste generated by human activities. Enhancing the effort has to be the focus of managing the waste appropriately.

Based on the APO survey study on solid-waste management in 11 member countries, it is obvious that every member country has put in a great deal of effort toward handling the solid-waste problems encountered. However, a lack of awareness, technical knowledge, legislation, policies, and strategies are major issues for solid-waste management in Asian developing countries. The regional governments have to strengthen their efforts to control the rapid growth rate of solid-waste generation and to allocate adequate resources for solid-waste management. GP measures including reduction, recycling, reuse, and recovery should be enhanced immediately. Governments may also have to enhance the appropriate legislation to promote GP measures with financial incentives.

Part II

Green Productivity Approaches to SWM: Turning Waste into Profit

GREEN PRODUCTIVITY APPROACHES TO SWM
Turning Waste into Profit

Augustine Koh
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INTRODUCTION

The 2002 World Summit on Sustainable Development in Johannesburg stated that sustainable development should continue to be a part of any development initiative. In addition, the concepts of sustainable development have been strengthened and broadened to incorporate aspects of poverty alleviation, production and consumption, and the efficient use of natural resources.

Solid waste has been a problem since mankind decided to live in communities. Urban settlements all over the world face the dilemma of how to dispose of their waste. Maslow's Hierarchy of Needs Theory says that every human being strives for the basic necessities of food, clothing, and shelter. Thus for as long as economic and population growth takes place, production will attempt to meet the demands of consumption by the expanding human race. Even small island nations are not exempt from the problems of solid-waste management (SWM). The Barbados Program of Action for Small-Island Developing States (SIDS) clearly stated that the management of waste is a critical issue for island nations because of its adverse effect on the tourism sector. It also highlighted that long-term disposal options are limited and will constrain sustainable development, and that therefore SIDS need to look for ways of minimizing and/or converting waste into a resource.

It is recognized that the fundamental changes in the way societies produce and consume are indispensable for achieving global sustainable development. Therefore delinking economic growth and environmental degradation through improved efficiency and the sustainable use of resources and production processes will ultimately reduce pollution and waste. Similarly, in the quest for solving solid-waste problems, the social, economic, and environmental gains should be an integral part of any development strategy to achieve the triple bottom line for business and society, i.e., profits, quality, and environment. This is the Green Productivity approach to problem solving.

TURNING SOLID WASTE INTO PROFITS

The growing volume of waste spawned by changes in consumption patterns is presenting a formidable challenge to all. The problem is how to deal with a large increase in waste without changing the lifestyles of the people.

The current practice in most municipalities is to dispose of their waste into open garbage dumps. More economically advanced countries have opted for sanitary landfills and/or incinerators. These options are still, however, generating controversies within the population. The search for environmentally safe and socially acceptable sites for waste disposal has become a perennial concern that seems impossible to solve. Many municipalities have investigated many options, but finding a site for a new landfill is becoming extremely difficult because of the "not in my backyard" (NIMBY) syndrome. It is expected that with further urbanization and industrialization, this problem will worsen.

Pressure to protect the environment is now coming from the public through media reports and Non-Governmental Organizations (NGOs). Many governments have responded by finalizing solid-waste management bills or plans. These planned actions are putting pressure on industry to change the way solid waste is managed in order to be compliant in the future. As a result of these actions, there is a significant change in the attitudes of public and local authorities toward waste disposal, particularly with the management of open dumps, in view of the low initial capital investment and operating costs incurred by the local authorities. Most island states, however, have the problem of limited site options for the development of land dumps.

As such, waste disposal and pollution control are national dilemmas that require a firm new initiative. New and innovative practical measures have to be implemented to avoid using landfill or incinerator options as the final and only solution, taking into account that land is limited within many urban areas. Therefore issues have to be dealt with in an integrated perspective, one that is in line with the vision of sustainable development as agreed at the 2002 WSSD in Johannesburg and in the Barbados Programme of Action for small island states.

An Alternative Option to the Current Practice of Landfills

The waste that is currently disposed of in dumps, landfills, or incinerators presents the greatest potential for recycling, processing, or reuse. In many countries, inorganic waste such as paper, metals, and plastics are readily recycled, as the world demand for this waste is growing. What is needed is the creation of a proper management system for recycling so that this waste can be sold based on world prices. More and more countries are using the materials-recovery facility option to gather these valuable items. With a proper management system at the institutional level (such as schools) most inorganic waste can be taken out of the disposal system. Many innovative systems are currently being practiced in Asia and when these systems are copied throughout the region, inorganic waste will not be a major problem to many mayors. Hazardous and medical waste will not be discussed here as it needs a totally different system.

Since organic waste forms the bulk of the problems, this chapter will focus on the strategies for handling organic waste. Organic waste can constitute as much as 70% of the total waste stream. Selected organic waste can either be reduced or transformed into organically beneficial products through the application of new and innovative approaches and technology for the reuse of these resources for energy, organic fertilizers, and animal feed. This will ultimately create new methods for improving the quality of life of the people. In addition, such an approach is in line with the principles of sustainable development where the efficient utilization of resources is closely linked with poverty alleviation goals. These come from the following dominant sources:

- municipal waste, e.g., restaurant and kitchen waste, domestic organic waste and sewerage, and waste from the food processing industry, and
- agricultural and crop processing, e.g., crop and garden waste, sawdust and fruit waste, chicken and other animal manure, and waste from abattoirs.

During the last two decades, development activities in the agriculture and fisheries sectors concentrated mainly on aspects related to the processing of inputs to produce outputs for consumption, with little concern about the waste produced—which often ended up in dumpsites. To a great extent such waste can be prevented from reaching dumpsites if a closed-loop system is developed. This system requires identifying compatible wastes so that they become the inputs and raw materials for another production cycle. Under the closed-loop system, commonly known as *Junkan* in Japan, it is possible for the idea of an eco-circulation to materialize.

The Current Approach to Waste Disposal

The current practice in waste management is for each sector or industry to deal with its issues of waste individually and usually within its own setup. For example, the food factory uses the end-of-pipe treatment as the only option for waste disposal to meet environmental quality requirements. Unfortunately industry has not realized that by going beyond their four walls food-waste problems can easily be solved, and at the same time it could also be productive to use its waste as a raw material for another production process, producing saleable outputs. This is the core concept of industrial ecology. It is therefore important to look at the issue of waste management horizontally, as one that cuts across all sectors. Figure 1.1 illustrates this idea.

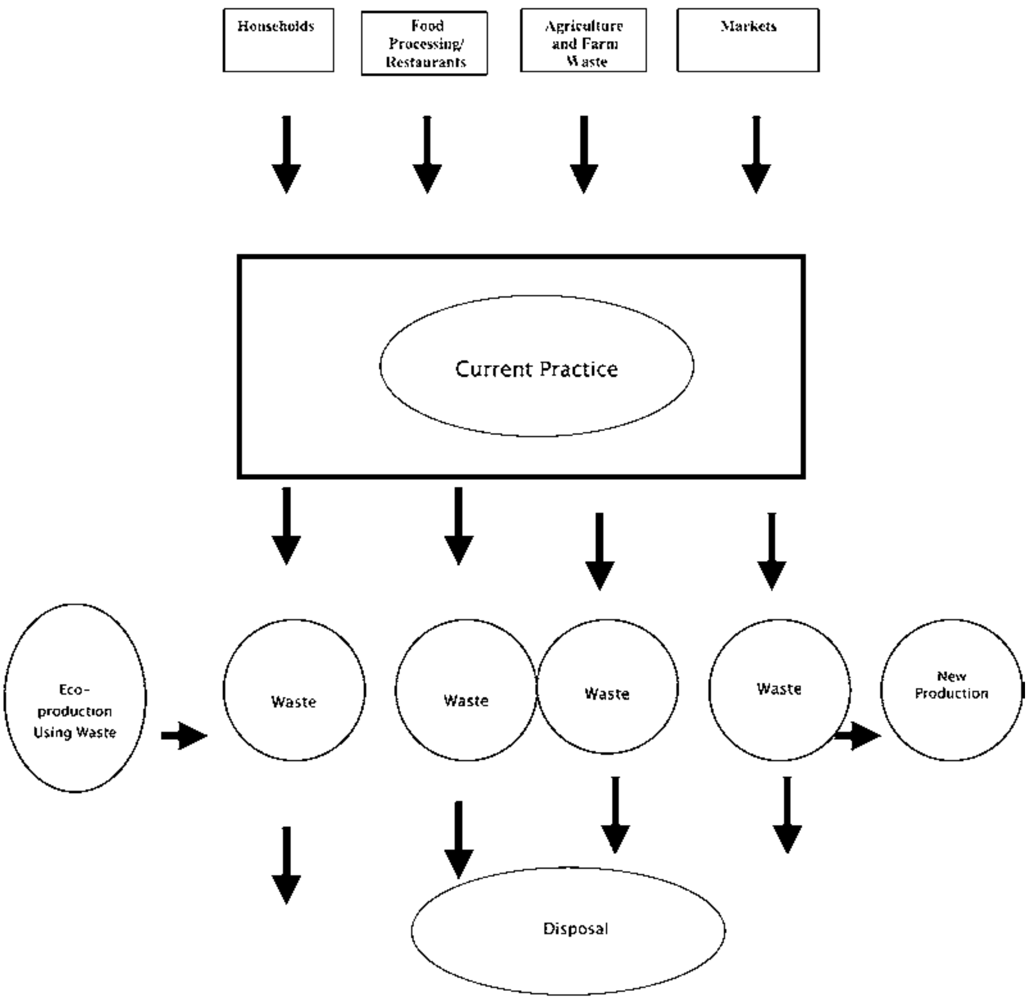

Figure 1.1: Cross-Sector Integrated Approach

NATIONAL PERSPECTIVE FOR THE CREATION OF ECO-CIRCULATION

From a national perspective, factories, farms, food-processing plants, restaurants, etc. that are located within or near the community could become part of the Green Productivity (GP) approach whose foundation is based on sustainability strategies. It is an approach that will ensure a clean, safe, and healthy environment for the proposed area and its surroundings.

The implementation strategy calls for a staggered approach. The first priority is to focus on waste that is not contaminated by hazardous materials. Thus restaurants, kitchens, and food-processing factories are our first target. The second priority is the organic waste from other sources, such as agricultural waste, domestic, and farm waste. Finally, we could go for domestic waste, which is more difficult due to the unknown quality of the waste and the need to deal with the general population.

The implementation of an eco-circulation society for a Green and Productive community is based on the sustainable development principle. The process views waste as an effective resource and input for the production of new products and not as a throw-away item that can become a source of pollution. The concept of *reduce, reuse, recycle* (3Rs) is an important component of the GP practice. To speed up the whole process of development, indigenous microorganisms and appropriate technology will be introduced. This process is based on an integrated system where every resource found in the locality would be considered for use. It would only utilize natural local resources. It is also a closed-loop system, as goods produced will ultimate find their way back into the system.

Implementation Strategies and Possible Implementation Plans

Organic waste should not be seen as a source of environmental pollution that has to be gotten rid of by putting it in landfills or burned in incinerators, as this could cause other pollution problems. It should be seen as a valuable resource that can be transformed into marketable products providing employment and profits. Natural or organic farming is an excellent possibility for integration into the process of *Junkan* for the creation of a Green and Productive society. The choice of plan(s) selected to be implemented would, however, be dependent on the prevailing situation in the area and the type of community/partners selected for implementation.

There are a number of possible plans for converting organic waste into valuable products as inputs for suitable and viable economic activities that will not only solve some of the environmental problems, but contribute to poverty eradication and sustainable development as well. They can be represented by the flowchart presented in Figure 1.2.

Given the situation in each country, we could prioritize our strategy as follows.

- Priority 1: Processing organic waste
- Priority 2: Possible activities for farming areas and communities

The plan calls for the processing of all organic waste that comes from factories, hotels, and restaurants into fertilizers or animal feed, which can be used in farms, animal production units, and aquaculture farms. Given the available technology, it will be possible to use high-speed processing machines to convert organic substances into fertilizers or feed. In addition, with this process there is a zero discharge of organic waste.

Agriculture is still a dominant sector of the economy in Asia, and many countries spend considerable foreign exchange for the purchase of fertilizers and feed for their farms. Producing fertilizers and feed, especially when they are organic in nature, will be good for the country

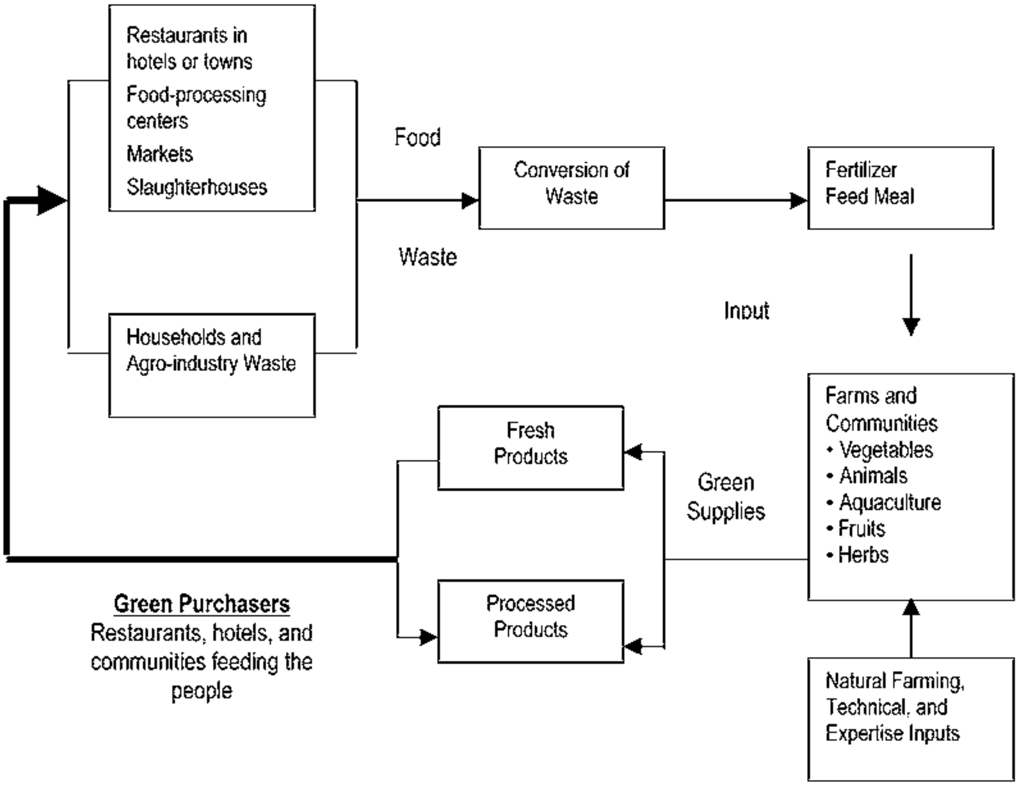

Figure 1.2: Flowchart of a Green and Productive Community

and will lead to foreign exchange savings. However, the farms are still not familiar with the usage of such fertilizers, so there is a need for training programs to educate the farmers on the use of these fertilizers and feed if they are to be utilized effectively and efficiently.

In proposing a production activity, it is important to link it with a ready and available market to absorb the organic fertilizers and feed that is produced in order to ensure viability. In this aspect, the Palace Hotel in Tokyo is an example, since it is processing all its organic waste and owns a farm that has the potential to absorb all the fertilizer that will be produced. The farm produce is then sold to the hotel for its guests' consumption.

Training, Research, and Development

It is of vital importance to establish a training, research, and development institute to ensure that the knowledge and skills related to natural farming techniques are constantly improved and updated, as well as disseminated to ensure sustainability. In this regard the existing farming ideas and activities being undertaken could be used to start up the activities related to training, research, and development. The research and development institute could:

- serve as a base for regional training in the techniques and methods of natural farming,
- establish demonstration plots showing different crops, and
- undertake joint collaboration with other international natural farming associations to upgrade the knowledge and skills in natural farming techniques

Besides conducting training in the techniques and methods of natural farming to farms and enterprises undertaking such activities, it is also important that training be provided to all other stakeholders—factories, restaurants, farmers, etc.—in creating an awareness that productivity and environmental protection can coexist harmoniously.

CONCLUSION

One of the results that is achieved through the implementation of these initiatives is the vast reduction in the mass and volume of waste. This alone represents a major breakthrough in reducing transportation and traditional landfill-disposal costs. In addition, several development activities such as processing, energy generation, and farming will be created, creating new employment opportunities for the local population and leading to income generation and poverty reduction.

Part III

National Reports

1. BANGLADESH

G. M. Jainal Abedin Bhuiya
Deputy Secretary
Ministry of Industries

INTRODUCTION

Bangladesh faces a huge solid-waste management problem. Much of the country, and especially the capital city of Dhaka, is facing the impact of urbanization, as a growing population houses itself in congestion, leading to a severe pressure on infrastructure facilities at all levels. This has resulted in a decline in sanitation, which in turn causes adverse health impacts. The legal framework is not supported by timely enforcement actions and there is a general lack of funding to develop common facilities for efficient waste management. This report is a commentary on all these aspects.

COUNTRY PROFILE

Physiography and Climate

Bangladesh lies in the northeastern part of South Asia. The country occupies a total area of 147,570 sq km. It is bounded by India on the west, north, and northeast, by Burma on the southeast, and by the Bay of Bengal on the south. The country is mostly low, flat, and fertile land except for the hilly regions and some highlands in the north and northwest.

A network of rivers—the Padma, Jamuna, Teesta, Brahmaputra, Surma, Meghna, and Karnaphuli are the most important—and their approximately 230 tributaries have a total length of about 24,140 km and flow down to the Bay of Bengal.

Demography

As of 1991, the population of Bangladesh was 111.4 million. The population was 20.1% urban and 79.9% rural. The intercensal population growth rate estimated by using adjusted population of 1991 census was 2.1% per annum. The population was projected to reach 135 million by 2005.

Governance

Bangladesh is governed by a parliamentary type of government. The constitution provides for a unicameral legislature, which is called *Jatiya Sangsad*. It consists of 300 members directly elected by adult franchise. The members of Jatiya Sangsad elect another 45 female members. Thus, the total number of members of the Jatiya Sangsad is 345. Jatiya Sangsad is the national parliament and is vested under the constitution with all powers to make laws for the country. The Prime Minister (PM) is the chief executive of the country and is the majority party leader. The PM is selected by the President. The PM has a Council of Ministers.

For administrative convenience the country is divided into six divisions placed under divisional commissioners. The divisions are further divided into 64 districts each of which is again divided into *Thanas* which are governed by *Zila Parishads* and *Thana Parishads*. The authorities at the local government are elected by the people. Such bodies in the urban areas are called Municipalities (*Paurashavas*) and in rural areas these are called Union Parishads (*Union Councils*). Ward is the lowest level of local government administration and is represented by a ward commissioner.

Economy

Bangladesh is predominantly an agricultural country, but a large number of industries have been set up. The raw material sources are both indigenous and imported. The GDP growth of the country between 1991 and 1996 was 4.1% per year. The agriculture sector grew at only 1.8% whereas the industry and commercial service sectors at 5.6% and 5.9%, respectively. The relatively low potential growth of the agriculture sector is due to little expansion of arable land and the slow increase in productivity. Future economic growth will depend more on the secondary and tertiary sectors, which are mostly located in urban centers. A brief on the national economy along with comparisons over the years is presented in Table 1.1.

The important industrial sectors of Bangladesh are garments, cotton and textiles, jute, paper and newsprint, sugar, cement, chemicals, pharmaceuticals, fertilizers, and tanneries. The other notable important industries are engineering, iron and steel including re-rolling mills, oil refinery, paints, colors and varnishes, electric cables and wires, electric lamps, fluorescent tube lights, other electrical goods and accessories, matches, and cigarettes. Important contributions to the economy from cottage industries come from handlooms, carpet making, shoe making, coir, bamboo and cane products, earthenware, brass and bell metal products, indigenous tobacco products, small tools and ornaments, and wooden and steel furniture. The industrial sector contributes about 11.5% to the GDP, of which the contribution from jute processing is the highest, followed by cotton, textiles, cigarettes, and the garment industry.

In Bangladesh the labor force grew faster than the population. It was estimated to be 42.97 million during 1996–97, of which 34.7 million were male and 8.27 million were female. These figures do not include the female labor engaged in activities like poultry, livestock, paddy husking, preservation of food, etc. conducted in rural households. The 1995–96 Labour Force Survey (LFS) estimated the female participation rate at 18.1%. Employment on a man-year basis has, however, increased and the absolute unemployment, as well as underemployment, has dropped. Nevertheless, agriculture still employs the highest percent of labor (63.2%). The informal labor force dominates the labor market. The LFS, 1995/96 showed that about 40.1% were unpaid family workers, 17.9% were day laborers, 12.4% were regularly employed workers, and 29.6% were self-employed.

Table 1.1: National Economy and Its Progress in Bangladesh

Indicators	Unit	1998	2001	2002
GNI, Atlas method	USD	45.1 billion	50.7 billion	51.1 billion
GNI per capita, Atlas method	USD	360 billion	380.0 billion	380.0 billion
GDP	USD	44.1 billion	47.0 billion	47.6 billion
GDP growth	Annual %	5.2	5.3	4.4
Value added in agriculture	Annual % growth	25.4	24.1	22.7
Value added in industry	% of GDP	25.8	25.9	26.4
Value added in services	% of GDP	48.7	50.0	50.9
Export of goods and services	% of GDP	13.3	15.4	14.3
Import of goods and services	% of GDP	18.3	21.5	19.0
Gross capital formation	% of GDP	21.6	23.1	23.1

More than one-third of the employed persons both at the national and rural levels are underemployed. The underemployment is much higher in the female population than in the male population.

Environmental Profile

Like all other developing countries, concern for the environment is growing in Bangladesh at all levels, including the government, for an effective and economic management of environmental issues. In Bangladesh, the Ministry of Environment and Forestry is the authority for making environmental policy, regulations, standards, and enforcement. Its implementing agency is the Department of Environment. In the fourth Five-Year Plan (1990) the government's environmental objectives have been described as follows.

- Control pollution and degradation related to soil, water, and air.
- Promote environment-friendly activities in the development process.
- Preserve, protect, and develop the natural resource base.
- Strengthen the capabilities of the public and private sectors to manage environmental concerns as a basic requisite for sustainable development.
- Create public awareness to encourage participation in environmental promotion activities.

National Environmental Regulatory Framework

The Environmental Conservation Act 1995 (ECA 1995), the Environmental Conservation Rule (ECR 1997), and other national-level basic laws and regulations are stipulated for environmental issues. However, even prior to these rules, provisions existed that addressed environmental issues. Subsequently, the government has given its highest priority to the environment and passed the Environmental Court of Law 2000 for completing environmentally related legal proceedings effectively.

The development of the environmental legal framework can be understood from Figure 1.1. The important environmental provisions of Bangladesh, along with their salient features, are presented in Box 1.1.

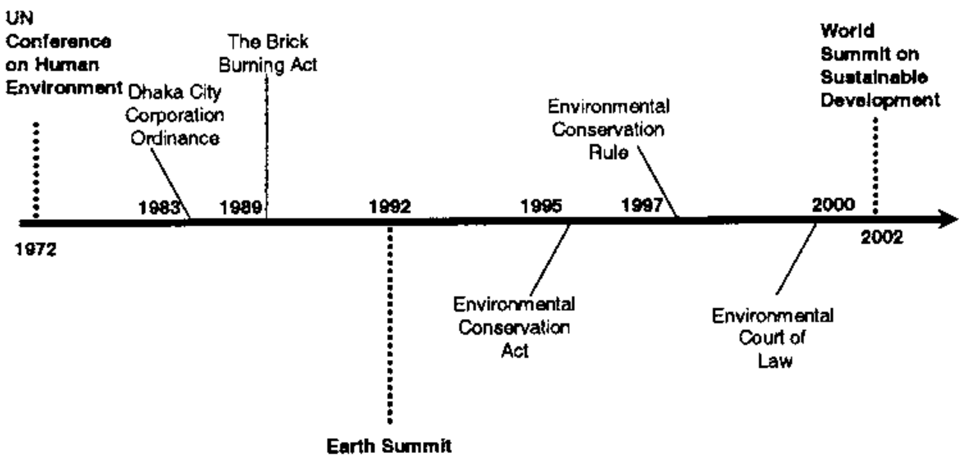

Figure 1.1: The Environmental Legal Framework of Bangladesh

Box 1.1: Important Environmental Provisions of Bangladesh and Their Salient Features
Brick Burning (Control) Act, 1989 (act number 8 of 1989), Amended 1992 • Controls brick burning • Requires a license from the appropriate authority • Restricts brick burning with wood fuel Bangladesh Environmental Conservation Act, 1995 (ECA 1995) • Declaration of ecologically critical areas • Regulation with respect to vehicles emitting smoke harmful to the environment • Environmental clearance • Regulation of the industrial and other development activities discharge permits • Promulgation of standards for air, water, noise, and soil quality for different areas and purposes • Promulgation of acceptable limits for discharging and emitting waste Environmental Conservation Rule, 1997 (ECR 1997) • The national environmental quality standard for ambient air, various types of water, industrial effluent, emission, noise, vehicular exhaust, etc. • Requirements of the procedures necessary to obtain environmental clearance • Requirement for TEE/ETA according to categories of industrial and other development inventories Environmental Court of Law, 2000 • To complete environmentally related legal proceedings effectively

The initiative on the legal front of environmental issues, however, has been far from adequate. This has been compounded by the lack of awareness and technical knowledge that is the major factor causing the deterioration of the environment.

Environmental Situation Analysis

The nature, extent, and impact of environmental problems are outlined in Table 1.2.

The contribution of Small and Medium Enterprises (SMEs) to the GDP is significant. However the increasing number of SMEs is aggravating the environmental problems due to the quantity of waste generated. The environmental performance of SMEs is poor and is understood to be because of a lack of policies, accountability, and technical knowledge in the concerned areas. The other features that have a bearing on the environmental condition and performance of Bangladesh are as follows.

- The government of Bangladesh is not providing any incentive to improve environmental performance in all relevant sectors.
- The Dhaka City Corporation (an autonomous organization) is providing very few incentives for managing municipal waste, which is inadequate for the existing management practices.
- Some development agencies like UNDP, UNICEF, and JICA provide some grants for the preparation of a master plan regarding solid-waste management. They have come forward to assess and to formulate policies and their implementation in different sectors of waste management.

Table 1.2: Nature of Environmental Problems and Their Impacts

	Nature	Impacts
Air Pollution	Urban air quality deterioration	Harmful for human health
Water Pollution	Untreated effluent disposal, fecal pollution, agrochemicals	Contamination of water sources Degradation of flora and fauna habitat Reduction of soil fertility Increased risk of water-borne disease Damage to ecosystem
Solid Waste	Industrial-waste disposal, municipal solid-waste disposal	Causes surface and groundwater pollution Damages ecosystem Decreases soil fertility Open dumping causes aesthetic problems Causes threat to public health

With very limited resources, the government has recently taken some measures that will apparently seem insignificant, yet in the long run they can potentially prove to be of significance and beneficial to the country. Some of the important measures adopted by the government are as follows.

- The three-wheeler two-stroke engine ban in effect since September 2002
- Introducing environmentally friendly compressed natural gas (CNG) auto-rickshaws in Dhaka City
- Introducing CNG buses in Dhaka City
- Conversion of all petroleum-based vehicles to CNG
- A ban on the use of leaded petroleum
- A ban on the use of thin polybags since 2002
- Relocation of tannery industries from Hazaribagh, Dhaka to the Savar industrial area which has a central waste-treatment plant. It was approved at an ECNEC meeting in May 2004.

OVERVIEW OF SWM

Solid-waste management (SWM) has so far been the most ignored and least studied area in environmental sanitation in Bangladesh, as well as in other developing countries. But in recent years concern is growing in Bangladesh both at the governmental and other levels for the effective and economic management of solid waste. Until recently the collection and disposal of solid waste was only of technical and economic significance. Now, however, recovery and recycling are considered important management tools for SWM. The major impediments to appropriate solid-waste management are deficiencies in awareness, technical knowledge, and legislation.

Environmental Impact of Municipal Solid Waste

The important negative impacts due to inadequate solid-waste collection are: aesthetics, public health, traffic obstruction, contamination of ground and surface water, air pollution, disease transmission, on-site noise pollution, public relations, and potential on-site fire hazards. Due to low population density, the dominant agronomic activities in rural areas impact solid waste insignificantly.

National Solid-Waste Management Regulatory Framework

The brief account of the existing solid-waste management policies and the institutional framework given below will describe the framework in Bangladesh. It should be noted that, as in others sectors, the existing policies, laws, and regulations in this field are inadequate. The enforcing mechanism is even weaker. However, a waste-management division has been formed very recently in the Dhaka City Corporation (DCC) to look after the management of municipal solid waste along with other activities.

There are no specific legislation, regulations, and policies for solid-waste management at the national level, but according to DCC Ordinance 1983, amended in 1999, Article 78, the DCC is responsible for the disposal of solid waste from bin to disposal site and for cleaning the roads and drains.

The Stakeholders in SWM

The stakeholders involved in domestic and industrial SWM in Bangladesh are the local government bodies, Non-Governmental Organizations (NGOs), Community-Based Organizations (CBOs), waste-generating industries, the common people, environmental activists, academics, research institutions, and the media.

Local Government Bodies like City Corporations and Municipalities

These bodies act on behalf of the government on the basis of policies, laws, regulations, directives, etc., and play a very crucial role. They take the necessary measures to collect, transport, and dispose of or treat solid waste. Normally they receive funding from the government. In some cases, they earn revenue in the form of a municipality holding tax, trade-license fee, or other local taxes. There are no provisions for separate SWM charges in Bangladesh.

Non-Governmental Organizations (NGO) and Community Based Organizations (CBO)

At present, the activity of NGOs and CBOs is very important and plays a significant role in various socioeconomic activities. They also participate in environment-related activities.

The Common People

The common people are the biggest generators of waste. Their awareness can lead to a major change in the quantity and quality of waste generated in the country. But knowledge about waste among the common people is inadequate. It is therefore necessary to educate them so as to have better results.

Environmental Activists

Environmental activists act as opinion builders at various levels of society and bring the issues into the limelight.

Academics and Research Institutions

This group of people is engaged in academic and research activities. They can disseminate new developments in solid-waste management through lectures, seminars, and symposiums.

The Media

To have a quick and widespread response on SWM, the importance of the press and other media is unavoidable. The media remain at the center of all the activities. The common citizen and the implementing agencies are brought closer together by them. The media can play a very important role in motivating all stakeholders.

Solid-Waste Management Situation Analysis

In rural areas of Bangladesh, the environmental aspect of solid waste is virtually ignored and is considered largely a natural phenomenon, but the situation is quite different for big towns and cities. The six divisional headquarters—Dhaka, Chittagong, Khulna, Sylhet, Barishal, and Rajshahi—are almost identical except that the magnitude of SWM in Dhaka is much larger in terms of scale and complexity. Also less information is available on the SWM status of other cities. For this reason, the status of SWM in Dhaka will be discussed. It can serve to give readers an overall understanding of the SWM situation prevailing in Bangladesh.

Quantification and Characterization

The amount of solid waste depends on various factors like country profile, national economy, national culture, heritage, etc. When compared to developed countries, the people of Bangladesh produce different kinds of solid waste, depending on the sources, such as households, commercial places, industries, hospitals, etc.

Data concerning the quantities of solid waste is limited, but some NGOs, academic institutions, and researchers have conducted research on solid-waste management with a limited objective. For this reason, the projection of MSW sources and quantities is not precise. One estimate puts the total generation of solid and liquid waste in the country's 223 municipalities and towns at 20,000 tons per day. Due to the huge volume generated in large cities, SWM has become a critical issue for them and requires huge expenditures.

Key Elements of SWM

Primary Collection

Usually household solid waste is stored in an open basket or bin in the kitchen. Most commonly it is collected by CBO workers in the afternoon. Open vans are used for collection and transfer into the DCC bins.

Secondary Collection, Transportation, and Disposal

A secondary collection system has been adopted by the Dhaka City Corporation. Waste is transferred to the dumpsite at night using trucks and trolleys. Little treatment is done here. The waste is dumped openly and causes severe environmental problems.

Infrastructure Development

The existing infrastructure is inadequate for solid-waste management and is at the elementary stage of development.

Green Productivity (GP) Practices and Other Proactive Measures

Bangladesh became a member of the Asian Productivity Organization (APO) in 1982. The Special Program for the Environment (SPE) was established in 1994. The Environment Department (ENV) was established to promote Green Productivity and other environmental projects. However the phrase Green Productivity (GP) is not commonly known or used in Bangladesh by policy makers.

The APO's campaign and follow-up has created a general awareness at the governmental level. Key government ministries such as the Ministry of Industry (MoI), the Ministry of Environment and Forest (MoEF), the Ministry of Local Government, Rural Development and

Cooperatives (LGRD & C), as well as other ministries, are being apprised of the GP concept and its policies.

Future Strategies

There is not yet a national strategic action plan developed by the government of the People's Republic of Bangladesh, but an action plan is being developed by the Dhaka City Corporation for Dhaka City. JICA is assisting the corporation to develop an SWM master plan. There is also a proposal for preparing similar master plans for all other city corporations.

SOLID-WASTE MANAGEMENT IN DHAKA CITY

City Profile

Dhaka City was established in 1608 along the bank of the Buriganga River and was made provincial capital in 1905. In 1947 the city emerged as the provincial capital of then East Pakistan. After independence in 1971, Dhaka became the capital of Bangladesh. The metropolitan city of Dhaka now has an area of 360 sq km.

Dhaka's dominant feature is the small amount of land that is permanently flood free. Based on the major floods experienced in Dhaka from 1987 to 1989, flood-affected areas cover about 400–600 sq km. Practically all the flood-free land close to Dhaka has already been developed.

Dhaka City is located at 23° 43′ N latitude 90° 24′ E longitude. The climate is tropical with heavy rains in the monsoon season and bright sunshine for most of the year. Typical summer and winter temperatures range between 30–37° C and 10–20° C, respectively. The annual rainfall is about 2,540 mm and humidity is about 80%.

The total population in Dhaka City grew from 0.10 million in 1906 to 5.4 million in 2001, according to the 2001 census. The rapid rise in population of Dhaka City has been caused mainly by the large number of people migrating from rural areas. The data shows a male/female ratio of 1000/765. According to the 2001 census, Ward 6 has the largest population (136,422) and Ward 78 has the smallest population (26,519). It has been reported that the average population density is about 170 persons/ha in the Dhaka City Corporation area and about 330 persons/ha in old Dhaka. However, due to the unavailability of data concerning the land area of each ward, the population density has not been calculated at this stage. It is further estimated that the current population of Dhaka City has already become approximately 10 million for the metropolitan area. With a limited availability of flood-free land in Dhaka City, further densification and haphazard encroachment to the peripheral areas are in progress.

The literacy rate of Dhaka City is about 64.1%. The unemployment rate is 10% and another 10% or so are underemployed. The per capita income is about USD450. About 55% of the people live below the poverty line and half of those poor people live in slums and squatter settlements. The slum population has increased to about 3 million in the last decade, with almost no access to water supply, sanitation, solid-waste management, and other civic and social services.

Dhaka's economic contribution is significant, although there is no official data or system to estimate economic products at the local level. Considering that the garment industry contributes largely to the country's economic growth and that more than 90% of the manufacturers are located in Dhaka, the per capita GDP of Dhaka is much higher than the national average. Since Dhaka is a large urban agglomeration, the contributions of the commercial and service sectors are also significant. With well-provided economic and social infrastructures, Dhaka will be the engine of economic growth in the country.

Land Use, Infrastructure and Their Impacts

The Urban Planning Department is in the process of preparing land-use maps for 38 wards. Another study, funded by JICA, is also preparing land-use maps for Dhaka City. These maps will be made available by the DCC and utilized later in the study. The available residential land area is very scarce in Dhaka City. With an area of 360 sq km, Dhaka City has to accommodate more than 10 million people. Being the capital of the country, central government offices, large educational institutions, and hospitals also form part of the city.

Legally there was no designated place for solid-waste disposal several years ago, and public land was used for waste disposal. At present the Dhaka City Corporation has acquired land at Matuail, on the outskirts of the city, for the disposal of solid waste. According to an UNFPA report, Dhaka is one of the most polluted cities in the world. The three major issues of concern are air pollution, water pollution, and municipal waste.

In Dhaka City more than 3 million people do not have legal access to a water supply. Only 41% of the city's population has a continuous water supply. However the quality of the water is poor and the incidence of water-borne diseases such as diarrhea, cholera, dysentery, jaundice, typhoid, etc. is very high. An analysis of the drinking water (World Bank, 2000) from different sources revealed that both the total and fecal coli form counts of the samples were unacceptably high. It has been reported that the Buriganga River contains soluble chromium, which causes cancer. The major source of chromium is the leather industries, most of which are situated along the river in Hazaribagh.

The bodies of water within and around Dhaka City are polluted mainly due to the indiscriminate discharge of wastewater. About 45% of the population is connected to separate or combined sewerage systems and 11% of the population is connected to septic tanks. The rest of the population discharges wastewater directly or indirectly into the bodies of water. Lakes within the city are polluted. These bodies of water are often loaded with human excreta, decomposable kitchen waste, nondecomposable waste, and industrial effluents.

Solid-Waste Generation and Sources

In the purview of management and legal aspects, the specific definition of solid waste has not been developed in Bangladesh's solid-waste management, but broadly, all waste other than liquid and gaseous waste is considered solid waste. Four broad sources have been identified during the study of solid-waste management in Dhaka City. They are: domestic waste, commercial waste, industrial waste, and hospital waste.

More than 4,000 metric tons of solid waste is produced each day in Dhaka City. This waste, when dumped with other municipal waste on the open land, poses a serious threat to the health of the city's people. The generation details for various types of solid waste are given in the following sections.

Solid-Waste Characteristics and Quantification

The solid-waste generated mainly consists of food waste, paper, polyethylene, cloth, rags, garden trimmings, construction debris (brick, concrete, sand, and dirt), wood, leaves and branches, ferrous and nonferrous metal, glass, shredded skins and leather, hospital waste, slag, animal waste, industrial waste, old appliances, and miscellaneous waste. The chemical composition of the MSW plays an important role in its management. However this was not included

Table 1.3: Solid-Waste Generation by Income

Income Group	Family Size	Generation Rate kg/person/day
High Income (BDT25,000+)	3–5	0.50
Middle Income (BDT5,000–25,000)	4–8	0.45
Low Income (BDT5,000 and less)	4–9	0.29

as part of the study. As shown in Table 1.3, 0.29–0.50 kg per person per day of solid waste is generated in Dhaka depending on the study area.

Industrial/Hazardous Waste

Dhaka City Corporation functions on the basis of Dhaka Municipal Corporation Ordinance, XL 1983. The ordinance has no specific clause or section for industrial, hazardous, or clinical-waste storage, handling, collection, transportation, and disposal either by DCC or privately. So there is no specific organization to handle industrial or clinical waste. Most of the industries pass their liquid waste into the nearby low-lying land or canals, DCC surface drains, or the storm-sewer drains of DCC or DWASA (Dhaka Water and Sewerage Authority). The industrial solid waste is dumped into DCC bins or waste containers. It is estimated that the industrial waste generated in Dhaka City per day is about 300 tons. A few industries, namely Apex Tannery, Bata Shoe Co., and Industries of Beximco Group, have recently installed waste pretreatment units.

Biomedical Waste

There are over 500 clinics and hospitals in Dhaka City. It is estimated that about 200 tons of hospital and clinical waste are generated. This includes toxic chemicals, radioactive material, and pathological elements. According to the Directorate of Health inventory, the present average clinical-waste generation in the hospitals and clinics is 1 kg/bed/day, plus an extra 200 kg/year. It is estimated that 20% of this waste is highly infectious and hazardous to human life. This waste is dumped with other municipal waste into surface drains, sewer systems, storm-sewer systems, and DCC bins. Only one hospital authority claimed to have a pretreatment system. It has been reported that the newly formed Solid-Waste Management Cell (SWMC) of the DCC is planning to choose one of the two modern mechanisms for medical-waste disposal—incinerator or autoclave sterilizer. Of the two, the latter is preferred due to its eco-friendliness and cost effectiveness.

Key Elements of SWM

The Dhaka City Corporation (DCC) is responsible for the collection and disposal of solid waste generated in the DCC area. Only about 42% of generated waste is collected and dumped at landfill sites. The rest of the waste remains uncollected, which makes the future environmental scenarios of Dhaka City dismal and gloomy. Such inadequate and uncontrolled waste management causes serious health hazards and environmental degradation in the city.

Collection

DCC has about 7,156 cleaners employed for street sweeping and the collection of waste found in lakes. This does not cover dustbins, roadsides, open spaces, ditches, etc. There are 2,500 brick/concrete dustbins and 2,000 made of galvanized iron sheet. Waste collection is facilitated by 3,000 hand trolleys. After sweeping the streets, the sweepers temporarily store the waste at waysides. From there it is collected by hand trolleys. This small equipment is very suitable for collecting waste from alleys.

Usually households bring their refuse to the nearby community bins/containers located on the sides of streets. Recently, house-to-house waste-collection service has been launched in residential areas such as Kalabagan, Malibag, Old Dhaka, Dhanmondi, Mohammadpur, Mirpur, Banani, Nikunja, Gulshan, Baridhara, and Uttara. It is operated by CBOs or through private initiatives. The households are charged on the basis of the amount collected.

Rickshaw vans are used to transport the waste from the houses to municipal waste bins or containers. Street sweeping is done manually and debris is loaded from the curbside into the hand trolleys and delivered to the collection bins. DCC sweepers and cleaners sweep roads and clean drains and then dump the waste into nearby dustbins or containers using hand trolleys. The whole system, however, does not operate in an environmentally friendly manner.

Transport

For secondary collection from the waste bins to dumpsites, the DCC has 128 demountable container carrier trucks to collect the accumulated waste. There are also 242 open/covered trucks. Table 1.4 summarizes the capacity of DCC's fleet of 370 collection vehicles.

The trucks used to transport solid waste are evaluated as follows.

- Open garbage trucks: these trucks create a nuisance as they pass through the street. Sometimes efforts are made to cover them after loading the waste.
- Covered garbage trucks: The one- or two-men crews who load and unload the trucks from inside the truck may feel suffocated due to the small space.
- Container carriers: Usually a large space is needed for maneuvering these carriers near the containers. The waste is carried by hand trolley or rickshaw van and loaded directly into the container carrier. The container carrier simply lifts the container onto it. Loading by shovel is not required. Unloading is also done in the same way. Thus container carriers are preferred to open or covered trucks.

Table 1.4: Summary of the Collection Fleet

Description of Vehicle	Capacity in Tons	Year of Purchase	Country of Origin	No. of Units
Isuzu truck	3	1983	Japan	38
Tata 608 truck	5	1994	India	30
Tata 609 truck	5	1996	India	10
Tata 407 truck	1.5	1997	India	13
Tata 409 container carrier	3	1995	India	12
Ashok container carrier	5	1995	India	74
Tata 709 truck	3	1999	India	54
Tata 407 truck	1.5	1997, 1999	India	60
Tata 1613 truck	5	1999	India	20
Volvo truck	5	1999	Sweden	8
Volvo container carrier	5	1999	Sweden	24
Yuzin truck	3	2000	China	12
Other				15

Disposal

There are a number of ways to dispose of municipal solid waste. Open dumping is the most common and the cheapest method. Therefore it is widely used in developing countries and even in some developed countries. In Dhaka waste collected from the municipal waste container or waste bins is carried to the lone dumpsite at Matuail, some 3 km from the city corporation boundary. The DCC employs crude waste dumping at the Matuail landfill site, an uncontrolled dumpsite having no sanitary landfill arrangement. Although this is the only officially designated site, 5–6 unofficial dumpsites are found near the embankment dam from Gabtali to Hazaribagh. It is estimated that only 50%, about 1,800 tons of waste, is dumped at the Matuail and unofficial sites. Of the remaining waste, about 900 tons are used in backyards and landfills, 400 tons are dumped on the roadside and in open space, 300 tons are recycled by the rag pickers, and the remaining 100 tons are recycled at the generation point.

Because of waste dumping, foul odors and air pollution are dangerously affecting the surroundings. Rodents spread germs and pathogens in the area and workers at the landfill are regularly exposed to hazardous diseases. MSW in the presence of moisture gives off organic and inorganic contents which turn into leachate. A huge amount of leachate is generated from the uncontrolled dumping as the MSW percolates through the surface and contaminates the groundwater. Consequently, the risk of polluting the underground aquifers increases. There is no provision for the removal or treatment of leachate. The DWASA supplies about 1,500 MLD (million liters per day) of water, of which 82% is extracted from groundwater sources through 400 deep wells located at different parts of Dhaka City.

More land, which is very scarce and expensive in and around Dhaka, will be needed in the near future for use as landfill. In addition, a large area around the landfill site is rendered unsuitable for living or other activities. Therefore the present system of unsanitary landfill is unacceptable, and there is an urgent need to build sanitary landfill sites or adopt even better alternative options.

Green Productivity (GP) and Other Waste-Minimization Approaches

The concept of Green Productivity (GP) refers to integrating socioeconomic aspirations and a means to harmonize environmental protection and economic development. The key aim of sustainable development is to enhance the people's quality of life. Considering Green Productivity, Bangladesh will formulate a sustainable solid-waste management policy.

Parts of the waste, which have market value or other utility, are being reclaimed for reuse or recycling in informal ways. Paper and newspapers, broken glass, metal, plastic, used shoes and sandals, etc. are purchased house-to-house by a class of mobile purchasers (*Feriwala*). A section of the poor people (*Tokai*) also collects reusable and recyclable waste materials from the dustbins, containers, streets, and dumping sites. The waste pickers usually collect PET/plastic bottles, polyethylene or plastic material, cans, pieces of glass or bottles, rubber waste, empty cement bags, etc.

Most of this is recycled. It is estimated that about 30% of the waste generated is inorganic, of which 15% is recycled. Recently, at five locations in Dhaka City, waste composting has started demonstrations of decomposting and the conversion of organic waste into compost that can be used to produce bioorganic fertilizer.

Future Strategies and Action Plan

BRAC (Bangladesh Rural Advancement Committee), the DCC, and West Concerns have conducted a few studies of household and commercial waste, but no detailed study has yet been made of industrial or medical solid waste in Bangladesh. A complete study of industrial solid waste may be organized under the coordination of a national expert in the field of industrial solid-waste management. Such a study should consider the following.

- Taking an appropriate and proper step to develop a modern waste-management system
- Developing a solid-waste management policy for Bangladesh
- Conducting a project to assess the nature, extent, and impact of industrial solid waste
- Securing APO help by providing expertise and financing
- Providing immediate training for the study group

OBSERVATIONS AND RECOMMENDATIONS

As the previous sections have shown, the state of MSW and solid waste in general in Bangladesh is one of dire concern. Even though a legal framework has been established and some rules have been implemented, the lack of incentives and enforcement has led to an aggravation of the waste problem. There is also a perceptible risk to the health of the population because of the absence of regulated disposal facilities, which leads to open collection and dumping. Furthermore factors such as uncontrolled leachate, mixing municipal and biomedical waste, and the presence of carcinogens in the waste contribute to increasing the health disparities in exposed population groups.

Some of the recommendations based on this study are as follows.

1. Initiate steps for scientific and organized waste management using GP principles. This includes putting in place the necessary measures to collect, transport, and dispose of or treat solid waste.
2. Develop a new policy based on a renewed understanding of the environmental situation in the country.
3. Enforce the existing waste legislation and promote education and awareness among the people toward solid-waste issues and adverse health impacts.
4. Develop a common waste-management infrastructure.
5. Introduce incentives and emphasize efforts that promote reuse and recycling.
6. Seek funding from national and international bodies interested in managing solid waste and other environmental problems in Bangladesh.

Overall, despite resource constraints, the government of Bangladesh, as a member of the APO, has demonstrated a high level of commitment in embracing GP technology. It has taken important measures in terms of policies, plans, and programs to adopt various international initiatives in environmental management and in combating environmental decline. Other important stakeholders, such as NGOs, CBOs, industries, environmental activists, researchers, and the public, have been involved in varying degrees in the country's efforts. However, while GP provides an opportunity for the country's sustainable development, translating polices and plans into reality poses a challenge.

Therefore, the government policies and will of the people will have to work on a concurrent platform to introduce sustainability in Bangladesh. This requires efforts both within the country and internationally by calling for greater cooperation and collaboration among countries of the world, and especially among the members of the APO.

2. REPUBLIC OF CHINA

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INTRODUCTION

Growing waste volumes have resulted in a very undesirable environmental nuisance to the people in the Republic of China and will seriously affect the lifestyles and living environment of the next generations. The Waste-Disposal Act (WDA) passed in 1974 contained merely 24 articles. After eight consecutive amendments, the current WDA as amended in 2004 contains 77 articles. In the trend toward sustainable development, the conservation of natural resources, reduction of waste generation, promotion of waste recycling and reuse, and building a society with sustainable resources will become the major issues to be addressed by both the government and its people.

The waste-management policies of the Republic of China have been changing continually, parallel to the waste problems encountered. Its policy development for waste treatment and the disposal of municipal solid waste (MSW) can be divided into three distinctive phases, dealing with waste treatment by means of landfill, incineration, and garbage minimization and resource recycling.

COUNTRY PROFILE

The Republic of China (RoC), founded on 1 January 1912, is Asia's first constitutional democratic country. In 1949, due to serious setbacks after a long-running civil war against the Chinese communists, the RoC government was forced to relocate itself to its present place with territorial jurisdiction only over the island of Taiwan and adjacent islets.

Physiography and Climate

Taiwan is a small island (about 36,000 sq km) very close to the southeast coast of mainland China. It is separated from mainland China by the Taiwan Strait, which is about 220 km at its widest and 130 km at its narrowest distances. The island of Taiwan is about 394 kilometers long and 144 kilometers wide at its widest span.

It is located at the orogenic belt of the Pacific Rim. About 69% of the area of Taiwan is occupied by mountains, hills, and terrace terrains. The central mountain range runs from the northeast corner to the southern tip of the country. The main topographic features of the island of Taiwan include dormant volcanic mountains, foothills, tablelands, terraces, coastal plains, and river basins.

Demography

The Republic of China has a population of about 22 million with a population density of 622 persons per sq km, the second highest in the world. Due to an influx of population from rural areas, many urban areas on Taiwan have spread outside the official limits of its major cities to form metropolitan areas. The natural population growth rate per annum declined from 3.158% in 1961 to 0.6% in 1998. It then rose to 0.81% and then stabilized at 0.4% in 2003. This was mainly due to a decrease in the birth rate, which dropped from 1.38% to 1% in 2003.

Governance

The administrative system is divided into three levels: central, provincial/municipal, and county/city level with specifically entitled powers. The central government consists of a president directly elected by the RoC citizens and has been given powers in accordance with the constitution. The central government also consists of the National Assembly and five branches (or *Yuans*): Executive, Legislative, Judicial, Examination, and Control. The Republic of China is a multiparty country with 80 registered political parties, of which only 3 to 4 are presently playing an influential role in electoral politics.

To improve administration efficiency and follow the organizational reform policy, the political power of the provincial level has been effectively nullified since 1998. Besides, downsizing and restructuring have been adopted in recent years as a strategy for the organizational reform of the central government agencies. It is hoped that the number of the ministerial-level organizations of the Executive Yuan can be reduced from 35 to 22.

Economy

The Republic of China is widely renowned because of its economic development over the past four decades. The country has been termed one of "Asia's Four Little Dragons," along with Singapore, the Republic of Korea, and Hong Kong. It has experienced one of the highest growth rates among the developing economies in the world. During 1953–1990, its annual average economic growth rate was 8.7%.

As indicated in Table 2.1, the economic growth rates in terms of gross domestic product (GDP) were 5.42% in 1999, 5.86% in 2000, and hit its lowest point of –2.18% in 2001, the only year that the Republic of China ever suffered a negative economic growth rate during the past 50 years. The GDP growth rate bounced back to 3.59% in 2002, and 3.31% in 2003.

The Republic of China's GNP per capita increased from USD3,748 in 1986 to USD7,510 in 1989, with an average growth of 8.5% between 1981 and 1990. In 2001 the GNP was

Table 2.1: Major Economic Indicators of the Republic of China, 1999–2003

Item	Unit	1999	2000	2001	2002	2003
Economic growth rate (real GDP)	%	5.42	5.86	–2.18	3.59	3.31
Gross national product (GNP)	USD billion	290.5	313.9	286.8	289.3	295.9
Per capita GNP	USD	13,235	14,188	12,876	12,916	13,156
Changes in consumer prices (CPI)	%	0.18	1.3	–0.01	–0.2	–0.3
Average exchange rate	NTD per USD	32.27	31.23	33.80	34.8	34.0
Unemployment rate	%	2.9	2.99	4.57	5.17	4.99
Foreign exchange reserves (end of year)	USD billion	106.2	106.7	122.2	161.7	206.6

Source: The Directorate General of the Budget. *Accounting and Statistics of the Executive Yuan.*

USD286.8 billion and the per capita GNP was USD12,876; the GDP was USD281.2 billion, of which 31.09% was contributed by the industrial sector and only 1.95% by the agricultural.

The RoC economy relies greatly on the knowledge-based and value-added service industries, which have rapid GDP percentage growth rates, but the manufacturing industry still plays an important role in its economic development. Today, the major RoC industries include electronics, information technology, and petrochemical industries. The production values of electronic and information industries increased very rapidly from 12% in 1981 to 35% in 2002, especially in recent years. The PC, IC, Notebook, and LCD industries contributed most to this increase, yet the metal, machinery, and chemical industries have kept their proportions of the production values stable in the last 10 years.

In 2002, the MOEA announced a "Two Trillion and Twin Star" program, a four-year project to stimulate new investment and output values on semiconductor and flat-panel display (TFT-LCD in particular) industries. The goal aimed to push the production value to NTD1 trillion (USD29.6 billion) each, and to build the digital content and biotechnology sectors into star industries, all by 2006. Special promotion offices have been established since June 2001 for these four strategic industries.

Environmental Profile

The history of environment-related legislation in the Republic of China can be divided into three distinct periods: prior to 1980, 1980–90, and 1991 to the present. The maturation of environmental-protection laws during the last decade was coupled with a large increase in manpower and an improvement in enforcement. The net effect pressed the pollution-prone industries to install pollution-control equipment and had a strong positive impact on environmental quality throughout the country. This has placed the RoC's environmental protection standards on a par with those of the leading industrialized nations. Present laws are expected to bear fruit gradually after the start of the coming decade.

National Environmental Regulatory Framework

During the decades of rapid economic expansion, the Republic of China paid scant attention to environmental issues. When problems arose due to rapid industrialization, the government drafted relevant laws and regulations to cope with them. Thus, the early days were characterized by disorder and lack of a purposeful legal framework.

Prior to 1980, three cornerstones of environmental protection laws—the Air Pollution Control Act, the Water Pollution Control Act, and the Solid Waste Disposal Act—were enacted. Since they were unable to abate multimedia pollution impacts, during the 1980s the above three acts were tightened and revised, and two new acts, the Noise Control Act (1983) and the Toxic Substance Management Act (1986) came into effect.

Things began to change for the better in 1986 when the Executive Yuan set up the Environment Protection Task Force under its jurisdiction and clearly established the importance of a sustainable environment. The task force then formulated plans and advised policymakers to achieve "Economic Growth while Protecting the Environment." It was then superseded in 1987 by the newly established Environmental Protection Administration (EPA) under the Executive Yuan.

Concurrent with the Environmental Impact Assessment Act (1990) came a full-scale review and revision of all current environmental laws and regulations. Since the establishment of the EPA on 22 August 1987, a total of 14 sets of laws have been promulgated. They are listed as follows.

Statutes establishing the EPA
Environmental Impact Assessment Act
Air Pollution Control Act
Noise Pollution Control Act
Water Pollution Control Act
Marine Pollution Control Act
Solid Waste Disposal Act
Soil and Groundwater Pollution Remediation Act
Toxic Substance Management Act
Drinking Water Management Statutes
Environmental Agent Management Act
Environmental-Dispute Settlement Act
Statutes Concerning EPA Inspection Organizations
Statutes Concerning the Training of Environmental Workers

Later in 2002, the Resource Recycling Act was put into effect. The environmental regulatory framework along with the other features are presented in Figure 2.1.

The EPA is the central authority for implementing the control measures to prevent pollution and support international environmental initiatives. Through the preservation of ecological balance and environmental quality, the EPA's ultimate objective is to achieve sustainable development in the Republic of China. The organization of the EPA is composed of 15 functional

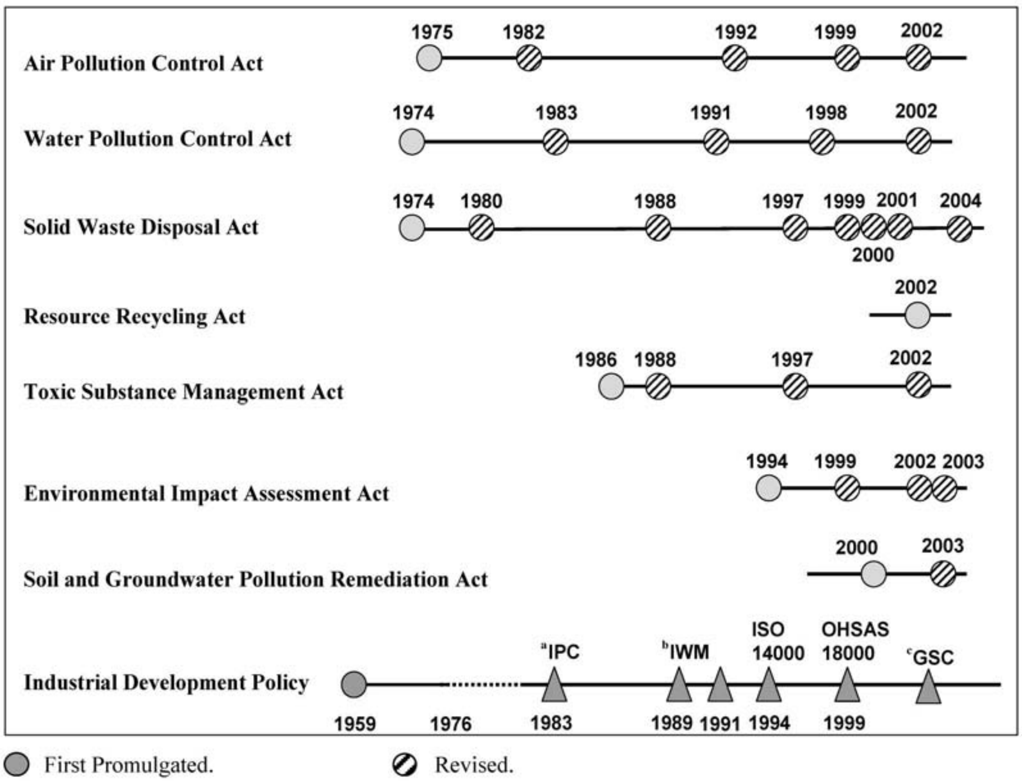

Figure 2.1: Development of Environmental Protection Laws

Notes:
[a] Industrial-Pollution Control Program
[b] Industrial-Waste Minimization Program
[c] Green Supply Chain

units as illustrated in Figure 2.2. In 2003 the EPA and the local authorities employed 1,048 and 3,311 staff members respectively.

Environmental Situation Analysis

The current state of affairs of regarding the environment in relation to compliance to the various environmental statutes and the present situation across the various media are described and elucidated below.

Air Quality

The EPA has gradually been tightening the air-pollutant emission standards and has continued to promote improvement in the quality of oil-production processing. Besides setting emissions standards for different industrial sectors and improving on-the-spot inspections, the EPA also works to establish a permit system and to provide technical assistance, quality control of oil-production processing, and auditing and subsidizing the county and city governments in implementing air-quality improvement programs. In 2002, for instance, the local environmental protection authorities throughout the island inspected 22,124 factories and 26,696 construction sites, of which 952 (3.57%) and 909 (3.41%) respectively failed to comply with air-pollution control regulations.

Air quality is improving year by year in the Republic of China. During 2002, the EPA's statistics indicated that the duration of poor air quality was recorded as 2.87% of the year, a 60% improvement over the situation in 1994. The EPA has also introduced measures to control ozone pollution, which makes up about 80% of the country's air pollutants. According to the EPA's statistical analysis of air-quality observations in various Air Quality Zones over a long period of time, the Kaohsiung-Pingtung Air Quality Zone in the southernmost part of

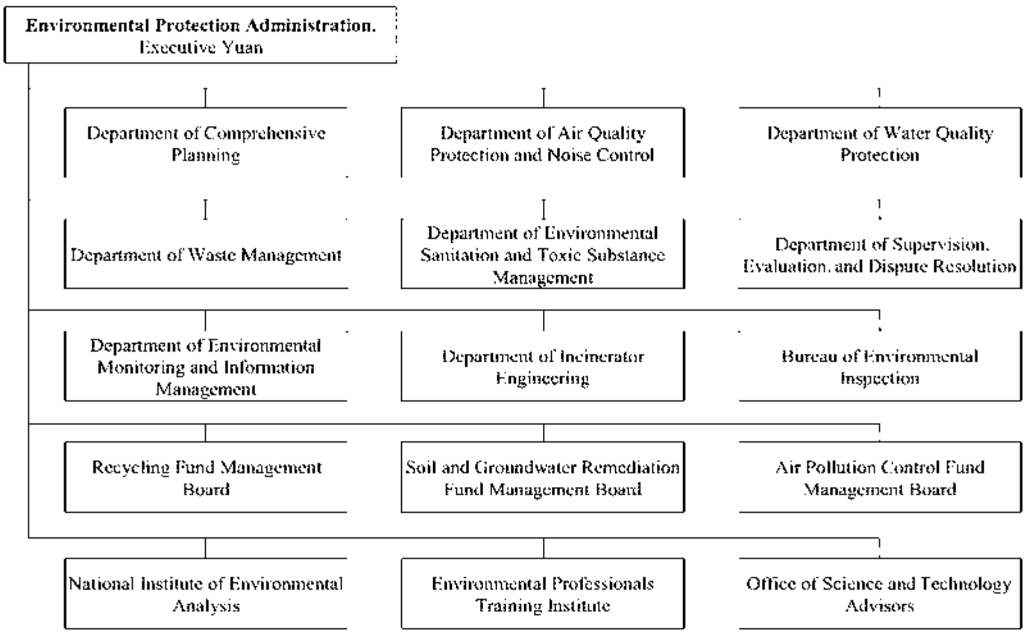

Figure 2.2: Organizational Chart of the EPA

the country showed the greatest improvement: its poor air-quality ratio decreased from 18.4% in 1994 to 7.45% in 2002. However, the nation's best air quality zones are Hualien-Taitung in the eastern and Ilan in the northeastern parts of the country. Their air-quality ratios are both 0%.

The main sources of poor air quality are air pollutants like suspended particulate matter and ozone, which in 1994 accounted for 76% and 24% of poor air quality, respectively. However, due to changes in the socioeconomic situation, in 2002 the suspended particulate matters among pollution sources dropped to the second largest one, accounting for 22% of poor air quality; while ozone pollution assumed a greater significance as the main source of poor air-quality pollution at 78%.

Water Pollution Control

The primary activities of industrial wastewater management in the Republic of China have focused on evaluating pollution prevention, investigating permit-system compliance, industry's self-monitoring reporting, the observance of polluter pay-related ordinances, and operating information support systems. These water-pollution control measures, aiming to provide broad and balanced approaches, have been enforced through education, voluntary compliance, and volunteer initiatives.

Permit system is the main structure of the industrial wastewater control programs in the Republic of China. In 2002, 10,004 business entities applied for wastewater discharge licenses, of which 8,378 (83.75%) applications were approved by the local authorities. The Department of Water Quality Protection of the EPA has built up a database to contain all the industrial-pollution related information requested by the permit system. Major information provided in the database consists of the following.

- Sludge production and examination
- Follow-up investigation of control plans
- Certified documents and personnel check-up
- Examination of self-reporting
- Follow-up analyses of variant recordings
- Inspection and penalty records
- Diagnosis and control measures and execution

Sampling and examining the effluent quality at the discharge points of factories have long been the major strategy of the wastewater auditing plans. Although it is advantageous and straightforward in terms of simplicity and efficiency, it cannot effectively prevent or detect any illegal manipulation such as bypass piping and the dilution of wastewater. In 2002 for example, the local environmental-protection authorities inspected 19,119 factories, of which 2,500 (13.08%) failed to comply with the water-pollution control regulations.

The pollution problems of all major watersheds in the Republic of China have been well characterized. Usually three major pollution sources can be found: domestic sewage, industrial wastewater, and pig-farm discharge. Generally domestic sewage accounts for 23% of all water pollution, whereas industrial wastewater accounts for 58% and pig-farm discharge 19%. In 2001 pollution removal efficiencies in terms of BOD removal for domestic sewage, industrial wastewater, and pig-farm discharge were about 20%, 79%, and 78%, respectively. It is clear that domestic sewage remains the most important pollution source and still has a great potential for further improvement.

After years of experience and studies, the EPA has promoted its "Sludge Compliance and

Tracking System" as the rule of thumb for wastewater auditing. Therefore, a system has been established to encourage the industries to document their operational records for the authority's inspection.

Solid Waste

The management of solid waste has been a perennial problem in the Republic of China. The EPA established the Industrial Waste Control Center (IWCC) in October 1999. The IWCC actively manages and controls industrial-waste flow by means of an electronic reporting system via the Internet. The information about waste collection, transportation, treatment, and disposal are reported by designated businesses, including industries, hospitals, waste clearance and treatment organizations, and wastewater treatment plants. Over 16,000 designated business entities reported their background information via the Industrial Waste Reporting System (IWRS) in 2003, according to the IWCC.

One of the main tasks of the IWCC is to analyze the reporting data and identify which factories, enterprises, and organizations have been engaged in illegal activities. The local authorities then inspect the suspected businesses and give citations for their violations. The Bureau of Environmental Inspection of the EPA then conducts a further inspection if necessary. By such dual inspections, authorities at all levels are able to control industrial waste and its sources to ensure that the waste generators properly manage their waste. In 2002, local authorities inspected 28,622 factories, enterprises, and organizations, of which 1,273 (4.45%) failed to comply with the regulations of the Solid Waste Disposal Act. That same year, they also conducted 142,864 and 16,161 compliance inspections respectively for the collection, storage, treatment, and final disposal of municipal solid and recycling waste, of which 49,805 (34.86%) and 381 (2.36%) violated the regulations. Further elaboration has been included in the following section.

The government provides incentives to improve environmental performance. Financial incentives including low-interest loans, import-tariff relief, income-tax credit, and accelerated depreciation are provided for pollution-control devices and technologies. Energy conservation, waste recycling, and water reuse equipment are also entitled to income-tax credits. Domestically made facilities are eligible for an income-tax credit of 20% of expenditures, while imported facilities are eligible for a credit of 10%. Only a 5% credit is provided for technology expenditure. Generally speaking, the low-interest loan has provided an interest rate of 2.18% per annum, lower than regular interest since 2002.

Perhaps the most effective mechanism that has been implemented in the Republic of China to help industries perform pollution control is through technical assistance. Since 1873 and 1990, respectively, the RoC's Industrial Development Bureau (IDB) of the MOEA has organized the Industrial Pollution Control Corps and the Waste-Reduction Task Force to provide technical assistance for the industries in operating pollution control and cleaner production. These groups have more than 200 well-trained full-time engineers and scientists providing free or graceful-price technical services. Their services include on-site audits, regulatory interpretations, and technical option evaluations and recommendations to industrial firms.

OVERVIEW OF SOLID-WASTE MANAGEMENT

With a dense population and limited land space, the Republic of China faces the environmental burden of growing waste volumes. This has resulted in a very undesirable situation.

Environmental Impact of Solid Waste

In earlier times, garbage was mostly disposed of in landfills or by dumping it in open spaces. This created numerous environmental problems. The treatment-capacity shortage of municipal and industrial waste in the late 1990s caused serious illegal dumping problems. As a result, about 160 illegal dumping sites were identified by the local authorities during those years. The government has since effectively addressed the problems of waste treatment and final disposal. The EPA has adopted a strategy favoring incineration as the primary treatment method for municipal solid waste, with landfill as a supplement.

National Solid-Waste Management Regulatory Framework

To solve the problems of MSW disposal effectively, in 1984 the Executive Yuan promulgated the Guidelines for the Disposal of Urban Garbage. Several sanitary landfill sites were established based on the guidelines. The first phase focused on setting up standardized sanitary landfill sites, the formulation of a proper definition of garbage disposal, and the improvement of environmental hygiene.

The Waste Disposal Act and the Resource Recycling Act are the major legislations concerning solid-waste management. Solid waste is classified as either "general waste" or "industrial waste." Industrial waste is further subdivided into "general (nonhazardous) industrial waste" and "hazardous industrial waste." These two components of industrial waste are further identified through the Standards for Defining Hazardous Industrial Waste. Concurrently, the EPA has promulgated the Measures for General Waste Recycling and Clearance and the Criteria of Industrial Waste Storage, Removal, and Disposal Facilities to strengthen general and industrial-waste management. For the purpose of conserving natural resources, reducing waste generation, promoting materials recycling and reuse, lessening environmental burden, and building a society of sustainable resource utilization, the Resource Recycling Act was passed on 3 July 2002, as mentioned previously. Since 1997 the EPA has promoted the widespread use of the "Four-in-One Recycling System," the details of which are given in the section "Green Productivity Practices and Other Proactive Measures."

Engineering Project for the Construction of Refuse Incineration Plants and BOO/BOT Projects

Through the EPA's Engineering Project for the Construction of Refuse Incineration Plants and the BOO/BOT projects initiated by the EPA, a total of 19 refuse incineration plants (RIPs) have been completed and another six plants were under construction as of July 2004. The total

Box 2.1: Catalyst to Address the Problem of Industrial-Waste Treatment
In July 2000, a waste-treatment organization illegally dumped waste solvent into Chishan Creek, a tributary of the Kao-Ping River on southern Taiwan. This incident compelled the Taiwan Water Supply Company to close its upstream pumping plants and hence negatively impacted the operations of three water treatment plants in the area. Normal water supply to at least 360,000 households in the Kaohsiung area was seriously affected. The government has used this unfortunate incident as a catalyst to address the problem of industrial-waste treatment and disposal and to promote the industrial-waste treatment business. In 2002 the estimated amount of industrial waste generated was approximately 22.69 million tons, composed of 21.66 million tons of general industrial waste and 1.03 million tons of hazardous industrial waste.

designed treatment capacity of these plants is 24,600 tons per day and the trash incineration rates can be expected to reach 70% and above in 2005.

National Industrial-Waste Management Program

The Executive Yuan approved the National Industrial-Waste Management Program on 17 January 2001. This program was designed to strengthen the management of industrial waste at its sources, waste-tracking systems, inspection work, and the establishment of treatment facilities for industrial waste. The EPA and the IDB of the MOEA have been designated by the Yuan to take charge of planning, allocate responsibilities, and coordinate the general and hazardous industrial-waste treatment. Presently the IDB is executing a plan to install temporary waste storage and treatment centers for hazardous waste. In Phase I of the plan, temporary storage facilities in three centers and two incineration facilities in the northern and southern centers have been installed. The contractor of the central center will start the commercial facility.

National Strategic Plan for Solid-Waste Management

The EPA announced the Three-year Action Plan for Environmental Protection on 15 March 2004. This three-year action plan contains the following six subplans.

1. Model Environmental Lifestyles Plan
2. Open Information and Full Citizen Participation Plan
3. Environmental-Pollutant Reduction Plan
4. Complete Sorting of Garbage for Zero-Waste Plan
5. Industrial-Waste Control and Zero-Waste Strategy
6. Environmental-Fate Monitoring Action Plan

Based on the contents of the Review and Prospects of the Garbage Disposal Plan approved by the Executive Yuan on 4 December 2003, the EPA is aggressively promoting the Complete Sorting of Garbage for Zero-Waste Plan. This action plan comprises seven major tasks: (1) garbage sorting, recycling, and reduction, (2) kitchen-waste recycling and reuse, (3) a follow-up plan for garbage disposal in the Taiwan area, (4) building a new image of municipal solid-waste incineration facilities, (5) promotion of environmental-protection related hi-tech parks, (6) promotion of awareness of new items to be stipulated as mandatory recyclables, and (7) raising the recycling rates of the waste items already regulated as mandatory recyclables.

To further raise the effectiveness of waste disposal and promote the reuse and recycling of resources, the action plan for the Industrial-Waste Control and Zero-Waste Strategy consists of seven focal work areas: (1) promotion of industrial-waste recycling, (2) improvement of the industrial-waste management strategies, (3) completion of the electronic management system for industrial waste, (4) industrial-waste-flow tracking and investigation, (5) promotion of the construction of agricultural-waste treatment facilities, (6) integrated management for incineration ashes from industrial waste, and (7) control of industrial-waste imports and exports.

Solid-Waste Management Situation Analysis

According to the EPA's statistics, the yearly general-waste generation amounts reached their peak in 1997, while the annual average amount of collected general waste decreased from 1.143 in 1997 to 0.752 kilograms per capita per day in 2003. Most RIPs, however, were designed prior to 1997 and their capacities were estimated based on the projection of increasing general waste over the next 10–20 years. This created an overcapacity problem in several counties and cities. In Taipei City, for instance, the city government needs to shut down one of the three RIPs it operates. Since private companies operate most of the RIPs in the south of Taiwan, they should make special efforts to collect and treat the general industrial waste to keep their businesses running efficiently. Because RIPs were originally designed for general waste, the quality of the air emissions, fly ashes, and bottom ashes will change if the received quality of general industrial waste is different from the designed general waste. Therefore the EPA requested the local authorities to strengthen the supervision of the RIPs under their jurisdiction to prevent their undesirable impact on the environment.

QUANTIFICATION AND CHARACTERIZATION

General Waste

The source of most general waste in the Republic of China is residences. The annual amounts of general waste collected and recycled are as shown in Table 2.2. From the table it is noted that in 2003 the total amounts of general waste collected and recycled by local authorities were 6,161,039 tons and 1,379,158 tons; the annual average amount of general waste collected was 0.752 kilogram per capita per day. Since 1998 the collected general waste has been decreasing, whereas the recycled general waste increased yearly from 1998 to 2003.

Industrial Waste

The sources of industrial-waste generation are the various industries under the jurisdiction of the MOEA, the National Science Council, the Department of Health, the Council of Agriculture, the Ministry of Transportation and Communication, the Ministry of National Defense, and the Ministry of Education.

Following the operation of the physical-chemical, solidification, and incineration facilities at the end of 2004, the final disposal sites in the central and southern centers and a set of solidification facilities in the southern center were installed in Phase II at the end of 2005.

The amounts of industrial waste reported from and estimated for the different sectors in 2002 are presented in Table 2.3, wherein it is noted that the total number of factories in the Republic of China was 98,865 and the total number of designated business entities obliged to report the transportation, treatment, and final disposal of industrial waste to the IWCC was approximately 12,500. The waste-reporting percentage of designated businesses was 73% (about 9,163 factories) and the amount of reported industrial waste was about 11.9 million tons in 2002.

In 2003, the yearly amount of reported industrial waste increased to 13.4 million tons. The waste-treatment flows are as illustrated in Figure 2.3. The main causes of the increase of the

Table 2.2: Amount of Collected and Recycled General Waste

	Collected General Waste (in tons)	Percentage	Recycled General Waste	
			Tons	Percentage
1998	8,880,487	1.135	554,210	5.87
1999	8,565,699	1.082	625,163	6.80
2000	7,875,511	0.982	853,665	9.78
2001	7,254,841	0.898	1,056,047	12.71
2002	6,723,639	0.829	1,242,935	15.60
2003	6,161,039	0.752	1,379,158	17.89

Table 2.3: Amounts of Reported and Estimated Industrial Waste in 2002 (in tons)

	Reported Industrial Waste			Estimated Industrial Waste		
	Hazardous	General	Total	Hazardous	General	Total
Manufacturing	673,919	8,628,501	9,302,420	957,596	12,619,640	13,577,236
Medical	10,165	46,831	56,996	10,943	50,420	61,363
Agriculture	3	136,361	136,364	132	6,033,294	6,033,426
Transportation	4,953	13,294	18,247	7,419	19,941	27,360
Military	192	1,573	1,765	6,001	49,167	55,168
Education	22	278	300	3,836	48,470	52,306
Other	36,631	2,393,853	2,430,484	40,788	2,842,512	2,883,300
Total	725,885	11,220,691	11,946,576	1,026,715	21,663,444	22,690,159

Source: EPA. *White Paper on Environmental Protection*. December 2003.

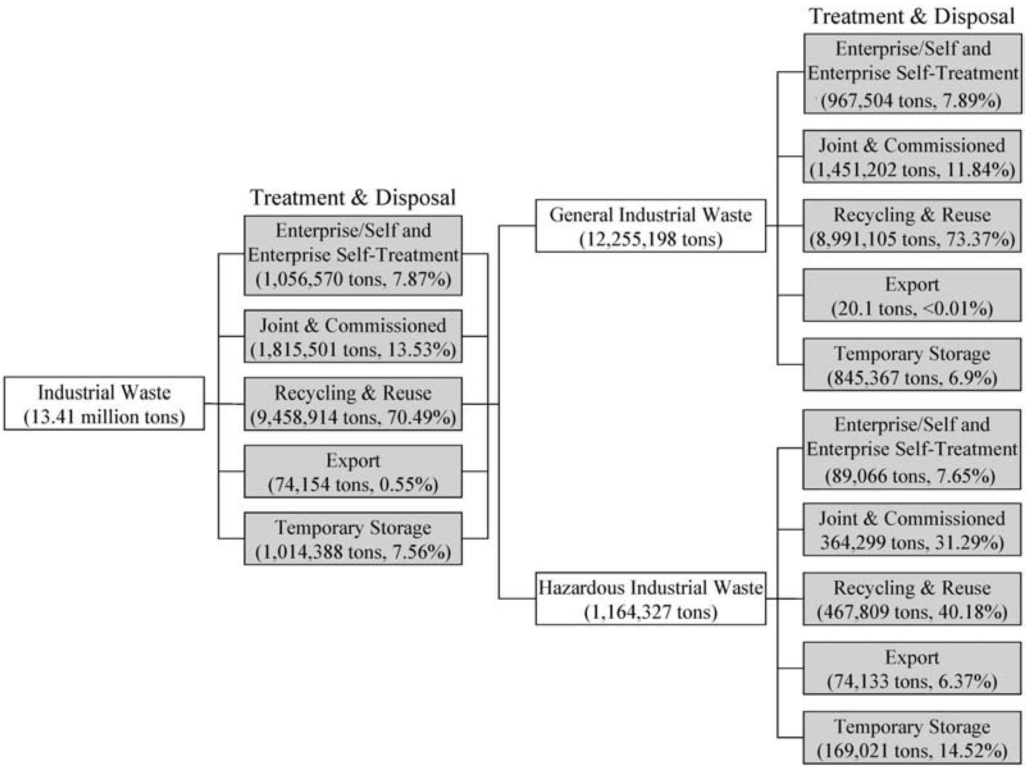

Figure 2.3: The Industrial-Waste Treatment Flow, 2003

Source: EPA. *Three-Year Action Plan for Environmental Protection*. March 2004.

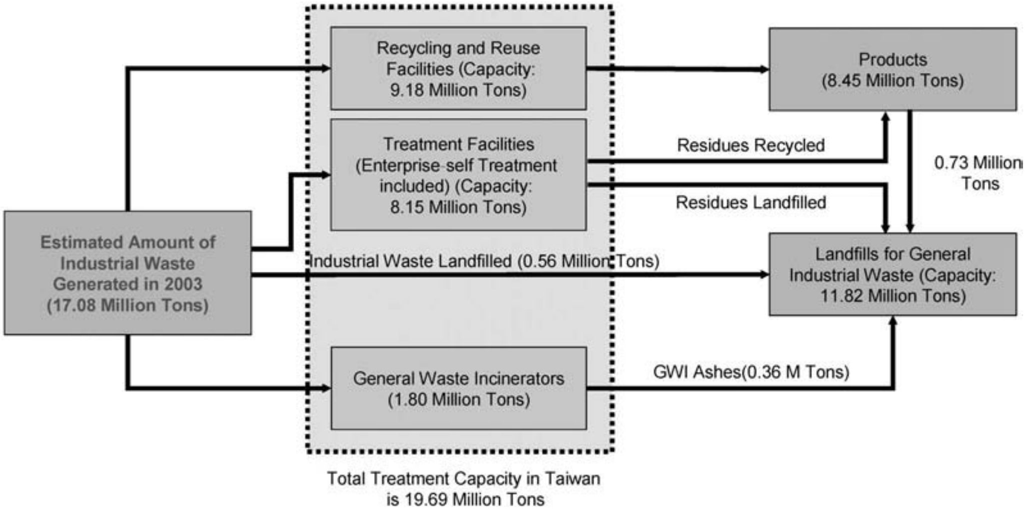

Figure 2.4. Mass Balance of Industrial-Waste Treatment in 2003
Source: EPA. *Three-Year Action Plan for Environmental Protection*. March 2004.

reported industrial waste were the booming business of the iron and steel industry and the designated factories that report their industrial-waste treatment flows to the EPA.

Industrial waste treatment in the Republic of China is carried on through four channels: enterprise/self treatment; joint-and-commissioned treatment; recycling, recovery, and reuse; and transboundary movement (exportation). According to the EPA's reporting regulations, the industrial waste that is temporarily stored in the factories shall also be reported to the EPA via the Internet.

The EPA conducted a mass balance study on the industrial-waste treatment flows in the year 2003. The mass balance is schematically illustrated in Figure 2.4. Based on the EPA's estimate, the generation amount of industrial waste was then around 17.08 million tons.

The quantities of industrial waste treated by the methods of recycling and reuse, industrial-waste treatment facilities (enterprise/self treatment included), and refuse incineration plants permitted to receive general industrial waste, as well as landfills used for industrial waste without treatment in 2003 are noted in Figure 2.4. The total capacity at the industrial-waste treatment facility is about 19.69 million tons, which is more than about 2.6 million tons over the total amount of industrial waste (17.08 million tons) generated in 2003.

Under this circumstance, competition among the industrial-waste treatment businesses has been quite sharp. As a result, the treatment budgets allocated by local governments have been insufficient for the proper treatment of industrial waste, and the legitimate businesses have had to struggle hard to survive in the market.

Key Elements of Solid-Waste Management

General Waste

In 2002, the waste-treatment percentages of general waste with methods of incineration, sanitary landfill, recycling, and composting were 56.62%, 27.93%, 15.60%, and 0.03%, respectively, and the general waste-treatment rate was 96.11%.

Industrial Waste

The methods for the storage, collection, transportation, treatment, and disposal of hazardous industrial waste in the Republic of China are stipulated in the Criteria Governing Methods of and Facilities for Storage, Clearance, and Treatment of Industrial Waste for 2003 passed by the EPA. In accordance with the criteria, incompatible industrial waste is to be segregated and placed in separated areas constructed with suitable materials.

The storage site, containers, and facilities should be maintained in clean and good condition, free from airborne or seeping waste, ground surface pollution, and malodors. The storage containers and facilities should be compatible with the waste stored, while incompatible waste should be stored separately. Also, the names of the wastes must be identified in Chinese at a conspicuous point at the storage sites, on containers, and at facilities.

On the other hand, the facilities are to have adequate equipment or equivalent measures to prevent the hazardous waste from infusion or infiltration by surface water, rainfall, or groundwater, and should have equipment or equivalent measures to collect waste liquids, gases, and malodors to prevent them from polluting surface waters, groundwater, air, and soil.

Vehicles used to haul industrial waste are to be marked clearly with the name of their organization and contact telephone number. During the handling process, care must be taken to prevent dispersal, loss, overloading, and release of odors from the waste. In the event of leakage, the hauler's staff should take the emergency measures necessary and immediately notify the appropriate authorities.

Industrial waste must be treated properly. The treatment methods approved by the EPA for some specific categories of hazardous industrial waste are listed in Table 2.4. In the event a company is not willing to follow the mandated methods, it may submit an alternative, better

Table 2.4: Approved Methods for Treating Hazardous Waste

Waste Category	Waste-Treatment Method
Heavy metals	Solidification, stabilization, electrolysis, membrane de-ionization, heat evaporation, smelting
Heavy metals containing cyanides	Oxidation, incineration, wet oxidation
Mercury (conc. > 260 mg/kg)	Heat treatment for recovery
Oils	Oil/water separation, distillation, incineration
Acids and alkalis	Evaporation, distillation, membrane de-ionization, neutralization
Solvents	Extraction, oil/water separation, distillation, heat treatment
Pesticides	Heat treatment
Polychlorinated biphenyl	Heat treatment
Dioxin	Heat treatment
Asbestos	Moisture-packed or solidified
CFCs	Recycle
Steel industry fly ash	Recycle
Leather tailings and shavings	Recycle using steam pressure

Table 2.5: Refuse Incineration Plants

Refuse Incineration Plant (RIP)	Designed Capacity (tons/day)	Designed Heat Value (kcal/kg)	Designed Electric Power Generation (w)
Neihu RIP	900	1,350	6,000
Mucha RIP	1,500	1,600	12,000
Peitou RIP	1,800	2,400	42,000
Shulin RIP	1,350	1,553	22,100
Hsintien RIP	900	1,552	14,670
Bali RIP	1,350	2,300	35,770
Taoyuan RIP (BOO/BOT Project)	1,350	2,300	35,000
Hsinchu City RIP	900	2,300	23,000
Taichung City RIP	900	1,500	13,000
Houli RIP	900	2,400	25,000
Hsichou RIP	900	2,400	22,600
Lutsao RIP	900	2,400	25,000
Chiayi City RIP	300	1,350	2,310
Tainan City RIP	900	1,600	15,800
Renwu RIP	1,350	2,400	33,700
Kangshan RIP	1,350	2,400	38,000
Kaohsiung Municipal Central RIP	900	2,400	25,200
Kaohsiung Municipal South RIP	1,800	2,500	49,000
Kandin RIP	900	2,400	24,700

Source: IWCC of EPA. IWRS website (http://waste.epa.gov.tw).

method of disposal with a request for permission to de-list. In general, industrial waste must be treated appropriately prior to its disposal in stable, sanitary, or sealed landfills.

Infrastructure for Solid-Waste Management

General Waste

The collection of general waste is the responsibility of the local authorities. According to the EPA's statistics, in 2002 the total number of government employees for general waste collection was 19,082, and there were 4,889 collection vehicle units.

By August 2004, there were 19 refuse incineration plants, as shown in Table 2.5. Their total treatment capacity is 21,150 tons per day. Furthermore, at least eight refuse incineration plants are presently under construction around the island. In addition, during 1985–2002, the local governments built 584 sanitary landfills sites, of which 205 sites are still under operation throughout the island.

Industrial Waste

According to the information provided by the IWCC of the EPA, in 2003 the total number of industrial-waste collection, treatment, and disposal facilities was 1,840, as listed in Table 2.6. All classes of facilities can conduct clearance and/or treatment business for general waste and general industrial waste, but only the Class A facilities are specified with the capacity to conduct clearance or treatment business for hazardous industrial waste. For a company to conduct

Table 2.6: Waste Collection and Treatment/Disposal Facilities, 2003

Types of Permission	Classification	Number of Permissions
Collection	Class A	145
	Class B	1,224
	Class C	374
Subtotal		1,743
Treatment/Disposal	Class A	32
	Class B	35
Subtotal		67
Collection and Treatment Disposal	Class A	18
	Class B	12
Subtotal		30
Total		1,840

Source: IWCC of EPA. IWRS website (http://waste.epa.gov.tw).

waste clearance and treatment businesses legally it must apply for a Collection and Treatment/ Disposal Permit.

The treatment methods used by certified treatment facilities include physical treatment, incineration, resource recovery, thermal treatment, composting, solidification, and chemical treatment. The permitted and approved (not installed) capacities for each treatment method are listed in Table 2.7. Also indicated in the table is that the total capacity of treatment/disposal facilities, excluding the enterprise/self-treatment facilities, was around 8.6 million tons per year at the end of year 2003.

Table 2.7: Statistics of Permitted and Approved Capacity of Treatment Methods (tons per year)

Treatment Method	Permitted Capacity	Approved (not installed) Capacity	Total Capacity
Landfill	1,983,120	372,600	2,355,720
Physical treatment	2,151,936	149,844	2,301,780
Incineration	1,109,124	437,592	1,546,716
Resource recovery	442,008	81,120	523,128
Thermal treatment (excluding incineration)	418,848	33,840	452,688
Composting	188,400	54,000	242,400
Solidification	240,240	0	240,240
Chemical treatment	167,076	0	167,076
Others	774,600	27,600	802,200
Total	7,475,352	1,156,596	8,631,948

Source: EPA. *Review and Plan for Industrial-Waste Integration Management Strategy*. November 2003.

Green Productivity Practices and Other Proactive Measures

The Four-in-One Recycling System

Since 1997 the EPA has been promoting widespread use of the “4-in-1 Recycling System,” as illustrated in Figure 2.5. The program for carrying out this system involves four parties: local communities, recycling management organizations, government trash-treatment crews, and the Recycling Foundation of the EPA. The goal is to implement the country’s comprehensive waste minimization and recycling effectively, and to encourage greater public participation. The manufacturers or importers of the regulated items must register with the EPA, report the amount of items sold or imported, and pay a recycling fee for such items.

Recyclable general waste, which is regulated in the 4-in-1 Recycling System, is classified into 15 categories and can be further divided into 32 items, including the following.

Paper containers (including aluminum-foil packaging)
Plastic containers (PET, PE, PVC, PP, PS)
Ferrous containers
Aluminum containers
Glass containers
Pesticide containers
Packaging puff
Mobile vehicles (sedans, scooters)
Tires
Lead-acid accumulators
Lubricants
Appliances (TV sets, washing machines, refrigerators, air conditioners, and heaters)
Computers and peripherals
Dry-cell batteries
Fluorescent lights (straight tube only)

Local authorities have collected less and less general waste since then. The reuse and recycling amount of general waste increased from 0.55 million tons in 1998 to 1.38 million tons in 2003, whereas the reuse and recycling rate increased from 5.87% in 1998 to 17.89% in 2003. The reuse and recycling rates in 25 counties and cities in the Republic of China are listed in Table 2.8, wherein only the rates of Taipei and Taichung Cities are 25.77% and 22.94%, respectively.

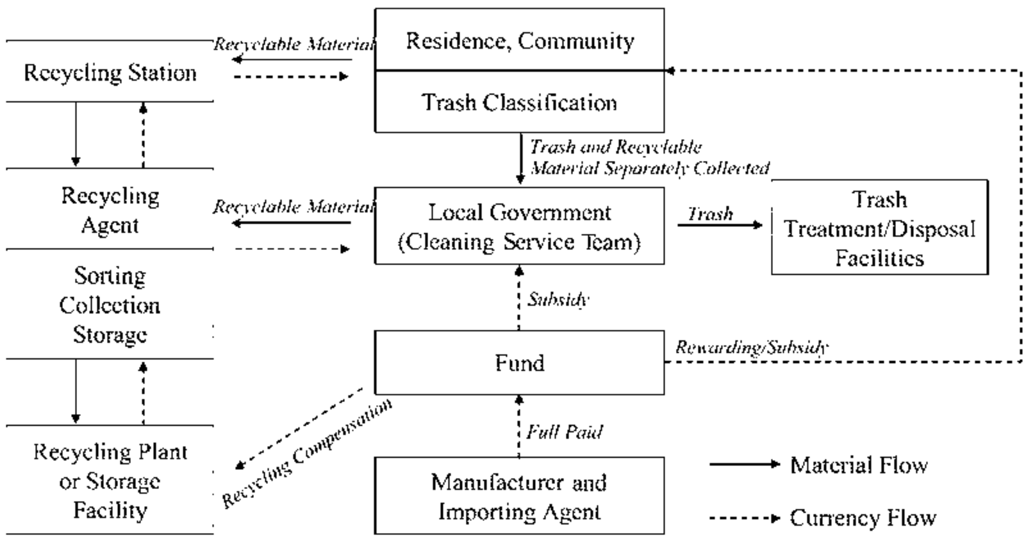

Figure 2.5: The 4-in-1 Recycling System for Regulated General Waste Items

Table 2.8: Analysis of Reuse and Recycling Rate of General Waste (including Kinmen and Matsu)

Reuse and Recycling Rate	Number of Cities/Counties	City/County (Reuse and Recycling Rate in 2003, %)	
Above 20%	2	Taipei City (25.77) Taichung City (22.94)	
12%–20%	14	Kaohsiung City (17.29) Keelung City (16.97) Tainan City (17.28) Hsinchu City (12.93) Ilan County (15.04) Nantou County (12.29) Changhua County (12.88)	Yunlin County (13.66) Kaohsiung County (12.91) Hualien County (12.60) Taitung County (17.18) Penghu County (18.42) Kinmen County (13.47) Matsu (12.21)
Below 12%	9	Chiaiyi (7.81) Taipei County (11.07) Taoyuan County (11.98) Hsinchu County (9.02) Miaoli County (10.17)	Taichung County (11.67) Chiai County (8.61) Tainan County (9.41) Pingtung County (5.36)

Source: EPA. *Three-Year Action Plan for Environmental Protection*. March 2003.

Green Mark

Green consumption has gradually become a world trend, and most developed nations have actively implemented eco-labeling systems. The EPA has promoted the RoC's eco-label to the public since 1992, as illustrated in Figure 2.6. As of the end of July 2003, Green Mark specifications for 80 product categories had been designated, and 1,859 products have been approved to use the Green Mark. In addition to Green Mark Products, the EPA announced an application for a second category of environmental products and actively encouraged priority procurement of green products by government organizations.

Kitchen-Waste Recycling

About 20–30% of ordinary waste is food waste, which is mainly disposed of in landfills or treated in RIPs. Converting this waste into fertilizers by the composting method will replenish the necessary organics contained in the soil environment. Enhancement of soil organics will relieve soil acidification.

The EPA has promoted the kitchen-waste recycling program to local authorities since 2003. According to this movement, leftovers have been recycled about 600T/D in 2003 and

Figure 2.6: Green Mark in the Republic of China

900T/D in 2004. It is predicted that the amount will be up to 1,600T/D in 2007. To date, 104 steam degerming piggeries and 11 composting factories have been approved by the EPA. The government 2004 subsidy is about NTD70 million.

Recyclable Industrial Waste

The Waste Disposal Act stipulates that recyclable industrial waste must comply with the regulations of the central authorities, who are responsible for formulating the relevant methods and guidelines for the facilities.

Pursuant to Section 2, Article 3 of the MOEA's Management Measures for Recyclable Industrial Waste (2002), the MOEA designated 53 categories of recyclable industrial waste and their management measures as of August 2004. The central authorities designated 85 categories of recyclable industrial waste as of 2003. According to the IWRS's database, reclaimed coal ash is the largest recyclable industrial waste. Its amount is reported to have been about 3 million tons in 2003. The Taiwan Power Company (Taipower) is the major generator of the ash, which is generally used as an ingredient in manufacturing ultra-high-strength concrete (with Portland cement). It is also used as structural-fill material in constructing highway embankments and roadbeds. In addition, coal ash is used for manufacturing concrete bricks, blocks, and paving stones.

The companies willing to recycle or reuse nonregulated categories of industrial waste must submit the relevant technical documents to the MOEA for approval. As of 2003 the MOEA approved 83 applications of industrial-waste recycle or reuse, and the permitted amount was about 87,506 tons per month (1 million tons per year).

The sludge generated from water-supply plants accounted for about 44% of the permitted amount and ranks number one of all the approved nonregulated categories of industrial waste. This kind of sludge is usually used as an ingredient in cement and garden soil.

Waste Exchange Information Center

The MOEA also supports the Waste Exchange Information Center (WEIC) to provide industrial-waste exchange information services to industries free of charge. The WEIC has successfully promoted 384 waste exchange cases and recycled 415,090 tons of industrial waste since 1987. Funding for reuse and recycling is provided to encourage people to minimize the impact and treatment of waste.

Recycling Fund

The recycling fees paid by manufacturers and importers are appropriated for the Recycling Fund, which contributes a segment of the EPA's budget and is administered by the Recycling Fund Management Committee. Of the appropriated funds, 70% are spent on subsidizing the collection or treatment of regulated items, and the remaining 30% are dedicated to education, research and development, audit and certification, and grants for municipalities and Non-Governmental Organizations (NGOs).

The government provides the following incentives for companies that are willing to minimize, reuse, and recycle industrial waste.

- Promotion of industrial-waste technology and transfer
- Assistance in establishing quality standards for recycled products
- Tax credit for shareholders or tax exemption for five years
- Zero tariffs on specific equipment imports
- Speeding up the depreciation of facilities

- Financial aids (low-interest loans) for significant investments
- Assistance in introducing foreign labor

Future Strategies

The Zero-Waste Plan for General Waste

In the Zero-Waste Plan, general-waste reduction and resource recycling are two main issues that the EPA is aiming at to replace the waste-disposal management strategies adopted in the past. In order to operate in coordination with the incinerator plants, the EPA will assist local government in the construction of reusable garbage-separation plants, incineration bottom ash reclamation plants, and leachate- and septic-treatment plants.

Two other treatment methods, the recycle and reuse of food residue and garbage and the recycle and reuse of bulky waste, are utilized to separate and classify the reusable waste from general waste and general industrial waste. The framework of the Zero-Waste Plan as formulated by the EPA is schematically illustrated in Figure 2.7.

Details of the Environmental Industrial Park Promotion Plan and the Incineration Bottom Ash Separation and Fly Ash Reclamation Plan in the Zero-Waste Plan are as follows.

Environmental Industrial Park (Eco Park) Promotion Plan

This plan was approved by the Executive Yuan on 9 September 2002. It is now part of the Challenge for the Year 2008 National Development Plan. The government has already set

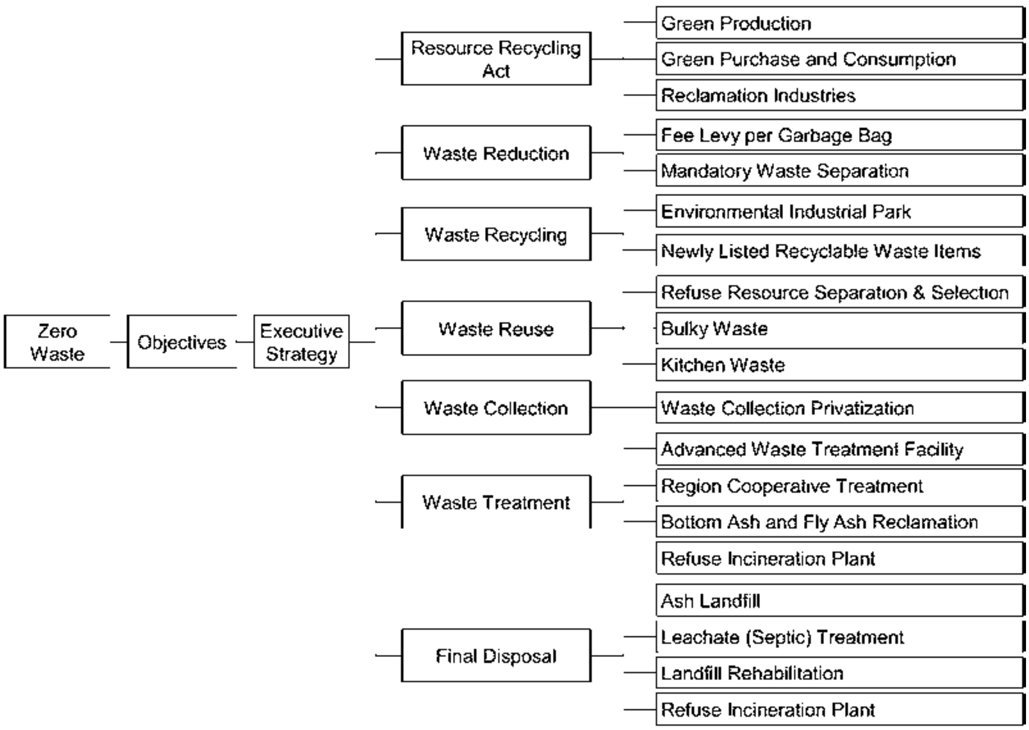

Figure 2.7: Framework of the Zero-Waste Plan

Source: EPA. *Three-Year Action Plan for Environmental Protection*. March 2003.

up the interdepartmental guideline committee and the facility installation application. The EPA has selected appropriate park locations in the northern, central, and southern parts of the country. These parks themselves will collaborate with the specific characteristics of local and peripheral businesses and academic institutions to produce a mutually circulatory system. This will expand the major township living circles, promote district-wide ecological recirculation, and construct ecologically sustainable townships.

Incineration Bottom Ash Separation and Fly Ash Reclamation

Bottom Ash Sorting Plant Bottom ashes will be categorized into different classes according to their particle sizes. Classified bottom ash can be used as supplemental materials for cement and tile production. Bottom ash can also be added in roadbeds. The potentially harmful microscopic particles will be treated along with fly ash. Metal substances will be recycled. Bulky substances or other miscellaneous substances will be sent to either incinerator plants or landfills for final disposal.

Actually, bottom ash from the RIPs in Taipei City and Taipei County have been successfully classified for roadbeds in a sorting plant run by a private company. From the other local governments' RIPs, about 71.5% of bottom ashes are sent to landfills for final disposal.

Fly Ash Reclamation Plant Currently, fly ash is solidified prior to being sent to landfills. Through detoxification treatment, the EPA plans to transform fly ash into construction materials or some other reusable materials. About 200,000 metric tons of fly ash can be utilized as fusing dregs. The rest of the ash will be disposed of in landfills. Table 2.9 presents ash generations from the various RIPs for the period January–December 2003.

CASE STUDY: MSWM OF TAIPEI CITY

City Profile

Taipei City, the political, economic, financial, and cultural center of the Republic of China, is located at the middle and slightly eastern part of the Taipei Basin on northern Taiwan. The interior of the basin is generally flat, and the topography is characterized by a gentle slope with an average of 10 m from southeast to northwest, and with an altitude of 5 m. Taipei City lies in the subtropical zone and is generally warm throughout the year, with an average annual temperature of 22° Celsius.

Taipei City has been built as a metropolis consisting of the city itself and several surrounding cities and townships. The city is divided into 12 administrative districts, with a total area of about 272.14 sq km. The population registered in Taipei City is about 2.63 million, accounting for approximately 12% of the total national population. Taipei City's economic development has grown rapidly in recent decades. About 20% of the nation's registered business and industrial companies are based in Taipei City and 92.3% of the businesses based there belong to tertiary industries, including commerce, transportation, finance, and the service industries. The major industries in Taipei City are light industries and technology-intensive industries. About 2,076 factories were registered in Taipei City in 2002. In recent years, several light-industrial parks, mainly for software and high-tech industries, have been developed in the Taipei City area.

Waste Disposal Act

According to the RoC Waste Disposal Act, solid waste is divided into two categories: general waste and industrial waste. The executing agencies, including the environmental pro-

Table 2.9: Ash from RIPs, January–December 2003 (in metric tons)

Plant	Fly Ash (A)	Solidification of Fly Ash (B)	Bottom Ash (C)	Combined Ash (D = B + C)
Muzha, Taipei	4,062.400	4,183.160	25,621.170	29,804.330
Neihu, Taipei	3,948.192	4,677.443	18,739.660	23,417.103
Beitou, Taipei	8,250.410	9,756.810	41,451.560	51,208.370
Xindian, Taipei County	5,031.770	5,031.770	38,865.800	43,897.570
Shulin, Taipei County	7,847.350	6,769.270	51,056.040	57,825.310
Bali, Taipei County	13,542.140	13,541.210	70,152.760	83,693.970
Taoyuan County	19,115.170	22,813.080	78,696.030	101,509.110
Xinzhu City	7,545.140	10,471.230	39,334.480	49,805.710
South Taizhong City	9,504.050	10,882.320	28,303.660	39,185.980
Houli, Taizhong County	11,425.970	12,376.230	47,365.880	59,742.110
Zhanghua County	12,915.590	15,318.170	42,890.790	58,208.960
Jiayi City	1,709.160	1,906.591	10,954.355	12,860.9460
Lutsao, Jiayi County	10,889.040	12,398.610	50,183.770	62,582.380
Annan, Tainan City	7,329.180	6,668.220	32,443.440	39,111.660
Center Kaoxiong City	6,458.000	8,101.770	30,040.250	38,142.020
South Kaoxiong City	18,567.988	21,076.799	73,018.160	94,094.959
Kangshan, Kaoxiong County	16,193.329	16,837.989	69,137.686	85,975.675
Renwu, Kaoxiong County	12,766.060	14,294.490	64,898.750	79,193.240
Kanding, Pingdong County	12,511.287	14,162.880	48,835.830	62,998.710
Total	189,612.226	211,268.042	861,990.071	1,073,258.113

Source: EPA. Website of the Department of Incinerator Engineering.

tection bureaus of municipalities, environmental protection bureaus of county (city) governments, and Hsiang township offices are responsible for recycling, clearing away, and disposing of general waste, and the inspection of waste-management activities for general waste. Accordingly, the execution agencies also have the authority to levy fees on garbage collection and treatment fees to support clearing and disposing of general waste. In order to implement the polluter-pays principle and cover the cost for waste-clearance and disposal, the General Waste Collection and Treatment Fee Regulation (hereafter referred to as Trash Fee Regulation) was passed on 31 July 1991. Several amendments have been made since then.

In accordance with the Trash Fee Regulation, trash fee collection is mainly based on the volume of tap water used. In addition to the water-based method, the authorities also have the right to submit alternatives for fee collection based on their requirements, and implement them after they are approved by the central government. Two types of collection methods, the per-bag trash fee system and the water-based trash fee system have been introduced.

Autonomous Decrees of Taipei City

With the authorization of the Waste Disposal Act, the environmental protection bureaus of the county and city governments are entitled to stipulate relevant regulations to control

Box 2.2: Environmental Problem
Due to the dense population and limited land spaces for waste disposal as indicated previously, Taipei City is facing several problems of waste disposal and treatment. The fast increasing waste stream and limited available land for waste disposal are the major problems. To solve the waste problem thoroughly, and at the same time work out an implementation plan for sustainable development, the Taipei City government has been undertaking a series of improvements in waste management in the past few years. Source-waste reduction and waste recycling are the most urgent issues of Taipei City.

trash-fee collection based on their actual needs for the operation of waste-treatment facilities. After many years of a water-based trash fee collection system, the Taipei City government switched to the per-bag, volume-based trash-fee system. An autonomic regulation for trash-fee collection was passed by Taipei City to regulate trash-fee collection measures. In addition to changing the trash collection fee system, waste categorization for collection purposes is also mandatory to the communities, schools, government agencies, and apartment buildings in Taipei City in accordance with the autonomy regulation for the mandatory categorization of waste.

Solid-Waste Generation

There are more than 3 million people passing in and out of Taipei City every day. Thus a huge amount of municipal and industrial waste is generated daily. The household garbage collection program of Taipei City's Department of Environmental Protection (TDEP) is based on fixed-time, fixed-route, and no-touch ground principles.

Solid-Waste Characteristics and Quantification

General waste and general industrial waste collected by private companies also go into city landfills and incineration plants. It is illustrated by the drop in the annual waste volume after the implementation of the "per-bag trash collection fee" policy. For instance, in 1999 the annual total waste volume collected by the TDEP was 1.069 million tons, and 293,186 tons by private collection companies. The combined annual waste volume was 1,362,388 tons, representing an average of 1.43 kg per capita per day. Table 2.10 shows the variations in annual waste volume over the last decade. Comparing this with the 2002 data, the annual total waste volume was 0.9 million tons, or an average of 0.95 kg per capita per day, representing a 33.1% reduction from 1991. Thus the per-bag trash collection fee strategy has successfully reduced the collected waste and achieved the goal of waste reduction and resource recycling.

Key Elements of Solid-Waste Management

Table 2.11 shows the development history of the municipal waste-management policies. Incineration has been adopted as the primary scheme and landfill as the auxiliary scheme for municipal waste treatment. Three municipal waste incinerators, namely Neihu (daily capacity of 900 tons), Mucha (daily capacity of 1,500 tons), and Peitou (daily capacity of 1,800 tons) are in operation in Taipei City. The total capacity far exceeds the quantity of waste generation. Incombustible waste and incinerator ash are sent to the second (and only operating) sanitary landfill, the No. 2 Landfill located at Nankang with a total capacity of 6.17 million cubic meters. Having been in operation for several years, the current remaining capacity is merely 0.48 million cubic meters.

Table 2.10: Waste Volume Collected in Taipei City

	Waste Volume Collected by TDEP Team		Waste Volume Collected by Private Operators		Total	
	Annual Total (tons)	Average (kg per capita per day)	Annual Total (tons)	Average (kg per capita per day)	Annual Total (tons)	Average (kg per capita per day)
1993	1,298,026	1.34	90,695	0.09	1,388,722	1.43
1994	1,302,850	1.35	101,730	0.11	1,404,581	1.45
1995	1,234,141	1.28	133,610	0.14	1,367,752	1.42
1996	1,260,147	1.32	156,615	0.16	1,416,764	1.49
1997	1,193,511	1.26	169,553	0.18	1,363,065	1.44
1998	1,030,682	1.07	443,606	0.46	1,474,289	1.53
1999	1,069,201	1.11	293,186	0.31	1,362,388	1.42
2000	870,993	0.90	333,026	0.34	1,204,020	1.25
2001	687,363	0.71	360,407	0.37	1,047,770	1.08
2002	625,487	0.65	285,297	0.30	910,784	0.95

Source: Bureau of Environmental Protection, Taipei Municipal Government.

Green Productivity and Other Waste-Minimization Approaches

Neither incineration nor landfill disposal is considered to be the best method to recycle resources. Such disposal methods have an obvious adverse impact on the environment and are against the principles of sustainable use. For this reason, Taipei City's waste policy on disposal options was switched to waste minimization, resourcification, and diversification in July 2000.

Taipei City is currently employing a strategy that combines the techniques of garbage categorizing, resource recycling, and garbage cleaning and transporting to manage the solid

Table 2.11: Development History of Taipei City's Municipal Waste-Management Policy

Treatment Policy	Time	Implementation Measure
Open-air Stack-up	1969–85	Waste is disposed of at north bank of Keelung River in Neihu district
Sanitary Landfill	1985–	Waste is disposed of at a sanitary landfill with a lining and leachate collection system
Incineration	1991–	Waste is treated by three incineration plants
Resource Recycling	1992–	Materials for recycling are collected twice a week
Three-in-One Resource Recycling Plan	1998–	A plan employing the techniques of garbage categorizing, resource recycling, and garbage cleaning and transporting Implementation of the no-touch ground waste collection measure
Per-Bag Trash Collection Fee	2000–	Implementation of per-bag trash fee and the frequency of materials collection for recycling is increased to five times each week

Source: Bureau of Environmental Protection, Taipei City Government.

Table 2.12: Classification of Kitchen Waste

Waste for Compost (uncooked waste)	Waste for Pig Feed (cooked waste)
Fruit: fruits, peels, and kernels Vegetables: leaves, roots, and seeds Plants: flowers, tree leaves, herbs, and their roots Nuts: seeds of plants and kernels Residues of sugarcane, tea, coffee beans, and medicine herbs Shells: eggshells, seashells, crab and shrimp shells, and animal bones Mixtures: organic substances mixed with cooked waste Other: odorous cooked waste, undone meat and animal internal organs, and organic substances impossible to classify	Rice products such as rice Flour foods: noodles, etc. Bean foods: all kind of bean products Meats: cooked chicken, duck, fish, and meat Snacks: biscuits, candies Canned foods: contents of all kinds of canned foods Powder foods: powdered milk and other powdered foods Dressings: all sorts of seasonings such as sauce

Source: Bureau of Environmental Protection, Taipei Municipal Government.

waste of the municipality. The method is termed the Three-in-One Resource Recycling Plan. The plan includes a garbage collection program based on the fixed-time, fixed-route, and no-touch ground principle, and is smoothly implemented by the TDEP.

Kitchen-Waste Recycling

According to the TDEP definition, the kitchen waste used for pig feed is cooked waste such as leftovers, and the waste for composting is uncooked waste that is inedible but decomposable. The various waste items of each of these two kinds of kitchen waste are listed in Table 2.12.

The rate of kitchen waste separated from garbage has reached an average of 8.28%, and all kitchen waste recycled was completely reused in pig feed and compost. Estimate of amounts of garbage and various kitchen waste collected in 2004 are as listed in Table 2.13.

Table 2.13: Collection of Kitchen Waste in 2004 (in tons)

Year/Month	Collected Garbage (A)	Kitchen Waste for Compost (B)	Kitchen Waste for Pig Feed (C)	Total Collected Kitchen Waste (D = B + C)	Kitchen-Waste Separation Rate (D/A × 100)
2004/01	53,424.61	2,135.50	922.68	3,058.18	5.724291
2004/02	37,436.34	2,212.32	846.86	3,059.18	8.171686
2004/03	38,482.67	2,364.65	818.38	3,183.03	8.271334
2004/04	39,789.75	2,403.13	813.88	3,217.01	8.085022
2004/05	44,316.88	3,176.04	822.72	3,998.76	9.023108
2004/06	42,489.19	3,391.84	821.61	4,213.45	9.916522
2004/07	43,033.64	3,265.44	764.83	4,030.27	9.365394
2004/08	43,674.03	2,672.81	707.54	3,380.35	7.739954

Source: Bureau of Environmental Protection, Taipei City Government.

Based on an evaluation of collected trash amounts in trial separations and collection operations in 2002, the amount of kitchen waste was estimated at approximately 10% of total amount of collected household garbage in Taipei City. If this high ratio of kitchen waste in household waste constituents can be lowered, the burden on landfill demand can be reduced. Because of this, Taipei City's citywide kitchen-waste recycling, separation, and cleanup program, the Household Kitchen-Waste Recycling Program, was implemented on 26 December 2003. It is called the second revolution in the RoC's environmental protection, following the implementation of the unit pricing system mentioned previously.

To separate and collect kitchen waste from general household garbage, the original garbage collection system and vehicles have been modified with a kitchen-wastebin mechanized lifting arm. A total of 222 garbage collection vehicles have been remodeled since December 2003. Kitchen waste is collected separately, but at the same time as garbage collection. To encourage kitchen-waste recycling, kitchen waste is collected free of charge. The TDEP also distributes free containers for the temporary storage of kitchen waste to every household.

At present, recycled kitchen waste is mainly from cooked foods and hence used for pig feed. However, the EPA is planning to shift the recycling of kitchen waste to either pig feed or composting. In this case, the quality and marketability of compost products will be the keys to the success of these recycling measures. In Taipei City, recycled kitchen waste is categorized into two types, "waste for pig feed" and "waste for compost."

Because of a lack of land sites for treatment facilities in Taipei City, the TDEP has signed a cooperative agreement with a private company, Formosa Environmental Technology Corporation, which will erect eight kitchen-waste treatment plants to treat and reuse the kitchen waste (collected by the TDEP) for composting. It will collect and treat the kitchen waste free of charge. The collaboration period has been set for eight years.

Recycling of kitchen waste can reduce unpleasant odors, benefit the sanitation of the home environment, reduce garbage collection costs, and extend a landfill's operating life. Since the implementation of the Household Kitchen-Waste Recycling Program, the average amount of kitchen waste recycled is 182 tons per recycling day.

Per-Bag Trash Collection Fee

In the past, residents were charged a trash fee based on the amount of tap water consumed per household: the more water consumed, the higher the trash fee paid. Obviously, the residents were not charged the trash fee based on the amount of trash they generated. As a result, this fee-collection system was not considered reasonable. Therefore to promote trash reduction and recycling, the Taipei City government switched its trash-fee collection method from water-based to per-bag in July 2000.

Based on the polluters-pay principle and the Waste-Management Act, all residents pay for their trash collection by buying the TDEP-certified trash bags, which are sold in sets according to size for different trash volumes. Thus, a unit pricing system was established, and residents pay for the unit of garbage that they set out for collection. The unit price encourages residents to reduce the amount of garbage. To encourage recycling, recyclable trash is collected separately, free of charge, without the need for certified trash bags. This policy of "throw less, pay less," recycling can save more money for the citizens.

Table 2.14 indicates the average cost per household based on the per-bag and water-based trash-fee collection systems. The average cost per household is about USD3.60 per month by collection with the garbage-volume pricing system. It is lower than the USD4.32 per month of the water-volume based system. This shows that the new per-bag unit pricing system does not increase residents' expense in trash-collection fees.

Table 2.14: Average Cost per Household for Different Garbage Collection Fee Systems

Fee System	Fee Rate Calculation	Average Cost per Household per Month
Water-based Trash Collection Fee	The rate is USD0.12 per degree On the average, 36 m^3 of water per household	USD4.32
Per-Bag Trash Collection Fee	The trash volume generated per household per day is around 9.6 liters. Sixty 5-liter trash bags are needed for one month, if trash is cleared on daily basis. Twenty 14-liter trash bags are needed for one month, if trash is cleared on three-day intervals.	5-liter bag costs USD0.06 per bag: USD0.06 × 60 = USD3.60 14-liter bag costs USD0.18 per bag: USD0.18 × 20 = USD3.60

Source: Bureau of Environmental Protection, Taipei City Government.

Table 2.15 indicates the collected recyclable waste volume in Taipei City during 1999–2003. After implementing the unit pricing system, the volume of recyclable waste increased dramatically to an average of 148.96 tons in 2001, 146.68 tons in 2002, and 133.26 tons in 2003, more than the approximately 60–70 tons of the recyclable waste collected in 1999. Correspondingly, the recycling rate increased from 2.38% in 1999 to 7.94% in 2003. It is obvious that the new policy has achieved the goal of promoting waste recycling effectively.

Table 2.15: Statistics of Waste Recycling in Taipei City

Year		Annual Total (tons)	Daily Average (tons/day)	Average per Capita per Day (kg)	Average Recycling Rate (%)
1999		26,481.62	72.55	0.028	2.38
2000		52,038.66	142.18	0.054	5.64
January–June 2000		15,694.77	86.24	0.033	2.86
July–December 2000		36,343.89	197.52	0.075	9.72
2001		54,370.82	148.96	0.056	7.33
2002		53,537.67	146.68	0.056	7.89
2003		48,638.13	133.26	0.051	7.94
Difference 1999 vs. 2000	tons	25,557.04	69.63	0.026	3.25
	%	96.51	95.97	94.570	136.42
Difference 1999 vs. 2001	tons	27,889.20	105.32	0.029	4.95
	%	105.32	105.52	104.350	207.58
Difference 1999 vs. 2002	tons	27,056.05	74.13	0.028	5.51
	%	102.17	102.17	101.450	230.97
Difference 1999 vs. 2003	tons	22,156.51	60.70	0.023	5.55
	%	83.67	83.67	83.700	233.19

Future Strategies and Action Plan

Taipei City is pursuing various strategies aimed at a better management of solid waste.

Vision of Zero Landfill, Total Recycling by 2010

In 2003, the Taipei City government proposed a new waste-management vision of "Zero Landfill, Total Recycling by 2010" to achieve a diverse garbage treatment and resourcification policy that will facilitate the transformation of Taipei City into an eco-city. According to the vision, all municipal waste will either be recycled or reused, including energy recovery from the incineration of waste, composting or animal feed from organic waste, and the reuse of resource waste such as metal, glass, paper, construction waste, incineration ash, etc. After effectively reusing or recycling all municipal waste, landfills will no longer be needed for final disposal. Under the zero landfill concept, the development of green production will be feasible and can therefore be promoted.

Several waste-management strategies have been developed to achieve the goal of the "Zero Landfill, Total Recycling" policy. The policy includes six subplans: incineration fly ash reuse, incineration bottom ash reuse, erection of garbage categorizing facilities, gutter and wastewater treatment/sludge reuse, extending the operation of the second landfill, and expanding the separation, collection, and reuse of kitchen waste.

Figure 2.8 shows the bottlenecks and obstacles that need to be overcome in the treatment of waste by incineration or landfill. These result from the immaturity of reuse technologies for some waste materials such as the products from incineration bottom ash and fly ash. The underdeveloped market for recycling products such as composting and aggregates from the incineration of waste also impose obstacles to resource reuse.

Garbage Classified for Zero Waste

In December 2003, the Executive Yuan approved the "Review and Prospect of Garbage Treatment Program," which defined the municipal solid waste (MSW) cleanup task with

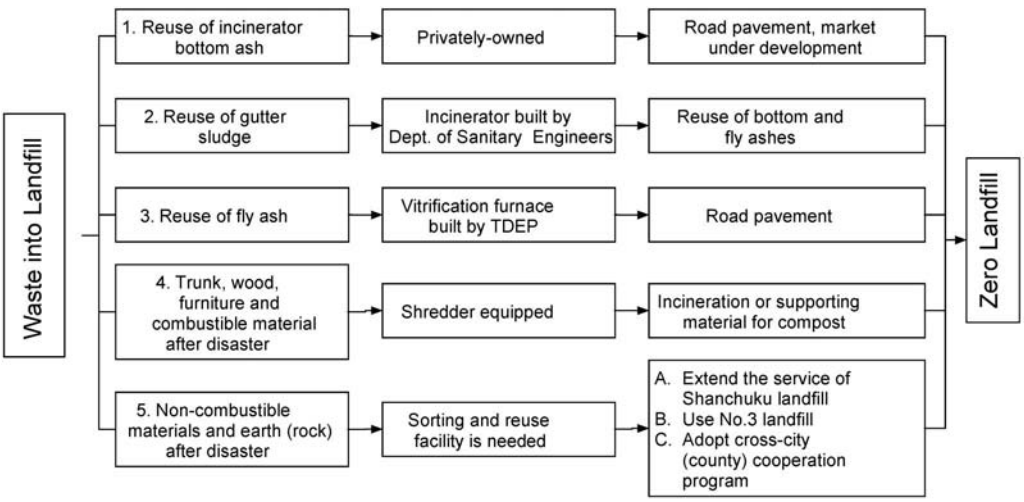

Figure 2.8: Bottlenecks Waiting for Breakthroughs in Landfill Waste
Source: Bureau of Environmental Protection, Taipei Municipal Government.

Box 2.3: Comparison with Industrialized Countries
Compared to the Republic of Korea and Japan, which have also adopted a per-bag trash-collection fee policy, Taipei City has charged a slightly higher fee. Because the trash-fee rate is calculated based on legislation and the actual cost of waste collection and treatment, it will be recalculated periodically by the city government. In the Republic of Korea, before the implementation of a pay-by-volume trash bag program in 1994, trash fees were collected based on the number of people in a household and the size of the house. Collected trash volume was reduced from 1.33 kg per month per capita to 0.98 kg per month per capita, while the recycling rate increased from 15.4% to 41.3%. At the same time the landfill processing rate was reduced from 81.1% to 47%. The unit price of the trash fee is KRW14.5 per liter, equivalent to approximately USD0.0145 per liter. In Japan, approximately 35% of the cities have introduced a trash-fee collection policy, and most of the cities have adopted volume-based system. After the implementation of the trash-fee policy, trash recycling rates have grown nearly 10–50%. Different rate systems, such as fixed rate, variable rate, and progressive rate systems are adopted by different cities. The average unit price of trash bags range from JPY0.82 to JPY1.23 per bag, the equivalent of approximately USD0.20 per bag.

the goals of "Zero Waste" and "Source Reduction, Resource Recycling, and Reuse" for the future.

The main purpose is that the garbage will be treated primarily by source reduction and reinforced by resource recycling and reutilization instead of landfill treatment. Since the industrialized countries have taken measures for the improved management and control of waste with a zero-waste goal, the Republic of China should keep pace with the trend. Therefore, the goal of zero-waste is based on the MSW quantity of 8.31 million metric tons in 2001. The total reduction rates are set up at 25%, 40%, and 75% respectively for the years 2007, 2011, and 2020. The milestone years and the reduction quantities are presented in Table 2.16.

Table 2.16: Zero-Waste Goals (percentages)[a]

Year	Reduction Quantity and Resource Recycling Device					
	Total Reduction Quantity Goal	Resource Recycling Quantity	Kitchen-Waste Recycling Rate	Bulky Garbage	Noncombustible Garbage	Other[b]
2002	14.2	13.2	1.0	0.0	0.0	0.0
2005	18.0	14.0	3.8	0.2	0.0	0.0
2007	25.0	18.5	4.0	0.3	1.2	1.0
2011	40.0	24.0	7.5	1.0	3.5	4.0
2020	75.0	38.0	20.0	1.3	6.7	9.0

Notes:
[a] Based on 2001 data.
[b] Waste not suitable for recycling or treatment by existing methods, but that may be suitable in the near future.
Source: EPA. *Three-Year Action Plan for Environmental Protection*. March 2004.

To achieve this goal, the EPA formulated a three-year action plan: "Garbage Classified for Zero-Waste Group Plans" and put it into practice during 2004–06. There are seven subplans, as mentioned earlier, to be executed. The details are summarized as follows.

- *Garbage sorting, recycling, and reduction plan*: to promote "coercive garbage sorting" and to increase the quantities of recycled resources.
- *Kitchen-waste recycling and reuse plan*: to establish patterns of kitchen-waste recycling and reuse, and to develop the channels of kitchen-waste reuse in order to increase the quantities of recycled kitchen waste.
- *Follow-up plan for garbage disposal*: to revitalize and re-green the sealed landfills and promote garbage clean-up by the private sector in order to increase efficiency in garbage cleanup.
- *Building a positive image of environmental protection facilities and incinerators*: to make the incinerators harmonize with environments and become important links among the concerned communities, and to build up a mechanism for the construction and installation of garbage treatment facilities with cross-region cooperation. Furthermore, to complete the surveillance and long-term tracking system in incinerating processes.
- *Promotion of environmental protection-related hi-tech parks*: by means of economic incentives, to assist and integrate industries; the relevant agencies, academies, and research institutions will establish sustainable environmental protection.
- *Promotion of awareness of new items to be stipulated as mandatory recyclables*: to continue to evaluate the newly stipulated items that are worth recycling and or reusing, or are hazardous to the environment; at the same time, to study and prepare the related supporting measures and action plans.
- *Raising the recycling rates of the waste items regulated as mandatory recyclables*: to adjust the recycling fees and subsidy mechanisms and subsidize the recycling facilities and factories in order to encourage and reward recycling achievements.

Scheduled Targets

- To reach the target of 20% garbage reduction in 2006, a basis for 2007 and subsequent years.
- To achieve 1,500 metric tons of recycled kitchen waste per day.
- To complete 34 sanitary landfill sites, revitalize and re-green 117 landfill sites, raise the rate of better treatment in remote areas, expand green lands in the parks, and increase public recreation areas.
- To manage incinerators effectively and raise the reusability of fly ash, thereby reducing public anxiety.
- To develop three environmental protection measures related to hi-tech parks, to accommodate more than 40 manufacturers for manufacturing eco-friendly products, R&D, education, and training.

Anticipated Benefits

- To complete coercive garbage classification, resource recycling facilities and equipment, plan for storage sites, and establish organizational systems by 2006.
- Achieving 1,500 metric tons of recycled kitchen waste per day by 2006 to help keep household waste from decaying. Thus an annual cost of NTD1.5 billion for garbage

treatment will be saved, and an income of NTD2 billion from the recycled waste will be obtained per year.

- To deal effectively with the waste resulting from the incinerator equipment shutdowns, as well as the massive rejects after natural disasters. Also, improving, sealing, greening, and beautifying the landfills will increase green parks and public recreation areas.
- To manage the incinerators effectively will minimize public anxieties.
- To achieve the goal of developing eco-friendly hi-tech parks with low pollution and low (zero) waste discharges through eco-technologies for "Zero Waste."

OBSERVATIONS AND RECOMMENDATIONS

Rapid economic development led to a series of negative effects on our environment. Over the past few years the Republic of China has made great efforts to enhance industrial-waste management and made many new policies, including promoting the construction of incineration plants and sanitary landfill sites. Due to land scarcity, landfill and incineration will no longer be the major methods for general waste treatment. The sustainable use of natural resources has become an important issue, and the nation's waste-management policies have shifted to resource reuse and recycling.

The government has attempted to set up Eco-Parks by combining upstream and downstream recycling systems. Actually, most of the 4-in-1 recycling factories are located on southern Taiwan. They keep their own recycling channels rather than following the government's policy of moving into an Eco-Park. To date, the Eco-Park plan is still in its infancy.

Taipei, the first area that implemented a unit pricing system, has successfully reduced the collected waste volume and promoted waste recycling. To solve the waste problem, the effective management of waste is far more important than the disposal of waste. After years of hard work and promotion, and owing to the advances in recycling technology, the TDEP declared its goal of Total Recycling and Zero Landfill for 2010. Once the goal of zero landfills is achieved, there will be no need to develop valleys or lowlands for waste disposal, and the natural environment can be preserved. Yet it takes time and energy to achieve the final goals of zero landfill and total recycling. To face the challenge, we need complete planning, promotion of other supporting projects, and most of all, the cooperation and support of the Taipei citizens to transform Taipei into an eco-city.

All kinds of waste for recycling need to take into account the market demand for recycled products. If the demand for reuse is high, the waste can be recycled smoothly and quickly. Consequently, that kind of waste will end up as zero-waste. However, if the demand is less than anticipated, the economic benefits—even if the government provides lots of incentives—of waste recycling will not work. The policy of "Zero-Waste" in the Republic of China still has a long way to go.

3. INDIA

Dass Ravi
Director-in-Chief
Municipal Corporation of Delhi

INTRODUCTION

Solid-waste management in Asian countries has given alarming signals because of their improper waste management. The urbanization, industrialization, and an increase in economic status and activities have increased the quantity of municipal solid waste and altered its contents. A lack of motivation on the part of the municipalities has created a grave situation. Although the developing countries generate less solid waste per capita in comparison to developed countries, the collection, storage, transportation, processing, and disposal of solid waste is highly ineffective, and consequently damaging to the environment. A poor understanding of solid-waste management leads to different kinds of environmental problems within urban metropolises. The emission of greenhouse gases and air pollutants, the pollution of groundwater, occupational hazards, etc. are other areas of concern.

The new millennium has introduced the global focus on sustainable development, especially in the area of solid waste. Solid-waste management is the responsibility of the municipalities under the provision of their respective acts. Solid-waste management practices in developing countries like India are far from satisfactory, and the associated problems are due to a lack of technical expertise, financial constraints, and legal provisions. Generally, state and municipal governments consider solid waste a low priority, and consequently give less budgetary support to this field. Slow decision-making processes in the municipalities create an additional hindrance. In a broader sense, municipal solid-waste management is a very complex task, as the social, economic, and cultural cooperation among households, communities, enterprises, and municipal authorities is minimal and a lack of awareness of the rules and regulations, as well as environmental concerns with poor resources, have created a chaotic situation.

Although India has formulated legislation relating to municipal solid waste, hazardous waste, and biomedical waste, the compliance and awareness of rules among communities and municipalities are lagging behind. Waste collectors and rag pickers take out the recyclable portion of solid waste and sell it to retailers, which is recycled in the informal sector to the extent of 10% of the waste generated, but no efforts have been made by the government to encourage a recycling industry.

The municipal corporations and municipalities generally collect solid waste through various modes of transportation like handcarts, animal-driven carts, rickshaws, etc. and street sweeping is carried out manually. Generally, municipal solid waste is dumped in low-lying areas by the smaller town municipalities without caring about the environment, whereas a regulatory framework is being partially followed by metro-cities. Cities with a million-plus population are complying with some of the regulations and Green Productivity practices in various activities of solid-waste management, namely the segregation of solid waste, composting at the community level, the transportation of solid waste in closed vehicles, and its disposal in controlled landfill sites having weighbridge facilities with a leachate-management facility.

Solid-waste management, especially in India, can be practiced efficiently and in an eco-friendly manner through Green Productivity measures, and by considering and incorporating various policy, legislative, financial, technology, and management issues.

COUNTRY PROFILE

Physiography and Climate

The Indian subcontinent displays vast diversity in its geographic area. It stretches from the snow-covered Himalayan heights in the north to the Deccan plateau in the south, Indo-Gangetic plains in central and eastern India, and Thar Desert in the west. It shares international boundaries with Bangladesh, Myanmar, Bhutan, China, Nepal, and Pakistan. India has a coastline of about 7,600 km. The total area of India is 3,287,590 sq km. The total land area is 2,973,190 sq km, and 314,400 sq km are occupied by water. About 54.3% land is arable, 2.66% of the land is permanently covered with crops, and 42.99% of the land is used for other purposes. Its climate is tropical and subtropical in south and temperate in north. The common natural hazards that occur in India are widespread and destructive—flooding by monsoon rains, drought, flash floods, and severe thunderstorms.

Demography

The population of India increased from 359 million to 1,028 million during 1951–2001. Out of the total population, 742 million is rural and 286 million live in urban areas; 37% of the population is under 14 years of age, while 56% is between 15 and 59 years. Those over 60 years comprise 7% of the population. The population density is 324 people per sq km. The population growth rate is 1.9% (1991–2001). The birth rate is 24–27 per 1,000, and death rate is 9–10 per 1,000.

India displays great diversity in religion. The majority of the population (about 81%) is Hindu. Other religions include Muslims (12%), Christians (2%), Sikhs (2%), and Buddhists, Jains, and Parsees (3%). As there is wide diversity in geographical locations and religions, 22 major languages have been recognized by the Indian constitution. In addition, 844 dialects are spoken in different parts of the country.

Governance

The Republic of India has a parliamentary form of government based on universal franchise. The Parliament consists of the president and two Houses, namely *Rajya Sabha* (Council of States) and *Lok Sabha* (House of the People). The President is the constitutional head, while the Prime Minister is the head of the government, and runs the country with the support of the Council of Ministers. The Indian Union has 28 states and 7 union territories (administered by the central government). There is a three-tier system of government, i.e., central government, state government, and local government.

Economy

India's economy encompasses traditional farming, modern agriculture, handicrafts, and modern industries, as well as a multitude of support services. The agricultural sector (including forestry and fishing) accounts for 23.7%[1] of the GDP and employs about 63% of the labor force. Rice, wheat, oil-seeds, cotton, jute, tea, sugarcane, and potatoes are the important agricultural products. The service industry has the largest share of the GDP (about 42%) and employs about 26% of the labor force. The manufacturing sector (including mining, quarrying, and electricity) accounts for 24.2% of the GDP and employs 11% of the labor force. The GDP per capita (purchasing-power parity) is USD2,900. The unemployment rate is around 9–10%.

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[1] Central Statistical Organisation, Ministry of Statistics and Programme Implementation, GoI. *India in Figures, 2004*.

The GDP growth rate has been 5–8% per annum. India has capitalized on its large number of well-educated people to become a major exporter of software services and software workers. The economy has had an excellent average growth rate of 6% since 1990. Within the industrial sector, textiles, food processing, steel, cement, transport equipment, and machinery are significant; it also includes mining and the software industry. The industrial production growth rate is 6%. Export commodities mainly include textile goods, gems and jewelry, engineering goods, chemicals, and leather products. The United States (22.4%), the United Kingdom (5.1%), Singapore (4.5%), Germany (4.3%), and China (4.1%) are the export promoting countries. Crude oil, machinery, fertilizers, and chemicals are the import commodities; the import promoting countries are the United States (6.9%), Belgium (6.4%), China (4.5%), Singapore (4.4%), and the United Kingdom (4.4%). In terms of Indian natural resources, coal (fourth largest reserve in the world), iron ore, and zinc concentrates are some of the major mineral products. Other important mineral products are bauxite, titanium ore, chromate, natural gas, diamonds, petroleum, and limestone.

There was a significant decline in the poverty ratio from 36% to 26% from 1993–94 to 1999–2000. The tenth five-year plan has targeted a reduction of the poverty ratio by 5% by 2007 and 15% by 2012. The rate of employment growth in all subsectors exceeded 5% per annum, but there was a decline during 1983–94 due to the near stagnation of employment in agriculture. The employment growth in the country improved to 2.07% per annum in 2000–02 as compared to 1.07% per annum in 1994–2000.

Environmental Profile

The constitution of India clearly states that, "it is duty of the state to protect and improve the environment and to safeguard the forests and wildlife of the country." It imposes on every citizen the duty to "protect and improve the natural environment including forests, lakes, rivers, and wildlife."

National Environmental Regulatory Framework

The Department of the Environment (DoE) was established in India in 1980 to ensure a healthy environment for the country. It became the Ministry of Environment and Forest (MoEF) in 1985. The government constituted the Central Pollution Control Board under the Ministry of Environment and Forest. The states have also been empowered to have State Pollution Control Boards/Committees (SPCB) to meet the challenges relating to environmental issues. The constitutional provisions are backed by a number of laws, acts, rules, and notifications. The Environment (Protection) Act of 1986 (EPA) came into force soon after the Bhopal gas tragedy and is considered an umbrella legislation as it filled many gaps in the existing laws. The major regulatory framework of the country can be described as follows.

- 1986: The Environment (Protection) Act authorizes the central government to protect and improve environmental quality, control and reduce pollution from all sources, and prohibit or restrict the setting and/or operation of any industrial facility on environmental grounds.
- 1986: The Environment (Protection) Rules lay down the procedures for setting standards for the emission or discharge of environmental pollutants.
- 1995: The National Environmental Tribunal Act was created to award compensation for damages to persons, property, and the environment arising from any activity involving hazardous substances.

The regulations specific to water, air, forests, and wildlife are as follows. Figure 3.1 depicts the development of the major environmental laws and regulations in India.

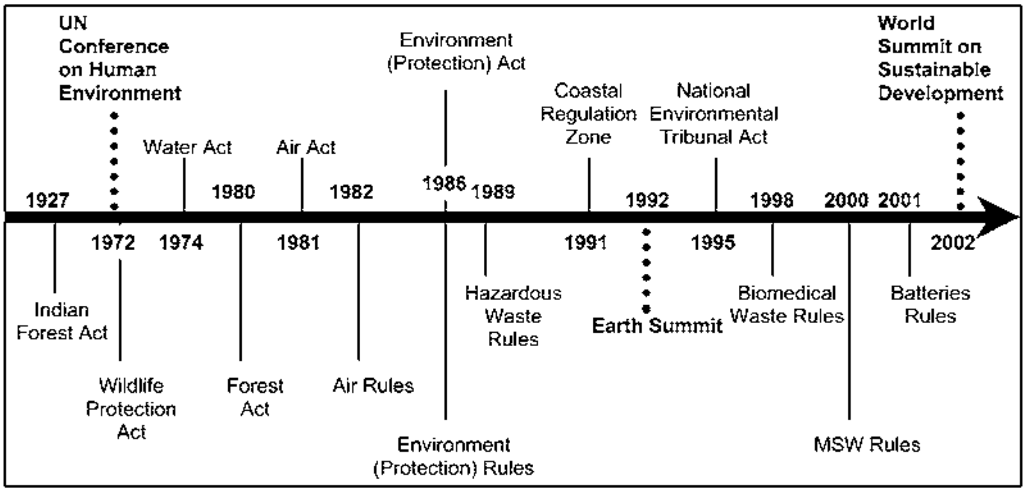

Figure 3.1: Timeline of Environmental Laws and Regulations in India

Water

- 1974: The Water (Prevention and Control of Pollution) Act established an institutional structure for preventing and abating water pollution. It established standards for water quality and effluent. Polluting industries must seek permission to discharge waste into effluent bodies. The Central Pollution Control Board (CPCB) was constituted under the Water Act.
- 1991: Coastal Regulation Zone Notification put regulations on various activities, including construction in coastal areas, and provided protection regulations for backwaters and estuaries.

Air

- 1981: Air (Prevention and Control of Pollution) Act provided for the control and abatement of air pollution. It entrusted the power of enforcing this act to the Central Pollution Control Boards.
- 1982: Air (Prevention and Control of Pollution) Rules defined the procedures for meetings of the boards and the powers entrusted to them.

The regulations related to forest and wildlife were in place before the establishment of the MoEF. The related acts are as follows.

- 1927: The Indian Forest Act and Amendment 1984 was enacted to consolidate the laws related to forests, the transportation of forest produce, and the duty to be levied on timber and other forest produce.
- 1972: Wildlife Protection Act, Rules (1973), and Amendment (1991) provided for the protection of birds and animals and the matters that affect them—their habitat, waterhole, or the forests that sustain them.
- 1980: The Forest (Conservation) Act and Rules (1981) provided for the protection and conservation of forests.

Box 3.1: Incentive Schemes
To improve the environmental performance of solid-waste management, the government of India has framed incentive schemes at the central level. • The government of India provides a reimbursement scheme for the expenses for acquiring certifications in the quality-management system (ISO 9001) and the environmental-management system (ISO 14001) in the small sector to the extent of 75% of the certification cost or INR75,000, whichever is less. • The Ministry of Nonconventional Energy Sources offers incentive to entrepreneurs for setting up plants to process solid waste into fuel/energy recovery. • The Ministry of Agriculture offers a subsidy of INR5 million for setting up a composting plant. • The government had started offering health check-ups and providing safety kits and housing to its waste collectors and sweepers. • The government is promoting Public Private Partnership (PPP) projects on a BOO, B.O.L.T., and B.O.O.T. basis. • Municipal governments are offering land for setting up processing plants for solid-waste management at a rate as low as INR1 per sq m per annum on a license fee basis.

OVERVIEW OF SWM

The growth in the amount of solid-waste generation in India poses many threats to the environment and to occupational health. The improper and manual handling of solid waste and the transfer of waste in open vehicles create unhygienic conditions. Disposal of waste in low-lying areas without proper liners, leachate collection, and treatment systems creates groundwater pollution, and the disposal of solid waste into streams and rivers creates water pollution. Air pollution is created by odor nuisances and the generation of greenhouse gases from most of the landfill sites.

In brief, open dumping of waste adversely affects the environment and human health. All the vectors of disease like flies, mosquitoes, rats, and stray animals like cows, dogs, and pigs breed at receptacles due to a very conducive atmosphere. They then multiply and become the causes of diseases like plague, malaria, typhoid, and cholera.

Environmental Impact of MSW

The environmental problems caused by MSW can be summarized as follows.

- Uncollected waste often ends up in drains, causing blockages that result in flooding and unhealthy conditions.
- Flies breed in some constituents of solid wastes and are very effective vectors that spread diseases. They have spread cholera in Delhi for many years.
- Rats find shelter and food in waste dumps. Rats consume and spoil food, spread diseases, damage electrical cables and other materials, and inflict unpleasant bites. In fact plague was caused in the city of Surat in 1999 by an increase in the rat population.
- Waste plastic bags are a particular aesthetic nuisance. They also cause the death of the grazing animals that eat them.

- Solid-waste collection workers face particular occupational hazards including strains from lifting, injuries from sharp objects, and traffic accidents.
- Dangerous items (such as broken glass, razor blades, hypodermic needles and other healthcare wastes, aerosol cans, and potentially explosive industrial containers and chemicals) pose risks of injury or poisoning, particularly to the rag pickers who sort recyclables from waste.

Current Practices

The existing practices in solid-waste management can be classified at three levels, depending upon the quantity of solid waste and the physical area covered.

- *Rural Level*: Rural people generally do not use plastic or metal containers to keep waste segregated as to biodegradable and nonbiodegradable. Instead, they throw it in the open fields. Sometimes it is naturally composted at the local level.
- *Town Level*: In most towns in India, the practices for the collection and transportation of waste are not defined. No specific mode of collection, transportation, and disposal exists. The garbage is generally dumped in low-lying areas and burned openly.
- *Big-City Level*: A more defined system of collection, transportation, and disposal/composting exists. People send their waste through locally hired waste collectors and organizations to the community bin. From the community bin, it is transported by various methods to sanitary landfill sites. Rag pickers can be seen at waste collection and disposal points.

National SWM Regulatory Framework

Legislation, Regulation, and Policies for Solid-Waste Management

The government of India has taken various steps to improve solid-waste management. The following are some of the steps taken.

- *National Waste Management Committee*: It was constituted in 1990 with the objective of identifying the contents of recyclables in solid waste picked up by rag pickers through Kabariwala.[2]
- *Strategy Paper*: The Ministry of Urban Development in collaboration with the National Environmental Engineering Research Institute (NEERI) formulated strategy papers and was asked to prepare a manual on solid-waste management.
- *Policy Paper*: The Ministry of Urban Development in association with the Central Public Health and Environmental Engineering Institute prepared a policy for the disposal of wastewater, sanitation, solid-waste management, and drainage utilities.
- *Master Plan of Municipal Solid Waste*: The Ministry of Environment and Forest, the Central Pollution Control Board, and municipal authorities devised a strategy and a master plan for managing solid waste including biomedical waste.
- *High Powered Committee*: A High Powered Committee was constituted in 1995 and headed by Dr. Bajaj. The objective of the committee was to suggest a long-term strategy for the collection, loading, transportation, composting, treatment, and disposal of solid waste using appropriate technology.

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[2] A person who makes his living by collecting recyclables and selling them to wholesale dealers.

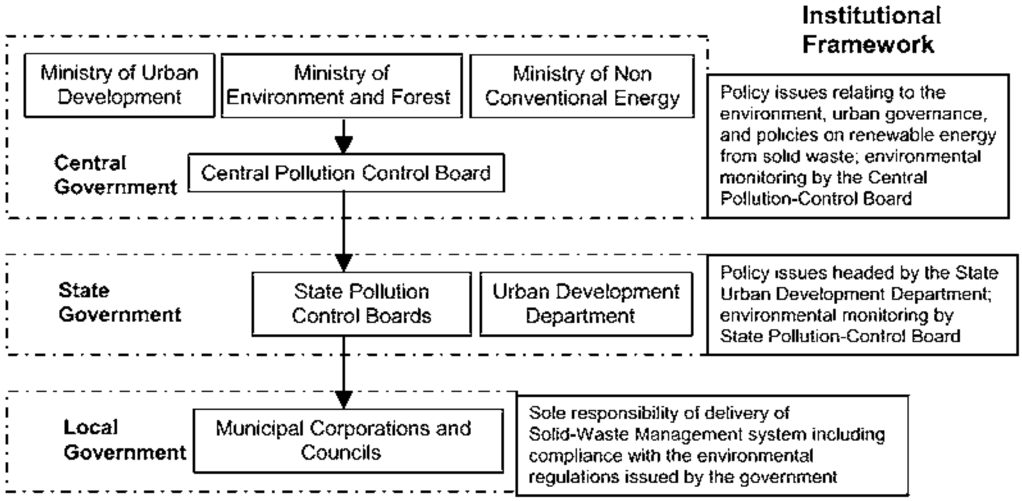


Figure 3.2: Institutional Framework in India

Many acts and regulations relating to protecting the environment have come up from time to time. These are described in the section entitled "National Environmental Regulatory Framework" above. The rules pertaining to solid-waste management are as follows.

- *Hazardous Waste (Management and Handling) Rules* (1989, amended January 2003): These rules deal with controlling the generation, collection, treatment, disposal, import, storage, transport, and handling of hazardous waste.
- *Biomedical Waste (Management and Handling) Rules* (1998): These rules are legally binding on healthcare institutions to streamline the process of proper handling (segregation, collection, treatment, and disposal) of hospital waste.
- *Municipal Solid Waste (Management and Handling) Rules, 2000*: These rules deal with the scientific management of municipal solid waste by ensuring proper collection, segregation, storage, transportation, processing, and disposal of municipal solid waste.
- The *Batteries (Management and Handling) Rules* (2001): These rules apply to every manufacturer, importer, re-conditioner, assembler, dealer, recycler, auctioneer, consumer, and bulk consumer involved in the manufacture, processing, sale, purchase, and use of batteries or components thereof.

The Municipal Solid Waste (Management and Handling) Rules (2000) and Dr. Burman's committee[3] report on the status of solid-waste management in Class I cities clearly indicated the following measures for improving solid-waste management practices: prohibit street littering, organize a waste-collection system, conduct awareness programs, provide adequate community storage facilities and color-coded bins, promote segregation at the source, covered transport vehicles, process waste through appropriate technologies including the composting, recycling, and recovery of materials.

Figure 3.2 describes the framework of government institutes operating at country, state, and local level.

[3] Dr. Burman's committee was appointed by the Supreme Court to review all aspects of solid-waste management.

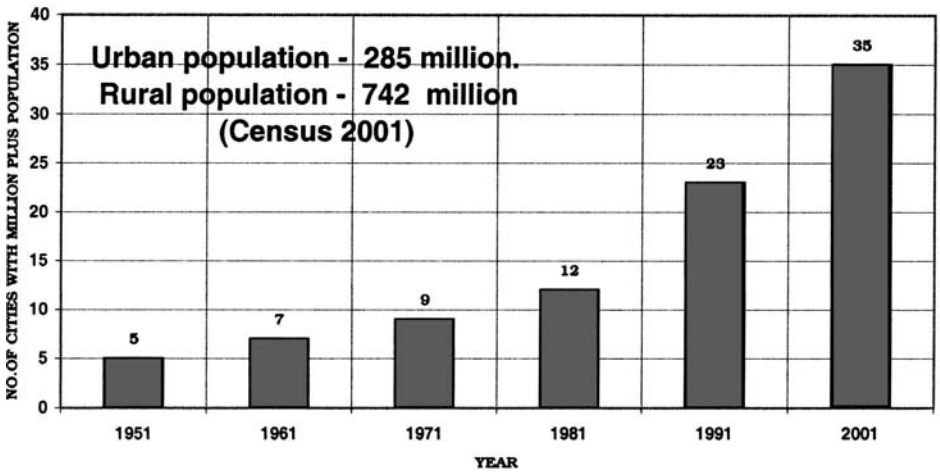


Figure 3.3: Urbanization Trends in India

Incentives and Disincentives

The provisions of the 2000 Municipal Solid-Waste (Management and Handling) Rules and Hazardous Waste (Management and Handling) Rules provide avenues for the recycling and reuse of waste. For waste minimization, the government and ministries offer the following incentives: financial grants to convert waste to energy or composting, land for such projects on very nominal license fee basis, and land at a subsidized rate for recycling industries.

SWM Situation Analysis

The population explosion in India, along with industrialization and urbanization, led to the degradation of the environment and natural resources. The rate of increase in a number of cities having populations of more than 1 million is described in Figure 3.3. The population at the urban and rural level as per the 2001 census report is also described. The SWM situation analysis described is in the context of 35 cities in India having populations of more than 1 million. It is observed that during 1991–2001, 12 cities have been added to the category of more than 1 million in population. This is the highest rate of increase in the last 50 years.

The sources and types of waste are described in Table 3.1. The status of hazardous and biomedical waste in India is briefly presented in Box 3.2.

Quantification and Characterization

The average MSW generation in India is approximately 100,000 MT/day. Out of that, only 60% (60,000 MT/day) is collected by municipal corporations and councils. The rest is disposed of in an unscientific manner.

Composition and Characteristics

Typical municipal solid waste has the following composition percentages:[4] inert matter (54%), vegetative matter (31%), paper, cardboard, and plastics (6%), glass and crockery

[4] CPCB, 2003.

Table 3.1: Sources and Types of Waste

Source of Waste	Type of Waste
Residential areas	Food waste, paper, cardboard, plastic, textiles, glass, metal and nonhazardous waste, batteries, construction debris, and demolition waste
Commercial area (general store, restaurant/hotel)	Paper, cardboard, plastic waste, glass, metal, and e-waste
Institutional area (school, hospital, government offices)	Paper, cardboard, plastic waste, glass, metal, e-waste, hazardous waste, processing waste, ashes, infectious and toxic waste
Industrial areas (light, medium, and major plants)	Paper, cardboard, plastic, metal, e-waste, hazardous waste, and nonhazardous waste
Municipal services (street cleaning, parks, water, and wastewater treatments)	Green trash, silt/ashes, construction and demolition waste, sludge

(0.94%), metal scrap (0.8%), bioresistant, e.g., leather and rubber (0.28%), and other (7%). The general characteristics of urban waste (based on population) is described in Table 3.2.

Physical Characteristics and Waste Generation

Table 3.3 describes the comparison of biodegradable and nonbiodegradable waste generation per day and the calorific value of waste across 35 Indian cities. It is observed that the percent of biodegradable content is low but uniform in cities having a population more than 10 million, higher in cities with population of 2–10 million (so the feasibility of composting

Box 3.2: Hazardous and Biomedical Waste

Hazardous Waste

The total hazardous waste generated by the country is 44,15,954 MT/year. This is generated by 13,011 hazardous-waste generating units. Authorization to 11,138 units is granted by the pollution control boards. Out of the total amount of waste generated 1,685,130 MT (38%) is recyclable, 188,097 MT (4%) is incinerable, and 2,529,947 MT (58%) is disposable. There are 116 incineration plants and 11 landfills for the disposal of hazardous waste. The authorization and monitoring of hazardous waste is the responsibility of the state pollution boards.

Biomedical Waste

Major hospitals and nursing homes are complying with the provisions of the Biomedical Waste (Management and Handling) Rules, namely the segregation/collection of waste in color-coded plastic bags and final disposal of the waste as per the provisions of the rules, including autoclave, hydroclave, or incineration. However no data concerning the biomedical waste generated in the country is available. Monitoring compliance of the rules is done by the state pollution control boards.

Source: Ministry of Environment and Forest.

Table 3.2: General Characteristics

Population of Cities (in millions)	Number of Cities	Moisture	Organic Matter	N%	P_2O_5%	K_2O%
Above 10	3	38.72	39.07	0.56	0.52	0.52
2–10	10	21.03	25.60	0.56	0.69	0.78
1–2	22	26.98	26.89	0.64	0.82	0.72

Table 3.3: Generation of Waste and Physical Characteristics

Population of Cities (in Millions)	Number of Cities	Waste Generation (MT)	Biodegradable	Nonbiodegradable	Calorific Value (kcal/kg)
Above 10	3	15,150	35–39%	65–61%	500–700
2–10	10	14,175	10–60%	90–40%	800–1,050
1–2	22	8,952	10–60%	90–40%	500–1,500

projects is greater), and highest in cities with population of 1–2 million. It varies considerably in cities with populations of more than 2 million.

Solid-Waste Generation per Capita and Collection Efficiency

Based on a survey of 35 cities having populations of more than 1 million, Table 3.4 shows the comparison of solid-waste generation per capita and solid-waste collection efficiency.

Key Elements of SWM

The current methods of solid-waste storage, collection, transportation, treatment, and disposal are illustrated for 35 Indian cities with populations of more than 1 million. The key elements start with sweeping and collection, followed by segregation, storage, transport, and waste processing. The disposal by landfill/biomethanation/composting is the last step being carried out in India.

Sweeping and Collection

Solid-waste generation per capita is described in Table 3.4. Table 3.5 shows a comparison of cities with respect to manual/mechanical sweeping, type of laborers (government or private-sector employed), and the collection mechanism being employed. The solid-waste collection

Table 3.4: Comparison of Solid-Waste Generation and Waste-Collection Efficiency

Population of Cities (in millions)	Number of Cities	Garbage Generation (kg/capita/day)	Collection Efficiency
Above 10	3	0.43–0.58	90–92%
2–10	10	0.35–0.71	80–100%
1–2	22	0.14–0.52	62–100%

Table 3.5: Sweeping Methods, Types of Laborer, and Collection of Waste

Population of Cities (in millions)	Number of Cities	Number of Sweepers (per 1,000 population)	Manual	Mechanical	Sweeping Labor		House-to-House Collection
					Government	Private	
Above 10	3	1.3–3.8	90–100%	0–10%	100%	0%	Private waste collector, municipal worker, and self-help groups
2–10	10	1.57–2.11	70–100%	0–30%	70–100%	0–30%	
1–2	22	0.15–3.51	100%	0%	100%	0%	

system consists of house-to-house collection by private collectors, municipal workers, or self-help groups. It can be seen that mechanical sweeping is practiced only in cities having populations of more than 2 million, whereas sweepers from private companies are working only in cities having populations of 2–10 million.

Segregation, Storage, and Intermediate Collection

Segregation of waste is done at the source or at the disposal site. The storage system is provided at street corners or at the places where house-to-house collection is not practiced. Intermediate collection is nothing but a transfer station where solid waste is collected from street-corner bins, containers, handcarts, wheelbarrows, and auto-tippers and transferred into dumper placers, long-haul trucks, and tractor trolleys at transfer points for transport to the final treatment and disposal site. Tables 3.6 and 3.7 compare the methods adopted for the segregation and storage of solid waste in cities having populations of more than 1 million.

Household-level composting and segregation at the source are practiced more in cities with populations of 2–10 million. The same type of machinery is used for intermediate collection in all cities, whereas the intermediate collection centers (transfer stations) are not being used in cities with populations above 10 million.

Transportation

The transportation system comprises hauling solid waste from intermediate collection and storage points to the final disposal site for treatment and disposal. Table 3.8 gives details on the various vehicles used for transporting solid waste and the agencies involved in it. The

Table 3.6: Segregation of Waste

Population of Cities (in millions)	Number of Cities	Transfer of Waste	Segregation at Source	Composting at Household Level	Recycling
Above 10	3	By rickshaw, wheelbarrow, handcart, and auto-tipper	0–10%	<1%	10–40%
2–10	10		5–90%	1–2%	0–25%
1–2	22		0–50%	0%	0–10%

Table 3.7: Storage and Intermediate Collection of Waste

Population of Cities (in millions)	Number of Cities	Type	Type of Machinery	Number of Transfer Stations
More than 10	3	Street-corner plastic and steel bins, dumper placer, steel containers, concrete/masonry structures, and open dumps	Loaders, dumper placers, refuse collectors, tractor trolleys	—
2–10	10			19
1–2	22			23

transportation system is mostly owned by the city governments, but in cities with populations of 2–10 million, private companies also have a sizable share in the transportation of waste. The cities use tipper trucks, refuse collectors, dumper placers, long-haul trucks, and tractor trolleys.

Waste Processing and Disposal

The processing technologies currently adopted are composting, biomethanation, and waste-to-energy. The disposal by landfill is considered here. Although the landfill sites are government owned, the operation of landfills in some cities is a public-private partnership, whereas in other cities it is by the government only. Table 3.9 shows the details of waste processing technologies and future plans along with future landfill sites. Composting technology is used in all cities, followed by waste-to-energy and biomethanation. New landfill sites are proposed in all cities. The operation of a landfill site is either owned by municipal corporations or through public-private partnerships. The machinery used at landfills consists of bulldozers, excavators, and weighbridges. The infrastructure for landfill sites, such as leachate management, gas management, compaction, leveling, and liner systems with covers are provided at few sites, but are planned for all sites.

Expenditure

The expenditure incurred for SWM by municipal corporations is described in Table 3.10. The SWM cost per capita and per metric ton varies considerably in all cities. The expenditure for SWM is low for cities with populations of 1–2 million, as compared to cities having populations of more than 2 million.

GP Practices and Other Proactive Measures

Waste minimization through reuse and recycling is one of the core activities of SWM. There is a thriving informal sector of rag pickers/kabaries, which minimizes roughly 10% of

Table 3.8: Solid-Waste Transport

Population of Cities (in millions)	Number of Cities	Transport Infrastructure	Type of Ownership	
			Government	Private
Above 10	3	Tipper trucks, refuse collectors, dumper placers, long-haul trucks, and tractor trolleys	45–100%	0–55%
2–10	10		30–65%	35–70%
1–2	22		2–100%	0–98%

Table 3.9: Solid-Waste Processing and Disposal

Population of Cities (in millions)	Number of Cities	Existing Processing in MT			Future Plans	New Landfills Planned	
		Composting	Biomethanation	Waste-to-Energy		Numbers	Model
Above 10	3	1235	10	0	Thrust for composting, biomethanation, and waste-to-energy	5	Some cities planned government ownership, others on a PPP model
2–10	10	812	0	400		9	
1–2	22	340	60	250		24	

Table 3.10: Expenditure by Municipal Corporations on SWM

Population of Cities (in millions)	Number of Cities	Expenditure on SWM per year (INR Crores)	SWM Cost per Capita per Year (INR)	SWM Cost per MT (INR)
Above 10	3	130–500	100–300	1,000–1,800
2–10	10	70–120	120–186	767–1,027
1–2	22	1.5–29.52	145–300	617–682

Box 3.3: Greenhouse Gas Generation from Municipal Solid Waste

Based on the solid-waste generation in India, the approximate greenhouse gas generation is calculated as follows.

- Total solid waste generated in India — 100,000 MT/day
- Carbon content in waste — 20–25% by weight
- In biomethanation, 50% of the gas is converted into CO_2 and the rest is converted into CH_4
- Total quantity of greenhouse gas generation* — 7,500 MT/day

*Greenhouse gas generation = 100,000 × (20/100) × (12/16)

the total waste by recycling. The municipal system handles 60% of the waste generated in cities, while the network of urban waste pickers deals with most valuable recyclable waste. Figure 3.4 depicts the typical flowsheet of waste recycling from municipal solid waste.

Waste minimization is happening in India in two ways. At the household level, newspapers, bottles, plastic, cardboard, etc. are sold directly to Kabariwala. Plastic and other recyclable items are sorted out and segregated by rag pickers from municipal receptacles/dhalaos and landfill sites, and are then sold in the recycling market.

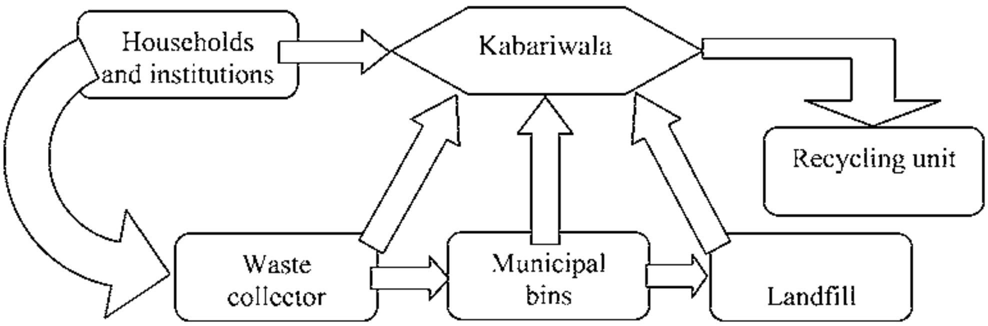


Figure 3.4: Flowsheet of Waste Recycling

Significance of NGOs and Recyclers in Municipal Solid Waste in Terms of Their Environmental Performance

Some NGOs are working in the fields of the segregation/collection of solid waste and composting at the community level with following objectives: (1) to promote local self responsibility for environment, (2) attitudinal change and resource efficiency, (3) creating awareness, and (4) to give protection to waste collectors and rag pickers.

Small-scale units recycling metals, plastic, and paper, etc. are protecting the environment through recycling, but some portion of recyclable waste remains with the solid waste and goes into landfills. The reuse of resources and recycling not only reduce the quantum of waste, but prevent natural-resource depletion and subsequently protect the environment. Waste minimization at the source has become a sensible and sustainable approach to handling solid waste in urban areas. This can be achieved through a continuous improvement in recycling technology.

Problems of the Recycling Industry

The recycling industry in India suffers from the following problems: (1) the present system of reuse and recycling is highly labor oriented and no organized system exists, (2) the processing done by small-scale industries without compliance with regulatory environmental requirements, (3) the poor state of the rag pickers' health and working environment, and (4) unhygienic working conditions at the Kabariwala Complex and recycling factories.

Future Strategies

Various efforts are being made by the government of India in the field of SWM improvement, but due to Public Interest Litigations (PILs) with respect to SWM in the Supreme Court, the court constituted Dr. Burman's committee to review all aspects of solid-waste management and directed the central/state/local bodies to review solid-waste management practices. This consisted of a survey that was carried out in Class I and II cities. In addition, the Supreme Court directed the formation of a technology advisory group (TAG) to update SWM practices. To prepare future plans and policies, a SWOT (strength/weakness/opportunity/threat) analysis of SWM was carried out. The Burman committee report acted as base for the SWOT analysis. Table 3.11 shows the findings.

Based on the findings of the SWOT analysis, the issues that surfaced concerning solid-waste management are still a low priority. Since decision makers do not consider it a main area of concern, environmental pollution is allowed to continue. As a result, the following measures were taken.

- Steps have been taken to implement and amend the Municipal Solid-Waste Management and Handling Rules (2000), the Hazardous Waste Management and Handling Rules (1989, amended in 2003) and Biomedical Waste Management and Handling Rules (1998), and the Batteries Management and Handling Rules (2001).
- The Central Pollution Control Board and State Pollution Control Boards are to identify the solid-waste processing options depending upon the solid-waste composition.
- A law relating to solid-waste recycling for a sustainable environmental-management system with targets and a time frame set for municipalities for solid-waste reduction and recycling is being framed at the central-government level.
- A law relating to electronic waste (e-waste) is being conceived by the government.
- The government of India in close coordination with the World Bank (WB) and the

Table 3.11: SWOT Analysis

Level	Strength	Weakness	Opportunity	Threats
Central Government	Laws related to SWM are in place	Poor enforcement Inadequate funds No master plan for SWM No awareness for SWM Lack of proactive approach on various recycling industries	Linkage between university and research institute with local bodies Waste-to-energy CDM Project Composting Environment improvement	Noncooperation of the states Lack of political will
State Government	Institutional set-up is in place	Inadequate funds Poor enforcement Lower priority for SWM related projects No database of solid waste Lack of political will for boosting SWM product No control on informal sector recycling No tax holiday for SWM	Wealth from waste Scope of Public Private Participation	No land for disposal Public resistance Inadequate capacity building
Municipal Government	Sufficient manpower Additional state legislation on SWM exists	Fully dependent on state for funds Lack of commitment Lack of capacity building No accountability Lack of database Red tape No community participation	Revenue generation from waste CDM and carbon credits Less health hazardous	Poor environmental concern among citizens Inefficiency Political interference Lowest priority No land available

Asian Development Bank (ADB) is trying to arrange for more funds for solid-waste management.

- The Central Government is carrying out awareness campaigns and proposes to reach more people through print and electronic media campaigns.
- The government has planned to increase the sanction/grant-in-aid to various institutions engaged in research/study on municipal solid waste.
- The municipal corporations/state governments in Indian cities have been asked to look into arranging the funding and financing required, on a Built, Operate, and Transfer (BOT) basis.

CASE STUDY: DELHI CITY

City Profile

Delhi, the capital city of India, is the second largest municipal corporation in the world after Tokyo. The population has grown from 13.8 million in 1951 to 14.7 million in 2001, with an annual growth rate of 3.8%. Being the capital city and with vibrant trade, commerce, and employment opportunities, lots of migration takes place from different parts of the country.

Delhi has a per capita income of INR38,864 (2000–01), the highest in the country, with 80% of the income coming from the tertiary/service sector. Around 45% of the population resides in unauthorized colonies and in unplanned settlements and slums.

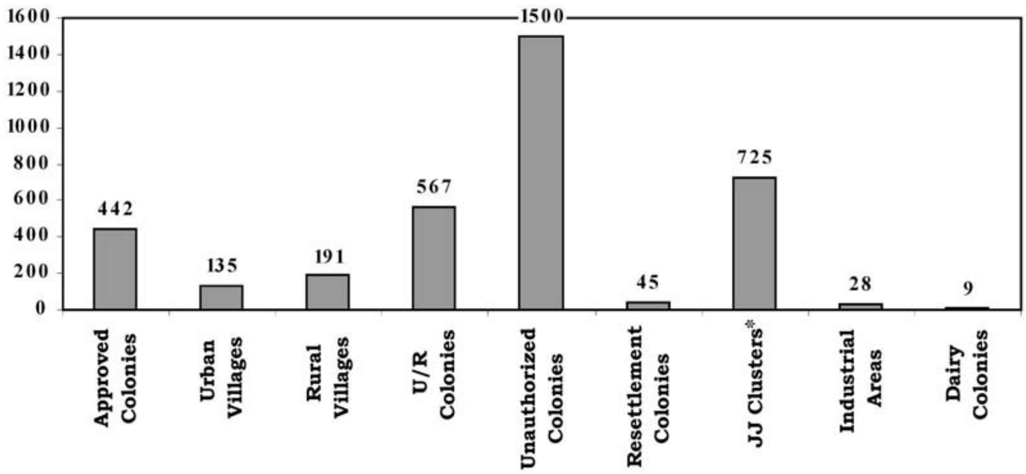
Delhi is surrounded by the states of Uttar Pradesh and Haryana. The geographic area, along with the population of National Capital Territory (NCT) of Delhi, Municipal Corporation of Delhi (MCD), New Delhi Municipal Council (NDMC), and Delhi Cantonment Board is shown in Table 3.12. The Yamuna River and Terminal and parts of Aravali Hills are the main geographic features of the city. The climate of Delhi is extremely hot during May–June and it is extremely cold during December–February.

Business and Commercial Activities

The MCD was incorporated in 1957 by an act of Parliament known as the DMC Act. The main workforces are primarily engaged in the trade sector (32.5%) and trade and commerce activities (31.9%). Manufacturing in nonhousehold factories represents the other sector. Employment in household business, construction, and transport constitutes very small proportion. There are 134 municipal wards in the municipal corporation area and these operate with two wings, the Deliberative Wing, headed by the mayor and various committees (Standing Committee, Education Committee, and Rural Area Committee) and the Executive Wing, headed by the Commissioner along with additional commissioners and heads of the functional departments. To have effective administrative control, the MCD is divided into 12 zones. Each zone is headed by a deputy commissioner. Each zone is responsible for 4–12 wards, depending on area and population. The settlement distribution is presented in Figure 3.5. The available data

Table 3.12: Geographic Details of Delhi

Local Body	Area (sq km)	Population (millions)
NCT Delhi	1,484.46	14.27
MCD	1,399.26	13.67
NDMC	42.4	0.46
Delhi Cantonment Board	42.8	0.14



*JJ Cluster = Jhuggi Jhonpri Cluster

Figure 3.5: Details of Settlements in Delhi

indicates that the total expenditure toward conservancy services by the MCD amounts to 18% of its total expenditures of INR4,145 million.

Solid Waste Generation

Municipal Solid Waste (MSW)

The sources of solid waste are described in Table 3.13.

Industrial/Hazardous Waste[5]

Delhi generates about 60,000 MT of hazardous waste per year from its 150,000 industrial units located in 28 approved industrial areas and several nonapproved areas. The hazardous waste consists of cyanide sludge, paint/pigment waste, oil waste, effluent treatment plant sludge, insecticide, and acidic/alkaline slurry. Industrial units dealing with electroplating, dying, and pickling units generate most of the hazardous waste and sludge. Under the provisions

Table 3.13: Sources of Solid Waste

Sources	Composition
Residential units	1,800,000
Commercial units	140,000
Shopping complexes	7,600
Weekly markets	100
Wholesale establishments	24,600
Hotels/restaurants	340
Floating population	500,000
Road sweeping length (single lane width)	30,000 km

[5] MoEF.

Box 3.4: The Current Legal Framework for MSW in Delhi

The Constitution 74th Amendment Act of 1994 transferred significant authority and responsibility for managing urban growth and development including municipal solid waste from the state government to the Urban Local Bodies (ULBs) and recognized the municipal corporations as the third tier of governance.

Municipal Acts are among the early legislations in the country, dealing with environmental pollution caused by municipal solid waste. The provisions of the Delhi Municipal Corporation Act of 1957 relating to municipal solid-waste management are described with the following important sections.

Section 42: Obligatory function of the corporation—the scavenging, removal, and disposal of filth, rubbish, and other noxious or polluted matters
Section 350: Provision for daily cleansing of streets and removal of rubbish and filth
Section 351: Rubbish, etc. to be the property of the Corporation
Section 352: Provision for the appointment of receptacles, depots, and places for rubbish, etc.
Section 353: Duty of owners and occupiers to collect and deposit rubbish, etc.
Section 354: Collection and removal of filth and polluted matter
Section 355: Collection and removal of filth and polluted matter through municipal agency
Section 356: Removal of rubbish, etc. accumulated on premises from factories, workshops, etc.
Section 357: Prohibition against accumulation of rubbish, etc.
Section 358: Commissioner's power to get premises scavenged and cleansed

Fines
Violations of sections 353, 354, 355(s), 356, and 357 are subject to fines ranging from INR25–100
Section 357(1) "Keeping rubbish and filth for more than 24 hours" carries an additional daily fine of INR10

In brief, the obligation of the MCD is to provide containers, depots, and places for waste disposal (and not necessarily as house-to-house collection).

of the Hazardous Waste (Management and Handling) Rules, 1989, a common hazardous-waste disposal facility is required. This is still under development in Delhi. An inventory of hazardous wastes is also in process under the Delhi Pollution Control Committee.

Biomedical Waste[6]

There are 946 hospitals, dispensaries, and nursing homes in Delhi, generating 60 MT of biomedical waste per day. As per the Biomedical Waste (Management and Handling) Rules, 1998, it is the responsibility of the generator to take care of biomedical waste generated on their premises by either providing incinerators (major hospitals) or by sending it to common waste-disposal facilities on a pay-and-use basis. The majority of the biomedical waste is generated from healthcare facilities. The total biomedical waste generated can be classified as: gen-

[6] Official Delhi website.

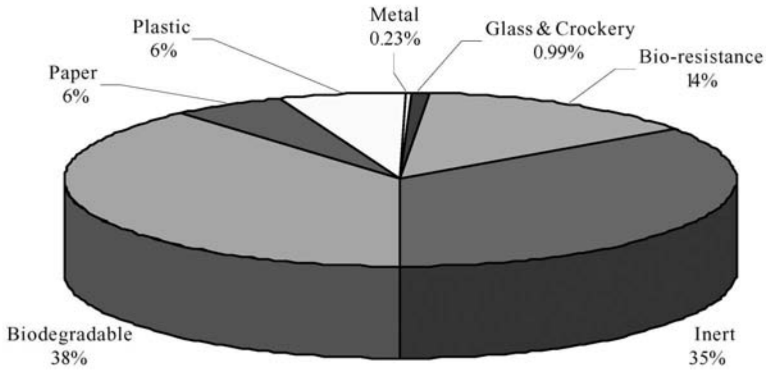


Figure 3.6: Composition of Solid Waste

eral category waste from healthcare facilities (85%), infectious waste (10%), and hazardous waste (5%).

The hospitals and healthcare facilities use color-coded plastic bags, depending on the categorization of waste. The Delhi Pollution Control Committee is the authority in control of the proper disposal of biomedical waste and issues authorizations to hospitals, dispensaries, and nursing homes.

Solid-Waste Characteristics and Quantification

The solid waste generated in Delhi is approximately 6,000–6,500 MT per day with a collection efficiency of 95%. The composition of solid waste is shown in Figure 3.6. The chemical characteristics of solid waste are as follows: moisture (43.65%), silt/inert (34%), organic carbon (20.47%), nitrogen (0.85%), potassium (0.69%), and phosphorus (0.34%).

Key Elements of SWM

The key elements of solid-waste management with respect to environmental compliance are described below.

Collection and Sweeping

The public roads and streets are swept by 49,000 sweepers. They clean the roads and streets with large brooms on a daily basis, from 7 a.m. until night. Generally, the sweepers sweep areas varying from 3,000 sq m to 12,000 sq m per day, depending on the density of the population. The sweepers take the waste to community bins by means of wheelbarrows and handcarts. Presently, there are no mechanical devices for sweeping the streets. Household waste and institutional/commercial waste are generally removed by the waste collectors from house-to-house and deposited in the community bins (container/dhalao). Segregation of biodegradable and nonbiodegradable waste is done at 10% of the colonies in selected areas. The Municipal Corporation of Delhi provides color-coded and covered plastic bins of 1,100 liter capacity, namely green for biodegradable and blue for nonbiodegradable waste. The residents/ waste collectors deposit the waste in these bins.

The Status of Environmental Compliance

In compliance to the MSW rules, the following actions have been taken in the collection of Municipal Solid Waste.

- House-to-house collection of waste: 70% of the area is covered by Resident Welfare Associations (RWA)/NGOs, which provide them with collection facilities.
- Biomedical/industrial waste is not to be mixed with MSW. Biomedical waste is the responsibility of the hospital authorities.
- The development of a collection and treatment facility for industrial waste in the city is in process.
- Construction/demolition waste and horticulture waste are to be kept separately. There is partial compliance.
- As per executive order, waste burning is banned.
- No animals are allowed at community waste containers. There is partial compliance.

Segregation and Awareness Program with All Stakeholders

- Segregation of Municipal Solid Waste: On average, 10% of Delhi's area is covered, and citizens are practicing segregation.
- Recycling and Recovery: 10% of the waste is being recycled in the informal sector by rag pickers/kabariwalas.
- Awareness Program and Community Participation: Group awareness/training programs for waste segregation have been organized.

Storage

The MCD has constructed 2,500 masonry-type community receptacles/containers approximately $4 \times 4 \times 4$ meters. These receptacles can accommodate around 12–16 tons of garbage. Wherever the segregation of garbage is not taking place, rag pickers segregate it at community receptacles. As per a survey done by an NGO, there are around 60,000 rag pickers working at receptacles in Delhi. Some of the receptacles are not properly designed for efficient and safe loading operations as well as from an aesthetic point of view. Efforts have been made to standardize the design of the receptacles by designating separate compartments for biodegradable and nonbiodegradable waste in each receptacle. Typically, wherever no watchman is available, stray cattle enter the receptacles.

In order to avoid contact with waste, manual handling at the receptacles is to be avoided, but there has been limited success. Adequate storage facility for solid wastes at all locations is to be provided, but there is limited compliance here as well.

Transport

There are two kinds of systems existing in the city to transport waste from community bins to landfill sites.

1. Conventional system: The MCD has provided 727 trucks and 120 loaders. To avoid spilling waste on the roads, plastic Hessian sheets are used to cover the trucks.
2. Modified system: As mentioned above, the MCD has already procured 1,100 color-coded bins to segregate waste in selected areas. Biodegradable and nonbiodegradable waste from these bins is transported by closed, hydraulically operated vehicles to the landfill sites. The modified system has drastically reduced the manual handling of waste.

Because of the geographic structure of Delhi, which is round and approximately 25 km in diameter, the MCD does not have any transfer stations, as it was felt that establishing them is not economically viable.

In order to avoid contact with waste and the spillage of waste during transportation, it was decided to cover transport vehicles and avoid multiple handling, but with limited success.

Treatment Processing

In the 1970s, the MCD installed a compost plant of 100 MT per day capacity, which was shut down on account of its nonviability and outdated technology. After that the MCD went one step further by setting up a 500 MT per day compost plant at Bhalswa under the Public Private Partnership. The government provided the land almost free of cost to the entrepreneur. Capital investment was incurred by the entrepreneur. This plant is running successfully and is producing compost and consequently preventing environmental degradation.

The status of environmental compliance is as follows.

- Setting up of waste processing and disposal facilities by 31 December 2003: compost plant of 500 MT was commissioned in 2000
- Monitoring the performance of waste processing and disposal facilities once every six months: partial compliance
- Biodegradable waste free from contamination to be composted: partial compliance
- Waste recycling: 10% being recycled by unorganized sector

Disposal

The MCD has three controlled landfill sites for the disposal of MSW, Bhalswa, Ghazipur, and Okhla, in different parts of the city. These landfill sites are equipped with 3 computerized weighbridges, 26 bulldozers, 8 hydraulic excavators, and 6 backhoe loaders for compacting and leveling the MSW received. Although these landfill sites are not provided with liners, the leachate is being recirculated through channels. The day-to-day mixed waste received at the SLF sites is covered with building debris and earth. Wherever segregated waste is received, separate biocells are created for its composting at the SLF sites. Although landfill sites are barricaded and fenced, ample number of rag pickers can be seen at landfill sites.

The status of environmental compliance is as follows.

- Improvement of existing landfill sites by 31 December 2001: Process was expected to start by 2005.
- Identification of landfill sites for future use and making site(s) ready for operation by 31 December 2002: Progress is slow, but the EIA of the new sites is progressing and new sites are expected to be functional by 2006.
- Monitoring the performance of waste processing and disposal facilities once in six months: Partial compliance.
- Waste at disposal site should not be burnt: Full compliance.

Green Productivity and Other Waste Minimization Approaches

The following Green Productivity measures were implemented in Delhi for the collection, segregation, transportation, recycling/reuse, and disposal of solid waste generated within the city: (1) the preparation of an environmental-management plan of the existing landfill sites, (2) a master plan and feasibility study of treatment/disposal (2004–05), (3) measuring the efficiency of fuel consumption by refuse transporting trucks, i.e., km/liter, and (4) a restructuring and inventory control system for the MCD automobile workshops and energy audits.

Box 3.5: Basic Features of Existing Sites around Delhi

There are three controlled landfill sites in Delhi where MSW is deposited. The quantification of landfill gas generation has been worked out based on the existing quantity of waste after its closure. The following table shows the details of gas generation at landfill sites.

Name of Landfill	Area (hectare)	Quantity of Existing Waste (million m^3)	Balance Life (years)	Maximum LFG Quantity Annually (million Nm^3/year)
Bhalaswa	26.22	2.91	1.5	18–28
Okhla	22.89	2.36	2	8
Gazipur	29.62	3.95	4–5	8–16

Implemented Measures

Collection and segregation program From 1 January 2004 it was mandatory on the part of citizens to segregate waste at the source, i.e., at the household level, and to bring it to the receptacle. The MCD is acting as a facilitator and is providing the following equipment to encourage household segregation.

- Twin-chamber dhalao/receptacle, roadside bins based on the field survey
- Refuse removal trucks and refuse collectors for bins
- Twin-chamber rickshaws and specially designed wheelbarrows
- Safety devices and handling equipment like brooms, belchas, and panchangras
- Awareness campaigns through posters and flyers
- One-to-one meetings with the Resident Welfare Associations (RWA) for problem identification and remedial measures
- Organization of training/awareness sessions for the RWAs concerning segregation and composting by the community
- Training on composting in collaboration with the horticulture department and self-help groups
- Development of training module for the MCD staff (in-house)
- The MCD has identified the manufacturers of biodegradable plastic bags and community bins. These are provided to the community at predetermined places.

A number of awareness and training workshops were organized among the citizens for all the zones of Delhi. The objective of the workshops was to give everyone the appropriate information on segregating garbage and the segregation system, to anticipate difficulties and find solutions, and to develop an action plan for implementing segregation at the source. More than 2,000 residents participated in the workshops. Stakeholders who attended the workshop were RWAs, housewives, eco-club members (students and teachers), the sanitation staff (junior- and senior-level municipal officials), NGOs, and rag pickers.

Collection and transportation With an objective of increasing the efficiency and effectiveness of its waste-management activities, the MCD engaged private-sector operators in six MCD Zones (City, South, West, Central, Karol Bagh, and Sadar Paharganj) to collect and transport solid waste. The MCD retained the Infrastructure Development Finance Company (IDFC) to advise it in this regard and to help conduct the bidding process. Toward this end, the MCD is in the final stages of its selection process for qualifying interested parties. It is estimated that 50% of the garbage generated by the city will be handled by private sector participation.

The MCD is planning to install a GPS-based tracking system to locate the position of its refuse-removal trucks and other vehicles, and thereby increase their efficiency and productivity. The GPS devices will be installed on a pilot basis in 50 municipal vehicles and if it is successful, the same will be done on all the vehicles of the conservancy and sanitation-engineering department. The MCD intends to have a GPS-based surveillance system (Automated Vehicle Tracking System) for its fleet of refuse-removal trucks and other related equipment to ensure regular and timely collection and to evaluate the amount of solid waste at the sanitary landfill sites.

Recycling and reuse of waste Recycling municipal waste is widely prevalent in Delhi and an extensive network of stakeholders is involved in the process. The recycled waste comprises paper, cardboard, metal, glass, and textiles. The recyclables are collected by the rag pickers; households also sell recyclables to roaming buyers. The only difference between the rag pickers and the roaming buyers is that the roaming buyers purchase saleable waste from the waste generators. They then sort these items and send them to factories for recycling.

The city, as per a survey carried out by *Shristy* (an NGO) has 80,000–100,000 rag pickers. Generally, these rag pickers and roving buyers reduce the waste for treatment from 1,500 MT to 1,200 MT per day. Recycling is usually done in a dirty and nonhygienic manner. Solid waste and slurry lying outside the recycling units cause air, soil, and groundwater pollution. Due to the outdated recycling technology, the recycling machinery runs inefficiently and consumes excessive power.

Disposal The technologies to be adopted for the disposal of solid waste have been identified through the master plan study carried out with UNDP assistance to the MCD. These technologies are as follows: windrow composting, in-vessel composting, biocell landfill, refuse-derived fuel (RDF), mass-burn incineration, biomethanation, and processing construction and demolition waste.

Financial aspects In accordance with the GP measures adopted with respect to disposal technologies and treatment plants for solid-waste management in the MCD, the cost functions have been developed on the basis of actual plant costs from European countries and therefore are not directly transferable to the context of India. However, they illustrate the cost aspects and the effect of economy of scale, i.e., the savings in investment and operating costs after building treatment facilities with high capacities. Following are the findings of the cost-benefit analysis.

- The introduction of new landfills will increase transportation considerably (127–144%).
- Solid-waste treatment will reduce the overall transport work by 15–21%, compared to merely adding additional landfills in the future.
- The revenue model will depend on the income generated by charges to the users of the facility.
- Sale of recyclable material

Table 3.14: Summary of the Financial Analysis for MSW Treatment Technology Options, 2005–24 (in INR millions)

Technology Options	Investments/Capital Costs	O&M Costs
Composting	1,223.6	2,244.3
Biomethanation	4,802.3	1,198.8
RDF with power generation	3,000.5	5,364.2
Construction debris and demolition waste processing facility	775.0	975.8
Sanitary landfill with gas recovery and power generation, including closure costs	11,222.9	6,391.4
Total	21,024.3	16,174.5

- Sale of compost and power generation due to waste treatment
- The possibility of obtaining CDM credits through methane capture

A number of assumptions were made to arrive at the capital costs for implementing the SWM master plan for Delhi. The total developmental costs based on these assumptions, in the form of investments and annual operation and maintenance costs, is summarized in Table 3.14.

All revenue streams from MSW treatment technologies are summarized in Table 3.15. The scrap value for plant and machinery is calculated assuming a 15-year plant life, a straight-line depreciation of 15% per annum, and a residual scrap value of 10% for all plants (compost, biomethanation, RDF, and C&D) is considered.

Financial Analysis

Since the objective was to produce preliminary financial data that will lead to a detailed technology design and costing at a later date, the focus of the assessment has not been toward calculating a return on investments or equity, but toward providing a basic cash flow or an investment plan. Moreover, the net-present-value (NPV) technique was used to predict the time value of money and the possibility of alternate investment.

Conclusion

The master-plan-project period deficit has been estimated at INR8,641.7 million. This is the expected level of funding required to make the master plan successful over and above the revenue generated by the plan.

Table 3.15: Comparison of Revenue Generation with Respect to Treatment Technologies, 2004–24 (in INR millions)

Revenue Source	Estimated Revenue
Power generation	14,731.3
Sale of compost	1,759.3
Sale of carbon credits	4,131.5
Sale of C and D waste products	3,149.1
Scrap value of plants and machinery in 2024	4,785.8
Total	28,557.0

Environment Management Plan of the Existing Landfill Sites

The environment management plan of the three existing landfill sites is in progress. These landfill sites are: Bhalaswa which receives more than 2,000 MT/day, Okhla, Phase 1, which receives more than 1,000 MT/day, and Gazipur, which receives more than 2,000 MT/day.

Master Plan and Feasibility Study of Treatment and Disposal, 2004–05

A master-plan study was undertaken for the MCD with assistance from UNDP and UNOPS on the treatment/disposal of municipal solid waste. The executive consultant COWI with M/S. Kadam Environmental services has given recommendations on the treatment and disposal of municipal waste, forecasting of waste until 2025, and existing and new landfill sites.

The study also indicated the treatment options most suitable for the MSW of Delhi. It is expected that the study will help the MCD identify the treatment options and the future planning for the forecasted quantity of municipal solid waste in Delhi.

Future Strategies and Action Plan

The Green Productivity tool can be useful for developing a sustainable environmental system through various options. This can be developed in India in solid-waste management in the following manner.

1. The APO should develop a mass awareness program in various states and municipalities to let all concerned know how Green Productivity measures can be replicated in solid-waste management areas throughout the country.
2. The APO should make themselves conversant with the environmental laws in the country, especially relating to solid-waste management, the extent of compliance to environmental laws, municipal acts, the organizational hierarchy and flow of information, the suitability of technology for a sustainable environmental system, and the benefits of Green Productivity. It should also define the cost concerns for each activity for long-term planning.
3. The data and functions of the APO and the municipalities should interact with each other, either through capacity building or by organizing special programs, so that both can understand the problems and seek solutions to them for a sustainable environmental system through GP.
4. The APO should work as a bridge between the state/municipalities and the funding agencies to understand their problems thoroughly.
5. The APO is to identify efficient and cost-effective technology relating to SWM, keeping local conditions in mind.
6. The APO presumably should have knowledge of time-and-motion studies, route planning, processing technologies (and their suitability and cost effectiveness), disposal technologies, and the data relating to landfill gases.
7. The APO should assist the state/municipalities to improve the existing solid-waste management system by incorporating GP measures through the identification of suitable technology.
8. The APO should assist the state/municipalities to develop a master plan for next 20 years for each city, along with a strategy and implementation plan.
9. The country expert should also be involved with the APO and the municipalities to look into how the measures can be implemented by state/municipal corporations through special audits from time to time.

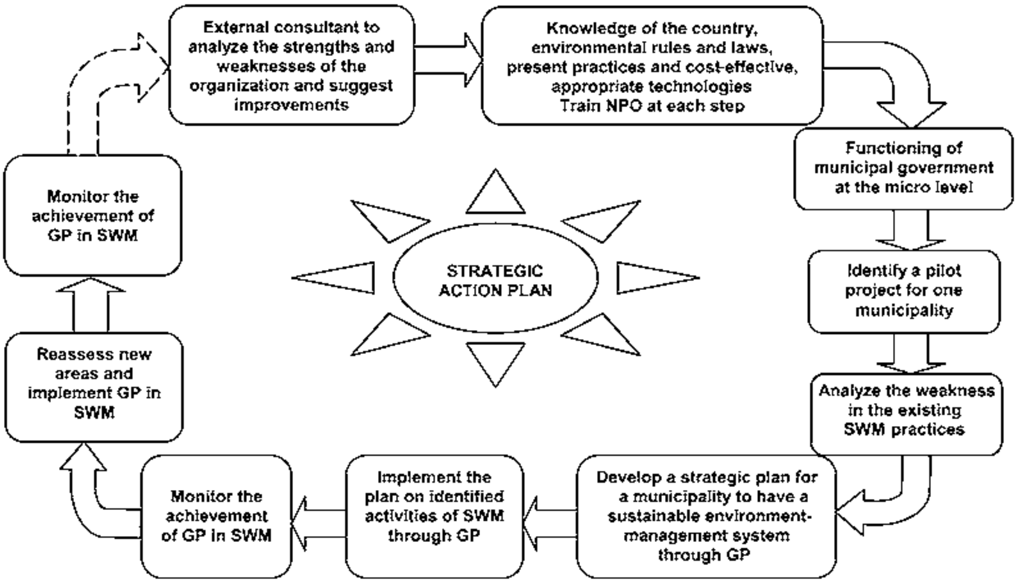


Figure 3.7: Strategic Action Plan for a Sustainable SWM System

Figure 3.7 describes the flow of the implementation of a strategic action plan by using the Green Productivity tool for a sustainable solid-waste management system.

OBSERVATIONS AND RECOMMENDATIONS

Observations

In light of the survey of the SWM in cities with populations of 1 million or more, it is evident that the various aspects of SWM practices have been analyzed. Green Productivity tools and technology can help municipal corporations achieve an efficient, sustainable, solid-waste management system. Presently municipal solid-waste collection in residential and commercial sites in most of the cities have two broad divisions, namely street-sweeping services and waste from households and commercial areas. In some cities house-to-house collection is done by municipal corporations, but in the majority of the cities it is the responsibility of the citizens to dispose of waste in municipal bins. There is not strict compliance to these rules because of illiteracy, poverty, etc.

Sweeping and Collection

Street sweeping is done by municipal workers using brooms and wheelbarrows. The collection efficiency is quite low due to nonuniformity in the collection system. Due to the financial constraints, the infrastructure required such as litter bins, twin bins for segregated garbage, handcarts with two chambers, safety equipment, brooms, and other equipment needed for efficient garbage collection are not made available in adequate number.

Segregation

The segregation of waste is not being done by citizens in the majority of cities. People throw their waste along the roadside or into the community bins without segregation. This is due to a lack of awareness about the rules and regulations and their implications. It is also a common perception among the citizens that it is the duty of the local government to manage municipal waste. A lack of infrastructure provided by the local government also leads to non-segregation of waste at the household level.

Transportation

Transportation is carried out in open vehicles and causes air pollution and aesthetic problems. Waste is transported to landfill sites by government-owned vehicles as well as by private vehicles. Most of the municipal corporations dump their waste in local low-lying areas with no provision for gas collection, a leachate treatment and liner system, boundary walls, weighbridges, washing facilities, etc.

Disposal

Some of the metro cities, however, have controlled landfills using compaction with bulldozers and covering with soil. Leachate recirculation and weighbridges also exist. Many cities have also planned newly engineered SLF sites on the PPP model.

The average calorific value of solid waste is about 500–700 kcal/kg, which is quite low. In most cities waste processing is limited to composting only. However some metro cities are doing waste-to-energy. Many new technologies are planned or are at the stage of initial planning. The budgetary provision for municipal solid-waste management is also not sufficient, as most of the expenditure is incurred for sweeping/collection and the balance of the budget is spent on transportation. Very little is spent on disposal.

Reuse/Recycling

The majority of the rag pickers operate at the household and municipal-receptacle level, and also at sanitary landfill sites. These rag pickers recycle 10% of the waste generated in the cities through an informal network.

RECOMMENDATIONS

Keeping in mind the scenario of MSW in India, there is a need for an overall improvement in all fields of solid waste activities, namely policy issues, legislative issues, financial issues, technical issues, management issues, and other supportive issues. These are briefly discussed below.

Policy Issues

- The government is to formulate a strategic SWM plan for at least the next 20 years and accordingly municipalities are also to formulate their detailed action/implementation plan as well as their monitoring plan.
- Periodic environmental audits of the MSW activities of each municipality is to be conducted by independent third party auditors.
- The central government is to provide fiscal incentives and encourage the recycling industry by adopting the appropriate technology through Green Productivity.
- The government should encourage obtaining carbon credits in a simplified manner.
- Wherever required, the central/state government should initiate actions to amend the municipal acts concerning incentives/disincentives.

- The "polluter-pays" principle is to be adopted, and the municipalities are to levy a SMW cess.

Legislative Issues

- Develop regulations and laws and also set up a mechanism for recovering materials, recycling, and source reduction to encourage the recycling industry.
- Declare all solid-waste disposal sites as pollution sources. Discharge from them should be regulated to establish standards.
- Review laws relating to SWM in accordance with the current situation and impose higher tariffs on commodities with packaging or that generate high volume of refuse.
- Declare landfill/processing sites as an industry with buffer zone of 500 m all around. No development is to be allowed in this buffer zone.

Financial Issues

Finance is an important resource for sustainable waste management. Generally most of the municipal corporations do not have many resources due to various constraints and priorities. Municipal corporations should have a "polluter-pays" principle and a compulsory tax on SWM.

- Transparency in financial regulations by incorporating the double-entry system.
- Fiscal incentive to PPP projects that provide a capital incentive for SWM alternatives.
- To encourage private-sector participation, grants of soft loans, subsidies, and exemption from taxes including the duty for machinery and equipment.
- The municipalities are to cost out each activity and try to reduce it in phases.

Municipalities should share their best practices among themselves for the effective and economical management of solid waste.

Technical Issues

Applying SWM without a local perspective would be misleading on the part of developing countries. It is desirable to introduce locally suited SWM technology after a detailed study. The study should address the following points.

- Efficient collection systems through color-coded bins
- Collection at fixed times
- Street and footpath sweeping on a daily basis
- Transporting waste in colored trucks based on the designated route
- An R&D cell for each municipality
- Controlled waste treatment and disposal facilities
- Route planning and time-motion studies
- Upgrading existing landfill sites and a system to manage the collection of gas
- Select new landfill sites for the next 20 years
- Safety kits and regular medical check-ups for workers
- New engineered SLF sites as legislated, with a gas-management and leachate-collection system and encouraging private-sector participation by providing tipping charges payable by the municipality

Management Issues

In a developing country like India, overstaffing, lack of motivation among workers, and absenteeism lead to inefficient SWM.

- Neighboring municipalities should combine and decide to have common treatment and disposal facilities on a cost-sharing basis.
- Municipalities should levy an SWM tax.
- Green Productivity linkages and mandatory recovery will reduce the generated waste at both the manufacturing and consumer ends.
- Promote information, education, and communication.
- Open municipal buy-back facilities that would sell the usable items to the general public on fixed days.

Supportive Issues

- Promote public education programs through the electronic media.
- Provide education and training programs, as well as enhance the administrative capabilities of local government officials and workers.
- Start public/private partnerships to counteract inefficient municipal workings. Encourage the participation of NGO, CBO, and self-help groups.

4. ISLAMIC REPUBLIC OF IRAN

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INTRODUCTION

Most of the Islamic Republic of Iran is dominated by an arid climate, but the northern part (Khazar region) enjoys a warm Mediterranean climate. Iran is an oil exporting country with a GDP of USD101.6 billion in 2001. Privatization of some key industries was started in year 2000.

Environmental protection in the Islamic Republic of Iran is laid down by the 50th principle of the constitution. The principle of environmental protection has been given a high legal priority in the constitution, but environmental legislation has not yet been developed to the extent needed. Municipal solid-waste management systems have not been fully developed and the uncontrolled dumping of waste is a common practice in Iran. Until very recently there was no legislation for this important issue. Traditionally each municipality is responsible for the municipal solid-waste management system (MSWMS) in its respective urban area.

Solid waste (SW) appears in different forms and has a broad spectrum. It consists of all kinds of waste arising from social, economic, and industrial activities.[1] During the past 30 years, the solid waste generated in the Khazar region of northern Iran has changed in quality and quantity, but in principle the methods of collection, transport, and disposal have remained the same.[2] As a result this region is facing serious environmental problems. For instance, some of the rivers are polluted and have been converted into dumping sites for waste from industrial, agricultural, and municipal activities. The main aim of this report is to assess the present state of SWM in this region and to evaluate alternative systems and the establishment of an efficient organization for SWM in the region. There are no universally applicable solid-waste management systems; every country must evolve an indigenous technology based on the quantity and characteristics of the waste, the level of national wealth, wage rates, its equipment-manufacturing capacity, energy costs, and the availability of foreign exchange for the purchase of imported plants. Although the utilization of data obtained in one region or country and the application of it to other regions or countries is technically inappropriate, some important similarities are evident in activities pertaining to the storage, collection, and transport of solid waste.[3]

COUNTRY PROFILE

Physiography and Climate

The Islamic Republic of Iran comprises an area of 1.648 million sq km and is located in the Middle East. It borders the Gulf of Oman, the Persian Gulf, and the Caspian Sea, between

[1] G. Tchoganoglous, H. Thiesen, and A.V. Samuel. *Solid-Waste Management*. New York: McGraw Hill, 1993.
[2] Netherlands Engineering Consultants (NEC). *Integrated Master Plan for Solid-Waste Collection, Disposal, and Recycling in the Provinces of Mazandaran and Guilan*: Final Report. Tehran: NEDESCO, 1978.
[3] L. F. Diaz, G.M.T. Savage, and L.L. Eggerth. "Managing Solid Waste in Developing Countries," *Wastes Management*, 1997: 43–45.

Iraq and Pakistan. Situated between 25° 03′ and 39° 47′ N latitude and 44° 05′ and 63° 18′ E longitude, Iran has a coastline of 657 km on Caspian Sea and 2,043 km on Gulf of Oman and the Persian Gulf. Tehran is the capital city of the Islamic Republic of Iran, located in the north at the base of the Elburz Mountains.

The Islamic Republic of Iran shows a wide range of variability of climate in different regions. Most of Iran is dominated by an arid climate because of the mountain ranges in the north and south, while the coastal area exhibits a warm Mediterranean climate. Temperature varies significantly from the mountain area to desert region due to altitude difference. The annual precipitation also differs from 21 mm or less in the *Yazd* region located in the center to 1,685 mm on the Caspian Sea coast. Summertime is considered the dry season and late autumn to winter receives cold rain. Roughly 90% of the land is highland or plateau where about half is mountainous regions that are mainly separated into northern, western, central, and eastern areas. The highest peak is Damavand Mountain (5,671 m), located northeast of Tehran.

Demography

Iranians are mainly Fars who originated from Indo-European groups. Other ethnic groups in Iran are Persian (51%), Azeri (24%), Gilaki, Mazandarani, Kurd, Arab, Lur, Baloch, Turkmen, and others (25%). Shia Muslim has been the state religion since the 16th century. The population is 99% Muslim, and also includes Jewish (0.5%), Christian (0.3%), and Zoroastrian (0.2%). The main languages are Persian and Persian dialects (58%), Turkic and Turkic dialects (26%), and Kurdish (9%).

The total population of Iran is 66 million (as of 2003) of which 39.5% are 0–14 years of age, 56.1% are 15–64 years, and 4.4% are more than 65 years. The population growth rate is pegged at 1.5%. The life expectancy at birth is 69.1 years in Iran. As of 2001 84% of the males and 71.5% of the females were literate.

Economy

The Islamic Republic of Iran is the second largest oil producer in OPEC with the fifth largest known oil reserves (8.7% of the world total) and the second largest natural gas reserves. Iran's economy is heavily dependent on the export of oil: 40% to 50% of the government's budget relies on oil, which is 10–20% percent of the GDP. The Iranian economy experienced a major slow-down due to lower oil prices in 1998–99, but the prices rebounded in recent years, helping the Iranian economy to recover. In 2000 the real GDP growth rate had reached 5.9%. The agriculture sector suffered repeated droughts in recent years, reducing its contribution to the GDP. The service sector has grown, while the mining and manufacturing sectors have declined compared to the industrial structure just after the revolution. Iran's exports amount to about USD28.35 billion and import amounts to USD15.21 billion for the years 2000–03.

The Islamic Republic of Iran is facing various issues, including a fiscal crisis in its national budget (the inflation rate was 12.6% in 2000), difficulty in securing employment for the younger generations, a high unemployment rate, overdependency on oil resources, huge external debts (many of which are short-term with high interest), excess subsidies for essential products, an inefficient public sector, and a national monopolistic enterprise. The Iranian government has planned for privatization and decentralization to deal with these issues. The privatization of some key industries like communications, the postal system, the railway system, and the petrochemical industries is within the scope of the five-year economic plan. This plan also aims to create 750,000 new jobs, a GDP growth rate of 6%, and reduce the subsidy for essential goods. The industry sector has also formulated strategies for sustainable development. These strategies include the identification of eco-friendly products, understanding environmental management, establishing effluent treatment plants, and establishing specialized industrial townships. Table 4.1 shows the number of industries in each group in the Islamic Republic of Iran.

Environmental Profile

Environmental protection in Iran is laid down by the 50th principle of the constitution, which states: "In the Islamic Republic, the protection of the environment, in which the present and the following generations should have a social life of constant development, is a public responsibility. As a result, every economic or other forms of activity, the execution of which necessitates the pollution or the irretrievable destruction of the environment is forbidden."

While the principle of environmental protection has been given a high legal importance by its inclusion in the constitution, environmental legislation has not yet been fully developed to the extent needed. The existing environmental legislation contains general requirements and bans to prevent irreversible change and damage to the environment. These laws, regulations, and standards are generally to control environmental pollution and are executable by the Department of the Environment (DOE).

National Environmental Regulatory Framework

In general, the environmental laws and regulations in the Islamic Republic of Iran are divided into two groups—for the natural environment and the manmade environment. In the former, rangelands, forests, wildlife, game, fish, and other subjects related to nature and the natural resources are covered. In the latter, subjects such as water, air, and noise pollution and environmental assessment are covered. In other words, this group of laws and regulations deals with issues concerning the human environment.

With the approval of the Environmental Protection and Enhancement Act of June 1975, the supervisory Organization of Game and Fish started its activity under the new name of the Environmental Protection and Enhancement Organization. The organizational chart underwent a dramatic change and received vast authorities to prevent pollution and any damage to the environment. The same laws, with the amendments of October 1993, are still in force.

Table 4.1: Number and Distribution of Industrial Groups, 1998

Index of Industrial Group	Number of Industrial Units	Rate of Employment (1000 individuals)	% of Industrial Units Out of All Industries	% of Number of Employers over the Whole
Food and medicine	5,118	144.6	11.74	14.20
Textile and clothing	6,583	248.3	15.10	24.48
Chemical and cellulose	8,328	136.5	19.11	13.40
Electronics	1,758	79.9	4.04	7.84
Nonmetal and mineral	9,706	200.7	22.26	19.73
Metal and household appliances	5,477	103.9	12.56	10.20
Car and motor vehicles	1,288	31.5	2.95	3.09
Machinery and equipment	5,334	72.9	12.24	7.16
Total	43,592	1,018.4	100.00	100.00

The Prevention of Water Pollution By-law was approved by the cabinet members in December 1985 in accordance with Note Number 46 of the Fair Water Distribution Act of 1983. This by-law defines the duties of polluting factories. It was revised in 1995.

The First Economic, Social, and Cultural Development Plan of the Islamic Republic of Iran was passed in February 1990 (Note Number 13). It concerned environmental issues. According to this law, factories and oil plants are to contribute 1% of their sales to prevent environmental pollution and to compensate for damages and loss to the environment. This expenditure is included as part of the tax bill. This concept was later included in the Law for Comprehensive Collection of Government Income that was included in the Bills of Article Number 45.

With the passage of the Second Economic, Social, and Cultural Development Plan of the Islamic Republic of Iran in December 1995, the government began to place more importance on the issues of environmental protection and conservation. The relevant notes approved defined the duties and commitments of those wishing to rebuild, develop, and utilize natural resources with environmental considerations. The Prevention and Control of Air Pollution Law was passed in April 1996 to protect the air from pollutants.

Rules and regulations were further approved in the Second Economic, Social, and Cultural Development Plan in September 1999 concerning: (1) utilization of natural resources with environmental considerations, (2) using energy in the best way, (3) utilization of sand and fine-sand mines as well as obliging mineral and industrial units to control their dangerous waste, and (4) air-pollution control in large cities.

Subsequently, in June 2002, the by-laws of the Prevention of Noise Pollution Act was passed in accordance with the Prevention of Air Pollution Act. The Executive By-law of the Prevention of Air Pollution Act was approved in September 2001, and the legal guidelines were defined and carried out.

The issue of environmental protection was more emphasized when protecting and conserving the environment became essential after the Third Economic, Social, and Cultural Development Plan of the Islamic Republic of Iran was approved in March 2001. This plan specifically dealt with environmental policies and some other items in brief. According to the law, the environmental policies and regulations are to be applied to developmental and construction activities.

To abate air pollution in accordance with the World Health Organization standards, the government named seven cities for air-pollution abatement programs. These cities are Tehran, Mashhad, Tabrize, Ahvaz, Arak, Shiraz, and Isfahan.

Relevant Environmental Legislation

The key environmental legislation enacted in the Islamic Republic of Iran are as given below. The salient features of these legislations have also been highlighted.

The Law of Protection and Improvement of the Environment (approved in 1974 and modified in 1992)

- Prohibits any actions/activities that may result in environmental pollution.
- Authorizes the DOE to "warn" polluting establishments. If compliance is not achieved within the time frame set by the DOE, the establishment could be closed.

The Law of the Method of Air Pollution (approved in 1995)

- Prohibits all establishments from conducting activities that would result in air pollution.
- Construction of new establishments and relocation of existing ones is required to meet the regulations and criteria set by DOE.

- Establishments and activities causing air pollution that do not meet the criteria and limits set by DOE are prohibited.
- Sets limits for noise.

The Law of the Third Plan of Economic, Social and Cultural Development of the IRI (approved in 2000)

- Requires all large-scale projects to be environmentally assessed during the feasibility and site selection study phases. It also requires the proponents of the project to meet all requirements and measures set by the EA.

The Law of Fair Distribution of Water (approved in 1982)

- Unless permitted by the Ministry of Energy, it prohibits any drilling or interface with the beds of rivers, natural streams, public channels, floodplains, wetlands, lagoons, regulated borders of coastal areas, and lakes.
- Requires permission from the Ministry of Energy to use groundwater resources (i.e., drilling wells, spring development).

Executive Agenda for Protection and Improvement of the Environment (approved in 1975)

- Prohibits, except with a permit, any actions that would result in changes in ecosystems within wildlife refuges and protected areas.

Agenda for Water Pollution Prevention (approved 1994)

- Prohibits any activity that would result in water pollution. In particular, it prohibits discharge of wastewater exceeding pollution limits.
- Mandates the DOE with waste sampling (liquid, semi-solid, solid). If water-quality pollution limits are exceeded, it requires the DOE to notify the violator and require him to comply within a set time frame. Failure to comply could result in the closure of the violating establishment/activity.
- Mandates the DOE with environmental inspection.

Agenda for Environmental Health

- Prohibits activities that would either threaten public health or pollute drinking water.

Agenda for Environmental Impact Assessment (approval number 156 in 1994 of the Higher Council of Environment)

- Requires conducting an EIA for a specified list of projects/establishments.
- Originally the list included neither solid-waste management projects nor landfill projects. However, these have been added to the list.
- EIA projects are required to address both the construction and operation phases of any project.

The development of the major environmental legislation can be understood from Figure 4.1.

Environmental management responsibilities have been distributed into various govern-

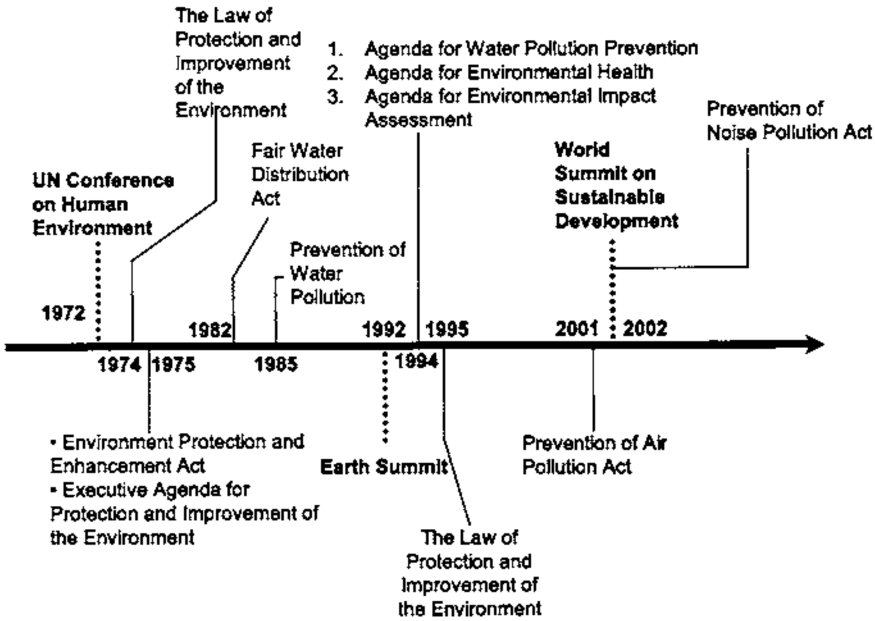

Figure 4.1: Time-Line of When Various Environment-Related Acts Came into Effect

ment departments. The key features of the responsibilities of the departments are elaborated in Table 4.2.

It needs to be stressed that the Environmental Impact Assessment (EIA) is mandated by the agenda for Environmental Impact Assessment. Originally EIAs were required only for a short list of some larger projects such as refineries, power plants, airports, industrial complexes, etc. The list has now been expanded and includes solid-waste management projects like landfills, composting plants, and materials recovery facilities (MRF).

OVERVIEW OF SWM

The history of municipal solid-waste management systems in the Islamic Republic of Iran goes back to 1911 when the first municipality was established. Since then the municipalities have been responsible for solid-waste management in their jurisdictions. During this long period, no systematic attempt was made at the national level to establish a well organized municipal solid-waste management system in Iran. In most of the cities, municipal solid-waste management is yet to be established as a well organized function. Traditional methods with marginal inputs of modern concepts appear to be a common practice.

Although solid-waste management is primarily a local responsibility, the problem is national in scope, and we need a national solid-waste management strategy to solve it. The passage of legislation is just the first step in developing a national solid-waste management strategy.[4] The intent of the strategy is to forge a clear path to meet national and local solid-waste management needs. Therefore it must clearly state goals and the actions necessary to meet those goals.

[4] Frank Kreith. *Handbook of Solid-Waste Management*. New York: McGraw Hill, 1994.

Table 4.2: Environmental Management Institutional Framework

Institution	Key Responsibilities Relevant to the Project
Department of the Environment (affiliated with the president of the Islamic Republic of Iran)	Responsible for environmental protection in general and prevention and control of any kind of pollution. Prepares proposals for new laws and regulations related to environmental protection. In coordination with other authorities, sets environmental standards and limits for water, air, and soil. Mandated with inspection, enforcement, and imposing penalties. Advises on waste-management issues through its Human Environment Bureau. Reviews and approves EIAs.
Environmental High Council	Supervises the work of the Environmental Department.
Environmental Health Department of the Ministry of Health and Medical Education	Responsible for environmental health issues. Supervise and advise on city services related to solid-waste management.
Ministry of Interior	Approves new guidelines. Responsible for vehicle emissions.
Water and Sewage Organization	Responsible for all water and wastewater services and activities. Responsible for specifying and classifying the pollution content of sewage and solid waste.
Municipalities	Responsible for collection and disposal of municipal solid waste.
Organization of Natural Resources	Responsible for land allocations.
National Organization of Management and Planning (guidelines for airports)	Issues guidelines for physical planning and standards to follow in different categories of development projects.

Despite the fact that solid waste is one of the most troublesome environmental problems in the Islamic Republic of Iran, there has so far been no well defined public authority with an all-embracing responsibility for waste. However over the past 15 years, considerable progress has been achieved in some of the largest cities, where collection has gone from manual carts to a fully functional waste-management system.

Of course, there have been some initiatives to set up solid-waste management strategies for the largest cities like Esfahan, Shiraz, Mashhad, and Tehran. For example, Tehran has started to strengthen its solid-waste management strategy, and it is in that context that the Tehran Solid-Waste Management (TSWM) project is being developed with the help of the World Bank. The main objectives of this project are: to improve the institutional arrangements for solid-waste management in Tehran, including the 3R strategy (reduce, reuse, and recycle), and to develop a safe system for the disposal of solid waste.

Recently the government of the Islamic Republic of Iran proposed a waste-management bill to the parliament. This bill comprises a comprehensive program for solid-waste management at the national level. This is the first national attempt toward setting a national solid-waste management strategy in the Islamic Republic of Iran.

Environmental Impact of Municipal Solid Waste

The improper management of solid waste is a real threat to man and his environment. Direct health risks concern workers in this field who need to be protected from skin contact with waste. There are no data available in this regard in the Islamic Republic of Iran. The general public may be affected indirectly from disease vectors, primarily flies and rats. The improper on-site storage of solid waste is the main cause of this risk in most cities in Iran.

In most urban areas, one of the major environmental problems caused by improper waste management is the destruction of landscape and scenery at on-site storage locations and the entrances to landfills and transfer stations. The unsightly appearance and ugliness of street litter and the destruction of the countryside caused by the improper handling of waste are very obvious in urban areas all over the country.

With a few exceptions, open dumping is a common practice for disposing of municipal solid waste in Iran. Consequently, air pollution, water pollution, vector breeding, animal grazing, litter, and aesthetic problems are prevalent in these uncontrolled dumping areas. The collection and transport of waste by improper and uncovered vehicles is also a common practice in the urban areas. Therefore roadside and street litter can be seen in most parts of urban Iran.

The water impact of municipal solid-waste disposal in most of northern Iran is very serious.[5] Dumping Tehran's municipal solid waste in the Kahrizak landfill has caused many environmental concerns among the citizens of Tehran and the surrounding communities.

There have been some social controversy, demonstrations, and unrest with respect to the environmental hazards caused by the mismanagement of municipal solid waste in different parts of the country. NIMBY fever is becoming common in most parts of the country, and especially in northern Iran. Solid-waste issues are moving to the forefront of public attention in the urban areas. In one city in Mazandaran province in northern Iran, controversy over a proposed landfill site for the city was prolonged, and the municipality was forced to transport its waste to the surrounding provinces, more than 200 km away. During this period the daily cost of waste management increased dramatically and the municipality was subsidized by the Ministry of Interior.

Open burning of solid waste is practiced in most of the uncontrolled dumpsites and the air impacts are very serious in the surrounding areas. All kinds of air pollutants like NO_x, VOC, SO_x, particulate, CO, CO_2, and methane can result from this open burning of waste. The environmental impacts of municipal solid-waste disposal in Iran may be summarized as follows.

Health-Related Environmental Aspects

- Municipal waste in the Islamic Republic of Iran usually contains human fecal matters that can contribute to the inadequacy of the sanitation infrastructure and management.
- It also contains some industrial and infectious waste that is disposed of within the municipal landfill.
- Decomposition of the municipal solid-waste materials in the landfill may release chemicals into the drainage seepage and atmosphere.
- Open burning and spontaneous combustion at dumps introduce air pollutants.

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[5] M. A. Abduli. "Solid-Waste Management in Guilan Province, Iran," *Journal of Environmental Health*, June 1997, vol. 59, 10:19–24.

- Secondary health-related environmental issues are related to ground water contamination from the co-disposal of municipal, hazardous, and hospital waste.

The National Solid-Waste Management Regulatory Framework

The municipalities in the Islamic Republic of Iran are the sole authorities responsible for solid-waste management. The general organizational chart for the executive functions of solid-waste management in Iran is given in Figure 4.2.

Solid waste includes three different waste streams, namely municipal, hazardous, and health-care waste. The sources and nature of each waste stream are different. Municipal solid waste comprises mainly domestic solid waste. Municipal waste also includes waste from trade, commerce, industry, public services, parks, and street sweeping.

Although during the past three decades a number environmental and environment-related pieces of legislation have been enacted, there have not been any specific regulations enacted for solid-waste management. Recently, attempts have been made to bring into legislation the environmental aspects of municipal solid-waste management. The regulations have been prepared and submitted to Parliament for approval. In addition, a number of guidelines are under consideration for the following issues: the separation, collection, transport, and disposal of medical waste; municipal solid-waste landfill site selection; and the separation, collection, and transport of municipal solid waste.

In 2002 the Department of the Environment and the Ministry of Interior prepared and proposed a bill for solid-waste management in the Islamic Republic of Iran. The bill covers municipal, industrial, healthcare, and hazardous waste. The solid-waste management bill was approved by the Commission's Office in 2002. The bill is composed of three chapters:

- Chapter 1 defines the terminology used,
- Chapter 2 includes the provisions and articles that regulate the categories of waste, and
- Chapter 3 addresses the penalties for violations.

In addition, the bill stipulates the standards related to waste separation, recycling, and disposal. Characteristics of disposal sites must be prepared by the Department of the Environ-

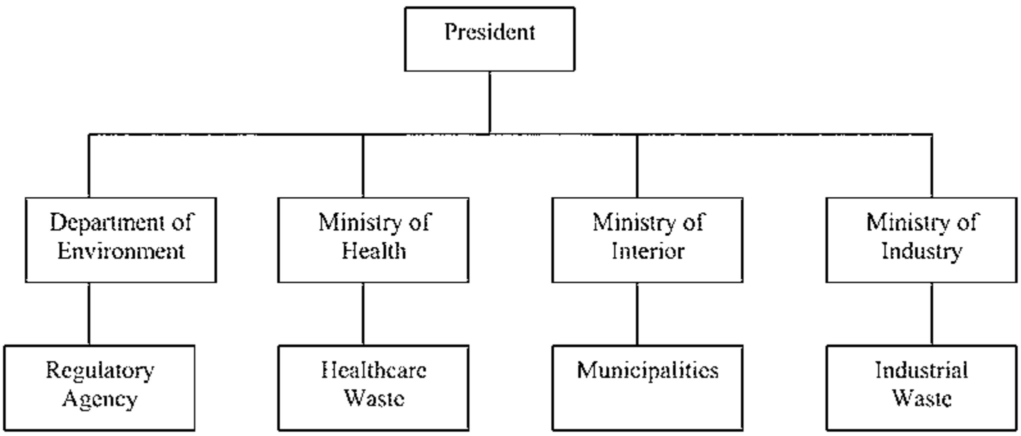

Figure 4.2: Organizational Chart of Environmental Management Functions in the Islamic Republic of Iran

Table 4.3: Quantity of Waste Generated in Urban and Rural Areas of the Islamic Republic of Iran (tons/day)

Type	Population (in millions)	Domestic-like Waste	Industrial Waste	Healthcare Waste	Total
Urban	44.22	35,376	752	1,150	37,278
Rural	21.78	10,890	0	0	10,890
Total	66.00	46,266	752	1,150	48,168

ment, Ministry of Health, Treatment, and Medical Education and other relevant organizations, as specified by the High Council of Environmental Protection. The proposed bill states that the responsibility of solid-waste management in urban areas rests with the municipalities. Outside the cities, the responsibility is shared by the counties and governing bodies of the rural districts. The bill also stipulates that the cost of solid-waste management should be paid by the generators of the waste, according to tariffs determined by the Islamic Councils.

The proposed Waste Management Bill is supplemented by executive by-laws that contain specific provisions for the various types of waste in respect to waste avoidance, reduction, recycling, and disposal as well as collection and transport.

Solid-Waste Management Situation Analysis

The Islamic Republic of Iran has 28 provinces comprising 950 cities and 68,000 villages. The size and population of the cities are very different. About 45% of the citizens live in the eight big cities of Tehran, Mashhad, Esfahan, Tabriz, Karag, Ghom, Shiraz, and Kermanshah. The other 55% of the population lives in the other 942 cities. Therefore more than 45% of the municipal solid waste is generated in the eight big cities. The population is divided into 33% rural and 67% urban. According to research carried out by the Ministry of Interior in 1993, the yearly average generation rates for municipal, industrial, and healthcare waste in the urban area of the Islamic Republic of Iran were 800 g/ca-d, 17 g/ca-d, and 26 g/ca-d, respectively.[6]

Factors such as improper collection and disposal have led to serious environmental pollution. The lack of a proper organizational structure for MSWMS and the lack of rules, regulations, and guidelines concerning SWM have made the situation critical. Geographical, climatic, and environmental conditions prevailing in the southern and northern areas of Iran have made the operation and maintenance of the SWMS very expensive and complicated.

Quantification and Characterization

According to the studies carried out by Ministry of Interior in 2004, the generation rates for municipal, industrial, and healthcare waste in the urban areas have remained the same.[7] It is estimated that the waste generation rate in rural areas is about 500 gm/capita/day. Table 4.3 shows the quantities and types of waste generated in the urban and rural areas.

As can be observed from Table 4.3, the amount of municipal waste generated in Iran each year is 17.58 million tons. This figure does not include demolition and construction waste generated in the urban and rural area of Iran.

The characteristics of the waste generated in Iran vary from one city to another, but as a general rule, compared to the industrial nations, the percentage of putrefiable materials in

[6] M. D. Abduli. 1993.

[7] M. D. Abduli. *Technical, Economic, and Feasibility Studies of MSW Recycling in the Caspian Region*. Tehran: Municipalities Region, 2003.

Table 4.4: Percentages of Major Components of Municipal Waste in the Islamic Republic of Iran

Major Component	%
Putrefiable materials	62.6
Paper and cardboard	10.9
Plastic	10.3
Glass	4.2
Metal	3.2
Textiles	4.1
Wood	5.5

Source: M. A. Abduli, *Municipal Solid-Waste Recovery and Disposal Management in Iran Municipal Organizations*, 2000.

municipal waste is very high. Therefore the density and moisture content of municipal waste as it is delivered is high. On the other hand, the percent of recoverable materials like paper, plastic, PET, and textiles is low. Consequently, the heat value of municipal solid waste in Iran is very low. The major components of municipal solid waste in Iran are indicated in Table 4.4. The major components of municipal solid waste for the biggest Iranian cities are shown in Table 4.5.

Key Elements of SWM

The on-site handling, storage, and processing of MSW in the Islamic Republic of Iran are not properly managed. The containers are not standard and can be of any type, size, and material: 17.5% use plastic bags, 26.3% use plastic bins, 44.5% use bins converted from used oil drums, and 12% use any miscellaneous container available.

Collection and Transportation

In 87% of the cities, collection is carried out by the municipalities. House-to-house collection is common in the small cities. The most common type of collection services in Iran are curbside and direct delivery. Collection frequency in most cities is six days a week; 96% of

Table 4.5: Physical Composition of Municipal Solid Waste for the Eight Biggest Cities

Component	%
Putrefiable	75.3
Paper and cardboard	8.5
Plastic	6.6
Metal	2.8
Glass	3.6
Textile	2.1
Wood	1.1

the collections are done in the daytime, 43% at noon, and 17% during the night. In the commercial and downtown areas of the cities, collection is done both day and night, sometimes three times a day. (That's why the sum of these collection services is greater than 100%.)

Due to religious belief and tradition, waste bread is collected separately and sold to hawkers. The dry bread is delivered to privately owned dispatch centers by the hawkers to be used as animal and poultry food.

The community containers are not standard and some MSW is stored in bins converted from used oil drums made of low-grade tin plates. These containers have sharp edges and frequently cut the hands of the collection personnel.

Municipal solid waste in the Islamic Republic of Iran is very high in putrefiable matter that serves as a breeding medium for flies and is a source of offensive odors. In 57% of the cities, the frequency of waste collection is six days per week. There is no collection on Friday; 30% is every other day, 8% is twice a week, and 7% is other.

With few exceptions, loading motorized collection vehicles is done manually (semi-mechanized) in most of the urban areas. Handcarts are used in 38% of collections and 62% of the collecting is done using other kinds of vehicles. Table 4.6 shows the types of vehicles used for collection.

Lack of community bins suitable for the different climatic condition in the urban areas of Iran has created unpleasant scenes. Dogs, cattle, and cats are frequently observed in the refuse due to the improper setting-up of interim dumping stations. The presence of solid waste on roadsides, river banks, and seashores is mainly due to the shortage of collection and transfer vehicles and workers in most cities and improper access roads to the existing sites.

The mechanization of SW collection in the old parts of the cities is practically impossible because the alleys are too narrow. Most of the existing sites are overfilled and 95% of the sites lack an adequate number of bulldozers to provide cover material.

Segregation and Disposal

In almost every city of the Islamic Republic of Iran MSW is subject to some kind of separation, either by hawkers or by the collection workers. Recyclable materials can be separated at the different stages of collection, transfer, and transport, and finally at the disposal sites.

Dumping MSW is a major method of final disposal of MSW in the Islamic Republic of Iran. Existing dumpsites possess many deficiencies. There are 977 dumping stations in the urban areas of Iran. These stations are any piece of available land within the cities. There are

Table 4.6: Different Types of Collection Vehicles Used in MSWMS in the Islamic Republic of Iran

Type	Number of Vehicles
Handcarts	12,120
Small vans	2,899
Standard commercial trucks	1,172
Tractors	440
Standard collection vehicles	202
Rolled containers	581
Containers	242
Other	125

Table 4.7: Methods of MSW Disposal in the Islamic Republic of Iran

Method	Percentage	Remarks
Open dumping	24	—
Open dumping and incineration	39	—
Unsanitary landfill	12	Dumping MSW in trenches, rarely with covering material
Sanitary landfill	24	Dumping MSW in trenches and use of covering material once a while
Other	2	Mainly composting

also 512 masonry enclosed transfer stations and 307 containers for intermittent storage. There are 160 semi equipped transfer stations in the urban area of Iran. None of these stations is sanitary or well maintained. The methods of disposal of MSW in Iran are shown in Table 4.7. The average life of these sites is 12.4 years.

Municipal solid waste is disposed of at uncontrolled dumping sites, which makes the land useless for any future uses and causes serious risks of water and air pollution and vector breeding. Daily cover material is not used regularly on any of these sites.

Managing Other Solid Waste

Public service offices are not the proper organizations to deal with hazardous waste in the Islamic Republic of Iran. An independent management system should be developed for the safe handling and disposal of these materials. This system would work under the supervision of a committee comprised of representatives from the Ministry of Interior, Department of the Environment, Hygiene, Water, Agriculture, and Fisheries.

CASE STUDY: SOLID-WASTE MANAGEMENT OF THE KHAZAR REGION

To determine the present status of SWM in the Khazar region, three different questionnaires were prepared and distributed among 102 municipalities. The questionnaires considered the present status of all the functional elements of industrial, municipal, and clinical solid-waste management systems, as well as some general information.

During 2002–03, waste sampling was carried out in ten cities on seven successive days in the four seasons (12–18 February, March, August, and November). Each sampling day, 20 samples of 1 cubic meter each were taken from the MSW in every city. Collecting the samples was carried out at weighbridge sites where all transfer vehicles were instructed to weigh their waste loads. Sampling and sample preparations were conducted according to the American Public Works Association's procedure for the physical and chemical analysis of refuse and compost.[8]

Regional Profile

Khazar region is located between 35° 47′ and 38° 27′ N latitude and 48° 45′ and 56° 14′ E longitude. It is about 61,400 km^2 in area, which is approximately 3.72% of the Islamic

[8] APWA. *Municipal Refuse Disposal*. Chicago: American Public Works Association, 1966.

Table 4.8: Quantity of MSW Generated in Khazar Region, 2002–03

Province	Urban Population	Population Receiving Collection Services	Solid-Waste Generation (tons/day)					Generation Rate (gm/capita/day)
			Spring	Summer	Fall	Winter	Average	
Golestan	752,223	718,982	481	485	444	428	460.0	640
Guilan	1,263,303	1,152,369	930	1,030	811	727	874.0	759
Mazandaran	1,384,586	1,318,017	1,069	1,261	1,063	1,031	1,106.0	838
Total	3,400,112	3,189,368	2,489	2,776	2,756	2,186	2,550.0	745

Republic of Iran's total area. The region comprises the three provinces of Golestan, Mazandaran, and Guilan. The cities in this region are: Gonbade-Kavoos and Gorgan in Golestan province; Sari, Ghaemshahr, Babol, Chaloos, and Ramsar in Mazandaran province; and Lahijan, Rasht, and Anzali in Guilan province.

Khazar's population was about 6,300,000 in 1995, which is equal to 6.7% of Iran's total population. About 44% of this population lives in urban areas. Khazar, with 102 cities, is one of the most populated and well developed regions of the Islamic Republic of Iran. Much of the Khazar region is forested.

Solid Waste Generation

Municipal Solid Waste

Every day 2,550 tons MSW is collected in the 102 cities of this region. The urban population of the region is 3,400,000 persons, but only 3,190,000 receives some kind of collection services. Therefore the municipal solid-waste collection rate of this region is about 800 grams per capita per day. Considering the amount of waste that is not collected by collection agencies, it is estimated that the generation rate for MSW in Khazar region is about 882 g/ca-d and the total amount of MSW generated in this region is 3,000 tons each day. Table 4.8 shows the present situation of MSW collection in Khazar region.

Industrial/Hazardous Waste

In the urban areas of Khazar region, there are 211 industrial plants with 10 or more employees. The number of industrial units in Golestan, Mazandaran, and Guilan provinces are 35, 61, and 115, respectively. Table 4.9 shows the number of the industrial plants in this region.

Table 4.9: Number of Industrial Plants in the Urban Areas of Khazar Region, 2002–03

Major Industrial Groups	Number of Units	Percentage
Food and beverage	85	40
Textile	68	32
Wood	10	5
Paper and cardboard	2	1
Chemical	15	7
Machine manufacturing	31	15
Total	211	100

Table 4.10: Quantity of Industrial Waste Generated in Khazar Region, 2002–03

Province	Industrial Waste (kg/day)	Collection Agencies	
		Private	Municipal
Guilan	22,000	1	2
Mazandaran	5,700	2	2
Golestan	0	—	—
Total	27,700	3	4

The industrial waste is collected and transferred with the same services used for municipal waste. Gonbad, Gorgan, Sari, Babol, Amol, Lahijan, and Rasht are the major producers of industrial waste within the urban areas of the region.

Table 4.10 shows the present situation of industrial/hazardous waste collection in Khazar region. The daily industrial waste generated in the urban areas of this region is 27,700 kg. With some exceptions most of the industrial waste generated is collected by public services owned by the municipalities of the region.

The management of hazardous waste in the Islamic Republic of Iran is even more problematic than that of municipal solid waste, with only minimal reduction at the source and a complete lack of modern disposal capacity across the country. The development of a national strategy and plan for the management of hazardous waste is a high priority for the Department of Environment and is an integral part of its mandate.

Biomedical Waste

The management of biomedical waste in almost all of the cities is problematic and a major concern of the public authorities. Table 4.11 shows the quantities of biomedical waste generated within the urban areas of the region. The total amount of hospital waste generated is about 27,000 tons per day. There are 99 hospitals in the urban areas, 80% of which are equipped with incinerator plants. With some exceptions, most of the hospital waste is collected by public services owned by the municipalities. In 94% of the cases, hospital waste is collected and mixed with municipal waste in a single truck.

Solid Waste Characteristics and Quantification

Of the municipal solid waste, 76% is composed of putrefiable materials. Plastic (7.5%) is the second most common component. Table 4.12 shows the daily average composition of MSW in Khazar region by season during 2002–03.

Table 4.11: Quantity of Biomedical Waste Generated in Khazar Region, 2002–03

Province	Hospital Waste (kg/day)	Incineration		Separate Collection
		Yes	No	
Guilan	11,000	5	38	2
Mazandaran	8,000	9	28	2
Golestan	8,000	4	15	2
Total	27,000	18	81	6

Box 4.1: Methodology Adopted for Establishing the Composition and Quantification of Solid Waste in Khazar Region
For the physical analysis, 13 components were separated. These components are putrefiable materials, paper, cardboard, tires, plastic, PET, textiles, glass, ferrous metal, nonferrous metal, demolition and construction waste, wood, and bread. In all of the ten cities the following items for daily average were measured or calculated as follows. • Heat value • Chemical formula • Percentage of flammable materials • Percentage of compactable materials • Percentage of dry materials • Carbon-to-nitrogen ratio Therefore, 140 samples were taken every week in each city.

The mean chemical formula of the municipal solid waste of the region is $C_{533}H_{840}O_{278}N_{14.3}S$. Table 4.13 shows the chemical formulas of MSW of Khazar region, percentage of dry materials, and percentage of compactable materials in MSW of the region in different seasons. In 2002–03 as shown in this table, the yearly average of carbon-to-nitrogen ratio was about 37.5%; 95% of the material is compactable and 23.5% of the material is dry.

Table 4.14 shows the percentage of flammable materials, moisture content, calorific heat value, and the amount of air required for complete burning. Since 96% is flammable, incineration can reduce the volume of MSW by 90%.

The moisture content of the MSW is three times the moisture content of the MSW in de-

Table 4.12: Composition of MSW in Khazar Region, 2002–03 (percentages)

Composition	Spring	Summer	Fall	Winter	Average
Putrefiable	71.50	77.00	77.60	78.00	76.00
Paper	6.50	6.20	7.30	7.40	7.00
Cardboard	1.60	1.70	1.10	0.60	1.30
Tires	1.20	0.50	0.40	0.30	0.60
Plastic	8.20	7.30	7.30	6.90	7.50
PET	0.40	0.40	0.30	0.40	0.40
Textiles	2.00	1.40	1.30	1.50	1.50
Glass	1.50	0.80	0.90	1.20	1.10
Ferrous Metal	1.80	1.30	0.90	1.04	1.25
Nonferrous Metal	0.13	0.06	0.05	0.04	0.07
Demolition Waste	1.00	0.70	0.95	0.60	0.80
Wood	1.70	0.70	0.90	0.73	1.00
Bread	2.00	1.40	1.00	1.05	1.40
Density (kg/m^3)	247.0	263.0	279.0	281.0	267.5

Table 4.13: Chemical Formula and C/N Ratio of the MSW in Khazar Region, 2002–03

Season	Chemical Formula	C/N Ratio	Dry Materials (%)	Compactable Materials (%)
Spring	$C_{532}H_{870}O_{277}N_{15}S$	37.0	27.0	91.5
Summer	$C_{513}H_{800}O_{269}N_{14}S$	36.0	23.0	96.0
Winter	$C_{543}H_{845}O_{282}N_{14}S$	39.0	22.0	96.0
Fall	$C_{545}H_{848}O_{283}N_{14}S$	38.0	22.0	96.0
Average	$C_{533}H_{840}O_{278}N_{14.3}S$	37.5	23.5	95.0

veloped countries. In contrast, the heat value is one-fourth of the heat value of the MSW in developed countries. Considering the low heat value and high moisture content, the application of waste-to-energy technologies must be studied very carefully.

The air required for complete burning of the waste according to the stoichiometric equation is about 7.5 kg air for each kg of dry MSW.

Key Elements of Solid-Waste Management

Collection

House-to-house solid-waste collection is a very common practice in urban areas. The most common types of municipal services used in the various cities are curbside and direct-delivery collection. Bins and plastic bags are put outside the house during the period when a curbside collection is expected. Permanent workers employed by the municipalities and a considerable number of other workers engaged on a daily wage basis collect 90% of the MSW of the region.

The existing communal bins are not suitable for the humid climatic conditions of the region. Dogs, cattle, and cats are frequently observed at the dumpsites and transfer stations. The presence of solid waste on roadsides, river banks, and seashores is very apparent.

The urban population of the region is 3.4 million, but only 3.19 million receive some kind of collection services, as described in Table 4.15. Thus the municipal solid-waste collection rate of the region is about 800 grams per capita per day. Taking into account the amount of waste that is not collected, it is estimated that the generation rate is about 882 g/ca-d, and the total amount of MSW generated in this region is 3,000 tons each day.

No mechanized collection system exists in this region. The daily house-to-house collection of domestic waste is accomplished with 1,500 handcarts. The total capacity of each handcart

Table 4.14: Percentage of Flammable Materials, Moisture Content, and Calorific Value of the MSW in Khazar Region, 2002–03

Season	Flammable Materials (%)	Moisture Content (%)	Heat Value (kj/kg)		Air Required for Incineration (kg/kg)
			Dry	Wet	
Spring	94.0	59	8,049	3,467	8.5
Summer	97.0	62	8,472	2,860	7.2
Fall	97.5	66	6,621	2,249	7.2
Winter	96.0	66	6,453	2,161	7.0
Average	96.0	61	7,252	2,684	7.5

Table 4.15: MSW Collection in Khazar Region, 2002–03

Province	Collection Agency			Number of Vehicles							
	Municipality	Private	Both	Handcart	Small Van	Standard Commercial Truck	Standard Collection Vehicle	Tractor	Rolled Container	Container	Other
Guilan	40	1	2	644	119	58	13	3	38	6	0
Mazandaran	34	1	2	488	116	121	14	1	21	17	12
Golestan	15	5	2	382	50	32	3	17	2	12	0
Total	89	7	6	1,514	285	211	30	21	81	35	12

is about 300–500 liters. Table 4.15 gives the municipal waste collection scenario for Khazar region.

MSW is separated at the curbsides, transfer stations, and dumpsites by the illegal waste pickers in 90% of the cities. Plastic, paper, metal, and glass are the major recyclable materials, but in all of the cities in Khazar region, plastic is separated from mixed refuse.

Storage

Workers collect all the MSW in the small cities, mostly by hand trolleys, and transfer it to temporary storage areas located inside the cities. In large cities such as Gonbad, Babol, Sari, Gorgan, Qaemshahr, Rasht, Lahijan, and Amol, however, collection is done using small vans.

Transport

Most of the vehicles used for collection and transportation of the MSW in the region are not suitable for this purpose. There are only 30 typical collection vehicles in all the Khazar region.

Treatment and Disposal

With few exceptions, open dumping is practiced in this region. There are many dump stations in the urban areas of Khazar. Most of these stations are pieces of available land. At the remaining places, the waste is disposed in 10 m^3 containers. None of these stations is well maintained. Most (90%) of the MSW is disposed of in dumpsites. Some adjacent cities use a single dumpsite. There are 211 industries in the urban areas of the region and most of them dump their waste at the dumpsites. Leachate at these sites has significantly altered the physical-chemical properties of the surface water in the vicinity.

About 32% of these sites are located within the cities' official borders, 75% percent of them are overfilled, and all of them have leachate, odor, and aesthetic problems. Thus, these sites have created social problems and, in some areas, have been the subject of many complaints by the surrounding inhabitants.

About 75% of the dumpsites are located near or along the river banks and 17% of them are situated at the seashore. In 90% of the sites, no cover material is used. Municipal solid waste is disposed of by uncontrolled dumping at these sites, which blights the land for any future uses and causes serious risks of water and air pollution and vector breeding.

Green Productivity (GP) and Other Waste-Minimization Approaches

Every day about 2,000 tons of material suitable for composting is generated in the urban area of this region. Most of these materials are dumped on the ground and create environmental pollution in the region. Each day 200 tons of plastic and 200 tons of paper and cardboard are collected by the MSW collection services. There is also about 10, 28, and 34 tons of PET, glass, and metal. The recycling potential of these materials is presented in Table 4.16.

Table 4.16: Recovery Potential in Khazar Region, 2002–03 (tons)

Composition	Spring	Summer	Fall	Winter	Average
Putrefiable	1,775	2,137	2,139	1,705	1,938.0
Paper and cardboard	201	219	231	175	212.0
Plastic	203	202	201	150	191.0
PET	15	11	8.3	8.7	10.2
Glass	38	22	25	26	28.0
Metal	48	38	25	24	34.0

Table 4.17: Recycling Activities in Khazar Region, 2002–03 (in tons)

Province	Separation		Place			Who		Component			
	Yes	No	Alley	Transfer Station	Dump-site	Collection Crew	Waste Picker	Plastic	Paper	Metal	Glass
Guilan	38	5	23	13	32	13	38	38	28	36	16
Mazandaran	36	1	36	12	25	36	36	36	35	32	28
Golestan	19	3	17	10	17	5	19	19	14	18	9
Total	93	9	76	35	74	54	93	93	77	86	53
Total (%)	91	9	74	34	72	58	100	100	83	92	57

Table 4.17 shows the status of the recycling programs during 2002–03. In 90% of the cities, the MSW is separated at curbsides, transfer stations, and dumpsites by the illegal waste pickers. Plastic, paper, metal, and glass are the major recyclable materials, but in all of these cities, plastic is separated from mixed refuse. In 58% of the cities, collection crews also separate recyclable materials from mixed refuse. Metal is separated from the MSW in 92% of the cities.

Table 4.18 shows the status of the recycling industries and market in this region. Some type of recycling industry exists in only four cities, Sari, Ghaemshahr, Rasht, and Gorgan. Joybar is a center for recycling activity in Mazandaran province.

The typical recycling industry of Khazar region is a small mill. A compost plant with the capacity of 500 tons per day operates in Rasht. In Babol and Gorgan, two small composting plants, each with the capacity of 120 tons per day, are under construction. All of these composting plants are owned by the municipalities. Marketing for compost is a real challenge for these plants. Khazar municipalities have not been active in recycling programs, and it seems that they do not have any planned recycling programs for the near future.

There are about 1,200 waste pickers in Khazar region. These people are not organized by the municipalities and they work under their own rules and organizational charts. Even though there are 25 Non-Governmental Organizations (NGOs) in this region, they are involved with neither recycling nor SWM activities.

Future Strategies and Action Plan

The uncontrolled dumping of hundreds of tons of solid and semi-solid waste along roadsides and in rivers, surface waters, forests, and any piece of available land around the urban areas is a common daily practice in the Khazar region. This waste encompasses all the types of waste generated from residential, commercial, municipal, industrial, agricultural, and health-care services within the region.

Considering the geographic and climatic conditions of the region, such as high rainfall, hydro-morphic soils, the presence of many rivers and marshes, high water tables, and rich green cover, uncontrolled dumping has created many environmental, hygienic, social, and political difficulties for the province.[9] Consequently, the continuation of uncontrolled dumping has reached a dead end in respect to finding a proper method of waste management.

In all of the cities, no inventory system for the collection, transport, and disposal of MSW

[9] Abduli, 1996.

Table 4.18: Status of the Recycling Industries in Khazar Region, 2002–03 (in tons)

	Willingness of Private Sector to Finance		Municipality Plans for the Future				Municipality Performance		Municipality Activity		Type of Market		Recycling Industry	
Province	No	Yes	On-Going Activity	Under Construction	Under Study	None	Unsuccessful	Successful	No	Yes	Sell	Conversion	Yes	No
Guilan	37	6	9	1	5	24	43	0	42	1	1	38	42	1
Mazandaran	32	5	2	3	5	32	37	0	33	4	2	36	35	2
Golestan	17	5	1	0	2	19	21	0	21	0	1	21	21	1
Total	86	16	12	4	12	75	101	0	96	5	4	95	98	4
Total (%)	84	16	12	4	12	74	100	0	95	5	4	96	96	4

Table 4.19: Proposed Large-Scale Treatment and Recycling Industries for Khazar Region

Province	City	Type	Capacity (tons/day)	Cost USD (million)
Guilan	Rasht	incinerator	500	31.25
	Lahijan	incinerator	250	1.56
Mazandaran	Tonekabon	incinerator	250	1.56
	Babol	incinerator	500	31.25
	Sari	incinerator	500	31.25
Golestan	Gorgan	compost	300	3.75
	Gonbad	compost	250	3.12
Total				103.74

exists. Thus there is no reliable data on cost accounting and budgeting of MSWMS throughout the region. During this study, guidelines for cost accounting, budgeting, and financing MSWMS were prepared and distributed among the public-service offices. This was the first attempt to acquaint the municipalities with this task. The cost of collection, transport, and disposal of MSW in this region is about USD0.015/kg.

Putrefiable, and therefore compostable, materials constitute an average of 76% of the MSW in this region annually. Home composting is recommended for the residents of small cities, but although ample raw materials for industrial composting exist, it is not given the highest priority in the east and central parts because of the high moisture content of the waste (61%) and the unavailability of a market for composted products. Despite the high moisture and low energy content, however, and because of the scarcity of land and environmental considerations, incinerator plants are recommended for the east and central parts of this region.

The mechanization of collection, transfer and transport systems, transfer stations, treatment, and disposal is also highly recommended. Tables 4.19 and 4.20 show the proposed treatment and recycling industries for the region.

OBSERVATIONS AND RECOMMENDATIONS

Observations

Traditionally municipalities are the executing agencies for MSWMS in their jurisdictions. In the rural areas and other settlement areas (countryside), however, no agency is responsible for waste management. The urban areas of Iran also face many problems that directly affect waste management. Today, 25% of the urban population of the Islamic Republic of Iran lives in Tehran and 50% of the urban population lives in the other seven big cities. Altogether, there are about 850 cities in Iran. The problems related to the mega-city of Tehran is well known. Infrastructure and waste treatment facilities are insufficient, and in all of the cities, industrial, healthcare, and municipal waste are dumped on the ground. Iran is facing rapid industrial growth that is not being followed by adequate measures to master the most urgent associated environmental problems.

Managing solid waste in the Islamic Republic of Iran must be seen in the context of the problems caused by rapid urbanization, migration from rural to urban areas and then from small to big cities, rapid and unplanned urban development, deficiencies in the basic infrastructure in

Table 4.20: Proposed Recycling Industries for Khazar Region

Province	City	Type	Capacity (tons/day)	Cost (USD millions)
Guilan	Rasht	Plastic and PET	70	0.875
	Rasht	Paper	70	2.620
	Rasht	Glass	15	0.075
	Rasht	Metal	15	0.180
Mazandaran	Joybar	Plastic and PET	50	0.625
	Joybar	Paper	40	1.500
	Joybar	Glass	15	0.075
	Joybar	Metal	15	0.180
	Chaloos	Plastic and PET	50	0.625
	Chaloos	Paper	40	1.500
	Chaloos	Glass	15	0.075
	Chaloos	Metal	15	0.180
Golestan	Gorgan	Plastic and PET	40	0.500
	Gorgan	Paper	30	1.120
	Gorgan	Glass	15	0.050
	Gorgan	Metal	15	0.180
Total				10.400

all of the cities, poor urban management, lack of knowledge of solid-waste management systems among the decision-making authorities and municipalities, lack of adequate rules and regulations for environmental protection and resource conservation, and a poor sense of public cooperation among the citizens.

Another type of issue concerning MSWMS in the Islamic Republic of Iran that is directly related to municipalities is their inability to collect all the waste within their jurisdictions, a lack of adequate data, financial resources, and appropriate skills, improper disposal facilities, the lack of a proper organizational chart for MSWMS, and a lack of knowledge of modern municipal solid-waste management systems.

Dumping is the major method of final disposal of MSW in Iran. The existing dumpsites possess many deficiencies. As the construction and operation of an independent landfill for all the small cities of Iran is not possible due to financial burdens and the scarcity of land suitable for sanitary landfilling, a regional landfill strategy is recommended. The management and control of a big landfill is preferable to several small landfills with the same total capacity.

The citizens are not directly charged for the services provided by the municipal solid-waste management systems. These systems are financed through the general revenue of the municipalities in each city. The cost of initiation, operation, and maintenance of SWMS is an important factor in the planning, design, and selection of alternatives.[10]

The shortcomings of the prevailing practices of MSWMS can be summarized as follows.

- Imperfect on-site storage, collection, and transportation
- Uncontrolled open dumping
- Existence of a large informal sector that is dependent on this work for their livelihood

[10] M. J. Suess. *Solid-Waste Management*. Copenhagen: WHO Regional Office for Europe, 1985.

- Lack of a proper organization chart for MSWMS in municipalities
- Indiscriminate collection and disposal of municipal, hospital, and industrial waste in most parts of the urban areas
- Underutilization of the existing resources such as manpower, machinery, and finance that is allocated to MSWMS
- Haphazard operation in spite of the high costs
- Weak public participation and poor public attitude
- Lack of adequate data
- Lack of financial resources in small and medium cities
- Lack of necessary skills
- Lack of knowledge of modern waste-management options in municipalities
- Lack of proper rules, regulations, and guidelines
- Poor health and safety conditions among the collection crews

The full mechanization of collection, transfer, and transport systems, including transfer stations, is highly recommended. This mechanization would promote phase-to-phase material recycling and separation programs at the sources. The preparation of rules, regulations, and guidelines for SWM can effectively solve many of the present problems, and the installation of suitable and adequate communal bins in the proper locations in urban areas would reduce the collection frequency to two times a week.

Due to the high moisture and low energy contents of MSW and high capital investment, maintenance, and operation costs, using incinerators for waste disposal is given the lowest priority for solid-waste management in the Islamic Republic of Iran. Thus, all hazardous waste must be transferred out of the northern and southern provinces of Iran. To correct this situation, an incinerator plant with an adequate capacity must be installed for the disposal of medical waste in the vicinity of each proposed big-city landfill.

Finally, the development of permanent educational and training programs for personnel involved in urban solid-waste management systems throughout the country is highly recommended.

The agency responsible for MSWMS in each urban area of Iran is the related municipality. Therefore it seems logical that any action plan concerning this issue should focus on municipalities' duties. In contrast to this viewpoint, management of these systems is under the influence of many issues and problems that are outside the duties and jurisdiction of the municipalities.

Solid-waste management is a multidisciplinary activity and should be considered as an integrated problem instead of looking separately at the technical aspects of these systems (such as collection, transfer, transport, treatment, and disposal) and the social, economical, and financial issues. Therefore a sound action plan should take into consideration the integration of these systems. A number of factors have to be taken into account in this action plan.

- The technical aspects of solid-waste management systems, such as generation, on-site storage, collection, transportation, reuse, recycling, recovery, minimization, treatment, and disposal
- The infrastructure and local conditions
- The socioeconomic level and standard of living in the Islamic Republic of Iran
- The health, safety, and working condition of formal and informal groups involved in these systems
- The legal structure, legislation, regulations, and organizational structure
- Rapid urbanization and migration
- Education, public information, and public participation

The National Iranian Productivity Organization (NIPO) should get involved in these activities, both directly and indirectly. Considering these points and enhancing NIPO's capabilities to promote GP for solid-waste management, the proposed action plan and strategy can be summarized as follows.

- Assist municipalities by providing proper technical and scientific information on the various aspects of solid-waste management, reuse, recycling, and reduction.
- Assist the Ministry of Mines and Industry by providing the appropriate technical and scientific information on industrial-waste management and minimization.
- Produce, publish, and disseminate appropriate information about clean technologies suitable for the Iranian economy and local conditions.
- Produce, publish, and disseminate appropriate technical and scientific information on reuse, recycling, and reduction.
- Conduct seminars, workshops, and training courses on all aspects of waste management in the Islamic Republic of Iran.
- Facilitate the exchange of waste-management information between the municipalities of the Islamic Republic of Iran and the related UN and other international organizations that deal with waste management in the Islamic Republic of Iran.
- Create a waste-management office at NIPO with enough personnel to promote GP in waste management.
- Develop and disseminate relevant information on urban management.
- Provide legal, institutional, and organizational charts for waste management.
- Provide and disseminate information on public awareness, public participation, and the cultural and socioeconomic issues of waste management.
- Work closely with the NGOs and promote their involvement in waste management.

Recommendations

Based on the issues discussed, the recommendations for solid-waste management are as follows.

- Preparation of a comprehensive solid-waste management plan at the national, regional and municipal levels. This plan should cover waste minimization, source reduction, generation, on-site handling, storage and processing, transfer and transport, recycling, disposal, and monitoring systems after disposal.
- Development of a proper organizational structure in each municipality.
- Biodegradable materials (yearly average of 63%), paper (11%), plastic (10%), glass (4%), and metal (3%) are the principle recoverable materials contained in the MSW. Hence a collection system must be developed to recover paper and plastic at the source.
- Public-service offices are not the proper organizations to deal with hazardous waste. An independent management system should be developed for the safe handling and disposal of these materials.
- In the vicinity of each proposed landfill, an incinerator plant with an adequate capacity must be installed for the disposal of medical waste. In general, the following golden rules for the safe management of medical waste must be applied:[11]
  - Separate collections in appropriate containers sorted according to the method of disposal required,

[11] E. Giroult. "Medical Wastes: A Worldwide Public Health Concern," *International Healthcare Network*, Nov. 1995–Jan. 1996, 1:2.

- Appropriate treatment of each class of medical waste to neutralize its infectious, toxic, or hazardous potential,
- Protection of medical personnel against wounds from contaminated sharps, and
- An awareness among regulatory authorities that the Basel convention restricts international trade in hazardous waste, including medical waste.

In any case, the safe management of medical waste must be seen as an integral component of a comprehensive hospital hygiene policy.

- The full mechanization of collection, transfer, and transport systems, including transfer stations, is highly recommended. This mechanization should promote phase-to-phase material recycling and separation programs at the sources.
- Preparation of proper rules, regulations and guidelines for solid-waste management at the national, regional, and municipal levels.
- Installation of suitable and adequate communal bins in the proper locations in urban areas.
- Finally, the development of permanent education and training programs for the personnel involved in medical, hazardous, and municipal solid-waste management systems is highly recommended.

5. MALAYSIA

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INTRODUCTION

One of the most common characteristics of the cities of many developing countries is a lack of cleanliness. Even to casual observers, the streets are littered with scraps of paper, plastic bags, paper cups and wrappers, and even plastic bottles. So are the drains. Many back lanes have piles of rotting rubbish.

What the visitors and tourists generally do not see is even worse. Along many isolated roads, there are piles of construction and industrial waste. Rivers are choked with rubbish, including plastic bags and bottles. It is not unusual to find broken household furniture, parts of bicycle frames, and even electrical equipment in the rivers. Landfills are open dumps with leachates polluting the surrounding areas.

It is fair to believe that all cities and towns have local authorities and that they do carry out solid-waste management (SWM). Unfortunately, in almost all developing countries, they have generally failed to manage their solid waste. In Asia, it is fair to say that except for Singapore and Japan, the countries have not succeeded in managing their municipal waste successfully.

However, failure to manage their waste is not uniform among the cities. There are countries that are doing much better than the others, such as the Republic of China and the Republic of Korea. More importantly, many countries have taken cognizance of their problems and are taking actions to improve their SWM. One such country is Malaysia.

In Malaysia, SWM is in transition as its leaders look for better ways to manage the waste. They are also trying to minimize the amount of waste going to the landfills. In the midst of this, the country is also transferring the responsibility of managing solid waste from the local authorities to private companies. This has advantages as well as disadvantages. It is advantageous because it shows that the government is taking cognizance that there are problems in the management of solid waste and that something strong must be done to improve the situation. It is bad because the future is uncertain. There is a fear that the cost of SWM will escalate. There is also no certainty that placing the responsibility of waste management on the federal government and private companies will be effective in ensuring that the towns and cities will be clean and pleasant for work, play, and bringing up families.

COUNTRY PROFILE

Physiography and Climate

Malaysia is a relatively small country by Asian standards, both in terms of size and population. It covers an area of about 329,758 sq km, and has a hot-wet climate due to its location just above the equator in the Southeast Asia. The annual rainfall ranges from 2,500 to 4,000 mm a year.

Demography

The population of Malaysia (2003 estimate) is about 25 million. The country has experienced rapid urbanization in last few decades. At present, more than half of the population lives in urban areas. However, unlike many developing countries, there is no phenomenon of a primary city. Kuala Lumpur, the capital city, has fewer than 2 million people. Even if the towns surrounding Kuala Lumpur are taken into consideration, metropolitan Kuala Lumpur has less than 4 million people, which is much lower than the population figures of Bangkok, Manila, or Jakarta, not to mention Mumbai, Beijing, or Tokyo.

Economy

Economically, Malaysia is considered a successful country with a per capita income of about MYR14,800 (USD1.00 = MYR3.80) in 2003. In the last two decades, except for the years of Asian economic crisis in the late 1990s, Malaysia enjoyed an annual economic growth of about 7–10% per annum, figures that were the envy of most developing countries. For 2004, the Gross Domestic Product was expected to be above 6%.

The economy of Malaysia is heavily dependent on the prices of palm oil and petroleum, but in the last two or three decades the country has undergone rapid industrialization. This has established Malaysia as a producer of electronics parts, especially microchips, electronic consumer goods such as audio-visual equipment, air conditioners, and refrigerators. In the last few years as the world moves into an era of the knowledge society, Malaysia has been projecting itself as a hub of software developers and biotechnologies.

As a result of its rapid economic growth, Malaysia has a very good infrastructure compared to Asian and other developing-country standards. It has respectable health and educational facilities, very good highways, and state-of-the-art transportation terminals. Malaysia's telecommunication system is comparable to the best in the world.

Environmental Profile

Malaysia is committed to protecting the environment and is conscious of its fragility. Malaysia's environmental profile, however, is not very encouraging to the international communities due to tree cutting at an enormous rate and the occurrence of haze. The hazy days are due to forest fires set in Indonesia to clear forest lands and is aggravated by emissions from the growing number of vehicles in Malaysia.

National Environmental Regulatory Framework

Malaysia possesses strict environmental rules and regulations. Currently it has more than 43 environment-related legislations. The core environmental legislation is the Environmental Quality Act of 1974 that provides the legal framework for laws to regulate the activities deemed to affect the environment. Rules and regulations that have been passed under the powers of this act include: the Environmental Quality (Clean Air) Regulations of 1978, the Environmental Quality (Prescribed Activities/Environmental Impact Assessment) Order of 1987, and the First Schedule of the Environmental Quality (Scheduled Waste) Regulations of 1989.

The Ministry of Science, Technology, and Environment is responsible for the environment in the country; the Department of Environment works under the Ministry. In addition, every state has its separate Department of Environment. The Environmental Quality Council assists the ministers about environmental policies and in the decision-making process.

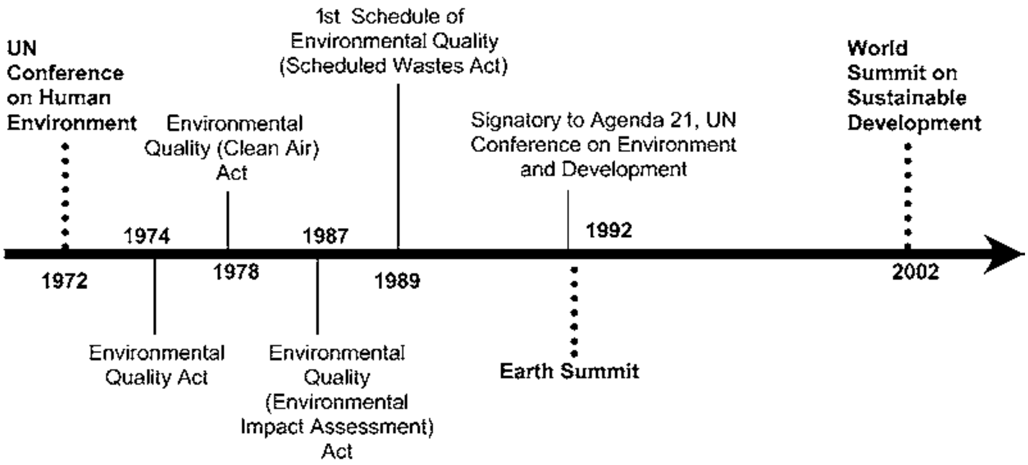

Figure 5.1: Timeline of Laws and Regulations in Malaysia

Malaysia has signed and ratified all the international protocols related to the protection of the environment. For example, it is a signatory for the implementation of Agenda 21 (Declarations of the United Nations Conference on Environment and Development, 1992). Figure 5.1 depicts the evolution of environmental legislation in Malaysia.

Environmental Situation Analysis

In addition to air pollution (hazy days), Malaysia is facing serious environmental challenges in terms of managing solid, hazardous, and toxic waste, water pollution, and coastal water pollution. Almost all the rivers flowing through urban areas are polluted; some are severely contaminated. The contamination is so high that the water is not safe for human contact. The causes of the pollution include discharge from farms, including pig farms, and industrial plants including industries generating toxic waste. This is further worsened by the illegal dumping of municipal waste into drains and directly into the rivers. As a result of river pollution, many coastal areas are also polluted.

Malaysia also has problems related to the disposal of toxic waste. There are just too many cases of illegal dumping of such waste in isolated areas. Many are not detected. The detected dumping areas cost the government huge sums of money to collect the waste and transport it to the proper disposal facilities.

Box 5.1: Hazardous-Waste Management
Hazardous-waste generation in Malaysia was estimated at about 431,000 tons/year in the late 1990s. To ensure the proper disposal of hazardous waste, the government allowed a private company to build a treatment facility, the National Toxic Waste Treatment Centre, in Bukit Nanas in the state of Negri Sembilan in 1998. The company that built the plant, Kualiti Alam, was given the exclusive right to collect and dispose of all waste generated in Malaysia for 15 years.

OVERVIEW OF SWM

The management of solid waste in Malaysia is neither carried out under the Environmental Quality Act nor managed by the Department of Environment. It is the responsibility of the local authorities and they operate under the Local Government Act of 1976.

National SWM Regulatory Framework

Using the provisions of the government act, all local authorities have passed sanitation-related by-laws that provide them with the power to regulate solid-waste disposal in their jurisdictions. In addition to general sanitation by-laws, there are other by-laws with waste-disposal regulations. For example in the hawkers by-laws, there are provisions on how waste generated through their business is to be stored and disposed of. It is important to note that although there is some similarity in the sanitation by-laws among the local authorities in Malaysia, there are also differences.

SWM Situation Analysis

SWM is the responsibility of the 144 local authorities in Malaysia, but there are variations in the way each local authority carries out the implementation. The variation depends on the size of the town. For example, the bigger towns and cities may have state-of-the-art compactors to collect waste from door to door and the smaller towns might only use modified open trucks. In addition, some local authorities might be very strict about the type and size of the garbage bins, while others might be a bit negligent. Hence it is not possible to provide a detailed description of waste management for the whole country.

The effectiveness of each council also varies. For instance, Kuching, Ipoh, and Kuantan, the capitals of Sarawak, Perak, and Pahang respectively, are generally acknowledged as cleaner

Box 5.2: Solid Waste: A Question of Definition
In solid-waste management surveys, there is some confusion on what exactly is meant by solid waste. Many writers equate this term with municipal waste and use them interchangeably. As a result, in some reports, solid waste is limited to waste under the responsibility of the local councils. As most local authorities are not responsible for waste generated by factories, this is not taken into consideration in any discussion of solid-waste management. Other writers use the term solid waste to include all waste generated except items that are classified as toxic. As such, nontoxic waste from factories, such as wood, paper, plastics, fabrics, and food waste are included in the survey of solid-waste management. This survey defines solid waste as all waste except items classified as toxic or hazardous, including medical waste. While such a definition is logical, it may pose some problems in using the existing data. Since this survey is based on secondary data, there might be contamination, as some of the data might be based solely on waste collected by the local authorities. Since the local authorities generally do not collect waste from hotels and factories, it is possible that nonhazardous hotel and factory waste might be missed. Furthermore, in some locations, construction waste and garden trimmings are not disposed of in designated landfills. For instance, on Penang Island, these two categories of waste are still sent to the Jelutong Landfill, which was officially declared closed. Therefore, these categories are not included in the amount of waste collected.

Table 5.1: Solid-Waste Management Zones and Their Managers

Zone	States	Manager (Private Company)
Northern Zone	Perlis, Kedah, Penang, Perak	E. Idaman
Central Zone	Selangor, Pahang, Trengganu, Kelantan, Kuala Lumpur, and Putrajaya	Alam Flora
Southern Zone	Negri Sembilan, Malacca, Johore	Southern Waste Management
Eastern Zone	Sabah, Sarawak	Not appointed yet

than other urban areas in Malaysia. Since it is reasonable to suppose that the behavior of Malaysians is the same everywhere in the country, it appears that the Ipoh, Kuantan, and Kuching authorities are doing a better job than other local councils in the management of solid waste.

Even within a local authority area, the effectiveness of solid-waste management is different depending on the localities. Generally, the richer areas seem to get better service than the poorer ones. However, as a result of numerous complaints about the lack of cleanliness in most urban areas and as part of the trend to privatize these activities, the federal government decided in the mid-1990s that SWM would be managed completely by private companies. In the late 1990s, the government divided the country into four zones and each zone was assigned to a private company who is to manage the solid waste, as highlighted in Table 5.1.

Since the proposed solid-waste management act that will provide legislative backing for the private companies managing solid waste is tabled in parliament, details about the privatization of solid-waste management are still not clear. However, in the Central and Southern Zones, a temporary system has been implemented. Since 2004, M/S. Alam Flora, the company appointed to manage waste in the Central Zone, has been serving 23 local authorities in the states of Selangor and Pahang and the Federal Territories of Kuala Lumpur and Putrajaya. In the Southern Zone, M/S. Southern Waste Management serves only three local-authority areas. Although the private companies of the Northern Zone have been identified, no work has started. No company has been appointed for the Eastern Zone yet.

Quantification and Characterization

No national study has been done on the quantification of solid waste in Malaysia, but data at the local level is available. Based on this data, the Ministry of Housing and Local Government says that Malaysia generates approximately 18,000 MT/day of solid waste.[1]

Since data on the amount of waste is generally collected at the entrance to the landfill sites, these numbers refer to the amount of collected waste. There is a portion of solid waste that is not collected or is illegally disposed of in isolated places or drains and rivers. In addition, part of the waste generated by factories is not counted since it is collected for recycling before its entry into the waste stream.

Unfortunately, there are no authoritative figures on the amount of waste not collected or diverted for recycling. Mohd. Nasir Hassan suggested that it could be as high as 30% of the total waste generated.[2] As such, the amount of waste generated in Malaysia is more than the figures above indicate.

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[1] Huszain Huzin. *National Waste Recycling Program*. Power-Point presentation at the Seminar for the Study on National Waste Minimization in Malaysia, Ministry of Housing and Local Government, 16 September 2004.
[2] Mohd. Nasir Hassan et al. “Solid Waste Management—What’s the Malaysian Position?” in *Urban Sustainability in the Context of Global Change*, edited by R. B. Singh. Plymouth: Science Publications, 2004.

Table 5.2: General Composition of Waste in Malaysia

Materials	% by Weight
Organic	47.0
Paper	15.0
Plastics	14.0
Wood, garden waste	4.0
Metal	4.0
Glass	3.0
Textile	3.0
Other	10.0

Source: Huszain Huzin. *National Waste Recycling Program*. Power-Point presentation at the Seminar for the Study on National Waste Minimization in Malaysia, Ministry of Housing and Local Government, 16 September 2004.

Physical Characteristics and Waste Generation

As in most countries, Malaysians living in urban areas generate more waste than those in rural areas. Indeed, there is even a noticeable difference between those living in bigger towns and those in smaller towns. The logical explanation is that those in bigger towns tend to be richer, and therefore consume more and generate more waste. It should also be noted that the bigger towns have more commercial establishments and factories. It is also possible that the collection rate is more efficient in the bigger towns. Generally, 64% of the waste is domestic, 25% is industrial, 8% commercial, and the remaining 3% is construction and institutional waste.[3]

Composition and Characteristics of Waste

The composition of solid waste in Malaysia is similar to that of most developing countries. Organic waste forms the biggest component, with paper and plastics (including rubber) at second and third positions respectively. Other categories of solid waste are metals, fabrics, and construction waste (debris). Table 5.2 describes the general composition of waste.

There are, however, variations in the composition of waste among the different areas. A detailed study in 2000 in and around Kuala Lumpur showed that there were differences in the percentages of different types of waste according to building use and the socioeconomic background of the residents. Table 5.3 describes the waste composition based on economic status, commerce, and offices.

There is also a difference in waste composition between the bigger cities and smaller towns. In Kuala Lumpur, the largest city in the country, organic waste accounted for about 48.4% while in Muar, an average-size municipality of about 0.5 million people, it was 63.7%. In terms of paper, Kuala Lumpur, the center of commerce and business, had higher percentage than that of Muar. Table 5.4 describes the waste composition in Kuala Lumpur and Muar.

[3] Anderson and Lee, 1998.

Table 5.3: Waste Composition of Selected Areas (dry basis, % by weight)

Materials	High Income	Medium Income	Low Income	Commerce	Office
Organic (food)	51.3	45.7	50.4	60.0	36.6
Paper	9.0	7.1	10.3	8.3	8.9
Plastics	16.9	24.4	24.3	17.5	30.7
Textile	2.5	2.1	2.3	0.8	1.0
Wood	0.7	0.7	0.8	4.3	0.3
Yard waste	6.8	3.8	1.0	0.1	6.7
Glass	3.3	3.3	4.4	3.2	2.8
Metal	6.3	6.6	4.1	4.3	12.1
Others	3.2	6.3	4.7	1.5	0.9
Total	100.0	100.0	100.0	100.0	100.0
Bulk density	273.1	310.7	278.8	371.1	277.1
Moisture	52.9	62.7	52.6	66.2	50.9

Source: Mohd. Nasir Hassan et al. "Solid Waste Management–What's the Malaysian Position?" in *Urban Sustainability in the Context of Global Change*, edited by R. B. Singh. Plymouth: Science Publications, 2004.

Solid-Waste Generation per Capita

As per the annual report of the Ministry of Housing and Local Government (1999), the per-capita amount of waste generated by Malaysians ranged from 0.45 kg to 1.44 kg. But there are differences of opinion concerning solid-waste generation per capita. Following are some of these per-capita generation values. With a population of 25 million, the per capita solid-

Table 5.4: Waste Composition for Selected Municipal Councils (% of weight)

Materials	Kuala Lumpur	Muar
Organic waste	48.4	63.7
Paper	30.0	11.7
Plastics/rubber	9.8	7.0
Metal	4.6	6.4
Others	7.2	11.2
Total	100	100

Source: Mohd. Nasir Hassan et al. "Issues and Problems of Solid Waste Management in Malaysia" in *National Review on Environmental Quality in Malaysia: Towards the Next Two Decades*, edited by Mohd. Nasir Hassan et al. Bangi: Institute for Environment and Development (LESTARI) UKM, 1998.

waste generation per day comes to 0.72 kg/day and it is close to the average generation in developing countries. Jamal Othman estimated that the per-capita generation is 1 kg/day.[4]

Key Elements of SWM

The current methods of solid-waste storage, collection, transportation, treatment, and disposal are highlighted based on Malaysia's four zones. The solid-waste management and handling system starts with household storage of waste, followed by collection and transportation. The next stage involves processing the waste, followed by landfill disposal.

Storage of Waste

The storage of waste until its collection can be divided into two phases. In the first phase, kitchen waste (vegetable leftovers, unwanted material) is stored immediately after its generation and near its generation point. In the second phase, the waste is collected and kept on the premises until it is collected by the waste collectors. This phase is usually done outside the homes or factories, but within their compounds.

In Malaysia, plastic bags are used extensively to carry almost everything from wet markets, supermarkets, and most goods from department stores. Many households store their waste in such bags. There are no standards for the size of the bags, since they come from various sources. In general, the plastic bags are not biodegradable except for the specially prepared, environmentally friendly bags. The use of plastic bags for almost every purchase of goods or disposal of waste in Malaysia has reached an alarming rate. Plastic sheets, bags, and bottles are the most ubiquitous sights in the country. Worse, they can be seen on the streets, in the drains and rivers, and even in the coastal waters. Fishermen complain about the large number of plastics being caught in their nets, even when they are far from the coasts.

All waste from homes (except newspapers and magazines) is discarded in these plastic bags. Segregation at the source is not practiced in Malaysia, as most of the households in Malaysia have only one bag for everything—organic waste, pieces of paper, broken glass or small bottles, wrappers, and soiled baby diapers. In households living in landed properties, the bags of solid waste are deposited in garbage bins outside the house, but usually within the compound. For those living in apartments, the bags of household solid waste are disposed of in community bins in the apartment complexes. For industries, waste is usually placed in black garbage bags before it is taken to the bins outside the premises.

Although most municipal by-laws require that those who generate waste must store it in proper containers before it is collected, many local authorities do not specify the size, color, and material of the garbage bins. As such, bins that are used to keep the plastic bags of waste come in all sizes and forms. They range from the properly designed 120-liter and 240-liter bins with wheels and covers to old oil drums, kerosene tins, and rattan baskets.

When containers without covers are used, the garbage bags get wet when it rains. In addition, they get torn apart by stray animals. Some households just leave the garbage bags by the roadsides for collection which results in garbage being scattered along the roads by stray animals.

More and more Malaysians are beginning to buy properly designed plastic bins with wheels. In some local authorities, the use of such bins is mandatory. However, the strategy employed to make residents use them is different. For instance, the Selayang Municipal Council in Selangor, a municipality adjacent to Kuala Lumpur, has made purchasing bins compul-

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[4] Jamal Othman. *Household Performances for Solid Waste Management in Malaysia*. Report to EEPSEA. Corpcom Services Sdn. Bhd. (www.eepsea.org), 2002.

sory at MYR21 for every landed property owner. (This is not expensive. The market price of such bins is between MYR80 and MYR200 each.) To ensure payment, this charge is included in the assessment bills. Unfortunately, this created some controversies, as some residents felt that the plan was unfair on the part of council.[5]

In 1995, the Penang Island Municipal Council (MPPP) made it compulsory for landed property owners to have the standardized garbage bins. However, MYR5.2 million was spent to purchase about 70,000 80-liter garbage bins.[6] By mid-2004, it had distributed about 58,000 units free of charge to the landed property owners.[7] Commercial premises had to purchase their own 240-liter bins.

In Kota Bharu, the capital of the state of Kelantan, all business premises were required to use approved bins by 2003. Failure to use such bins would result in the nonrenewal of the business license by council.[8]

In apartments, the normal practice is for the management to provide circular community bins. Similar bins are also provided by the local authorities at the entrances of illegal settlements. If they were not provided, the garbage from these residents would end up in illegal dumps, rivers, or bins around the markets.

In wet markets, the local authorities or private companies usually provide Rolled-on/ Rolled-off (RORO) bins. These are usually rectangular 12 m^3 bins that can be rolled on and off the trailers.

Collection and Transportation

The most visible part of solid-waste management is collection and transportation. After the collection of waste from their homes, offices, or industries people have no interest in where it is taken or what is done to it. Very few residents have seen disposal sites such as incinerators or landfills. Door-to-door collection is provided to all landed properties. Those living in apartments and illegal settlements have to bring their waste to the community bins.

Generally the collection of waste is done three times a week on alternate days except on Sunday. In some apartments, shops, and business offices the collection of waste is done daily, except Sundays. In vegetable markets the collection is done daily including Sunday. In areas of unplanned or illegal settlements, collection is done once or twice weekly. On festive occasions such as Chinese New Year or the end of Ramadan (fasting) month, frequent collection service is provided.

The collection and transportation system in Malaysia is fairly common. From the 1980s this activity has been privatized. Since major settlements are under local authorities, collection and transportation is available to all residents except those living in isolated areas such as the hilly region. On Penang Island, the infrastructure is relatively better, and almost 95% of the residents are provided with a solid-waste collection service.

There is no special service provided to collect garden waste as it is included in household waste. Sometimes it is left along the roadside or burned. Some bigger municipal authorities provide a special service once a week to collect garden waste. For this service, the owners need to cut the waste into manageable pieces or bag the leaves to facilitate collection.

On-call, chargeable service is also available in some local authorities. For example, on

[5] *New Straits Times*, letters, 29 February 2002 and 5 March 2002.
[6] Goh Ban Lee. *Non-compliance: A Neglected Agenda in Urban Governance*. Skudai: Sultan Iskandar Institute, 2002.
[7] Zulkifli Zakaria. *Solid Waste Management and Recycling: The Penang Island Municipal Council Experiment*. Paper delivered at the Workshop on GP and Solid Waste Management in Vietnam, Hanoi, 3–7 November 2003.
[8] *New Straits Times*, 14 February 2003.

Penang Island the council charges MYR50 per lorry truckload. Charges by private companies range from MYR100 to MYR400, depending on the distance and type of waste.

Usually12 m^3 compactors, each costing about MYR210,000, are used to carry the waste from their sources to the transfer stations or landfill. On average each compactor is able to collect from 600 to 1,000 houses in each shift. Other vehicles include compactors with a 6 m^3 capacity, multilift trucks, high-side loaders, RORO trucks with 6 m^3 or 12 m^3 capacity, and utility vans. The cost of a 12 m^3 truck is MYR0.11 million, whereas high-side loaders cost about MYR0.163 million. Private collectors have to register their vehicles with the local authorities so that they can keep track of waste generated within the city.

Some new methods are being tested. For example in Malacca in 2000, the residents were told to keep the garbage bags inside until the workers came to collect them at night. The garbage trucks played music to make their arrival known.

The collection and transportation of nonhazardous waste from industries, hotels, and institutes is arranged between the owners and the private-collection services. The collection is generally done three times a week or on a call basis. Construction firms that engage part-time waste collectors dispose of their construction debris in illegal dumpsites such as isolated roads, as they do not have permission to enter the official landfills and have to pay on a per-entry basis.

Similar to other developing countries, the cost for collection and transportation accounts for 60–70% of the total SWM expenditure and the cost of SWM to local authorities is approximately 30–40% of their annual budgets.

It has been calculated that the cost of collection per premise is between MYR12 and MYR20, i.e., it costs between MYR40 and MYR70 per ton to collect and transport waste from its sources to transfer stations or landfills. Like most developing countries, it accounts for 60–70% of the total SWM expenditure. Since the total cleansing bills for managing solid waste in a local authority comes to about 30–40% of the total budgets of the councils, the collection and transportation of waste costs the ratepayers dearly. Table 5.5 shows the cost of collection and transportation in individual states in 2001.

The collection method in Malaysia is labor intensive. There are two methods of waste collection. In landed housing areas, the collectors go from house to house to collect the garbage bags, which are then left at strategic locations to wait for the vehicles. Two or three workers follow the garbage truck and load the garbage as the vehicle slowly moves from door to door. Although this method is followed by most contractors, there are complaints from citizens since stray animals tend to get to the garbage bags before they are loaded into the compactors. In addition no one wants waste stored in front of his house because of the odors and unsightliness.

Table 5.5: Cost of Waste Collection and Transportation

State	Manager (Private Companies)	Cost of Collection and Transportation (in MYR)
Ampang Jaya Municipal Council	Alam Flora	0.7 million
Kuala Lumpur City Council	Alam Flora	100 million
Penang Municipal Council	E. Idaman	108/ton
Johore Bahru, the then Municipal (now City) Council	Southern Waste Management	2.5 million
Johore Bahru Central District Council	Southern Waste Management	1 million

As an incentive to the workers, Alam Flora, the private company for the Central Zone, has an annual Saluting Waste-Management Workers nationwide campaign to coincide with World Earth Day. Residents are encouraged to nominate their favorite workers. Those who receive the most nominations are given cash rewards. In 2003, 31 workers were awarded MYR1,000 each.[9]

Unfortunately the quality of service is still not satisfactory. Complaints include selective collection (some items are left behind), failure to collect on scheduled days, spillage, leachate when compactors operate in residential areas, and a demand for extra payment.

M/S. Alam Flora managed the waste in 23 local communities and received 20,779 complaints in 2001, while M/S. Southern Waste Management managed the waste in three communities and received 1,540 complaints. In a study conducted among 600 residents in two municipal communities in the Central Zone (Kajang and Seremban), approximately 52% of the residents were not satisfied with the quality of their waste-collection services.[10]

As a result of poor collection, although not necessarily the fault of the waste collectors, there are numerous illegal dumpsites in Malaysia. It is estimated that for every legal landfill, there are three unofficial dumpsites. For example, in Ipoh City, the capital of Perak and a city generally considered as among the cleanest in the country, there are 14,000 illegal dumpsites ranging from small garbage heaps to large dumps.[11] In most of the illegal dumpsites, the nearby residents are the culprits, although in some cases it is the fault of part-time contractors.

In some cases, waste from illegal dumps is eventually collected and sent to landfills when there are complaints from nearby residents. According to Alam Flora, it routinely collects about 102 tons of illegally dumped waste per day in Kuala Lumpur alone and City Hall has paid extra MYR2.6 million to M/S. Alam Flora. To make things worse, in cases where clearing the waste is not done, nearby residents often resort to setting fire to the dumps, thereby causing air pollution and other irritations to the neighborhoods.

Transfer Stations

At each transfer station, the collection service is to transfer the waste from the collection vehicles into compacting containers for the longer journey. Each compacting container can hold about four or five times the amount of waste as the collection vehicles.

There are few transfer stations in Malaysia, as most disposal sites are not very far from the cities and towns. In recent times new transfer stations have been developed, such as Jinjang Hill in Kuala Lumpur (waste from here is taken to the Air Hitam Landfill at Puchong) and two in Penang state, one at Ampang Jajar at Butterworth and the other at Batu Maung on Penang Island. However, in the case of the Batu Maung transfer station, there is no compaction. The waste is just transferred to containers, which are then taken by barges to the landfill on the mainland part of the state. Each container can hold between 12 to 15 tons of waste and each barge can ferry 16 containers. Each 22-nautical mile trip takes about 3.5 hours.

Landfill Disposal

Malaysia is facing serious landfill problems. They include a shortage of landfills, overused landfills, poor management, leachates, and the cost of disposal. As per the Minister of

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[9] *The Star*, 26 April 2004.
[10] Jamal Othman. *Household Performances for Solid Waste Management in Malaysia*. Report to EEPSEA. Corpcom Services Sdn. Bhd. (www.eepsea.org), 2002.
[11] *New Straits Times*, 3 December 2001.

Housing and Local Government in 2000, 80% of the country's 230 landfills had only two more years of life. By 2002, the number of landfills dropped to 170 and at the beginning of 2004, there were still 170 registered disposal sites.

Issues of MSW Management

Problems Faced by Landfills

- *Landfills are used beyond their capacities*: Few landfills were commissioned in 2002–04 and more than 120 landfills or at least 2/3 of the total landfills are now used beyond their capacities. For example Jelutong Landfill in Penang was closed in 2002 due to a lack of space, but it is still used for the disposal of bulk and garden waste.
- *More than 50% of the landfill sites are open dumpsites:* According to Ministry of Housing and Local Government, there were 177 dumpsites in 1998. Out of that, 90 sites (50.7%) are open dumpsites, 76 sites (42.7%) are level 1 landfills (daily coverage with soil), and 11 sites are level 2 to 4 landfill sites.
- *Overflowing of landfill sites due to poor management*
- *No facility for venting gas*: This has resulted into the self-ignition of dumpsites, causing visible environmental pollution, and is common at many places. For example, a fire broke out at Taman Beringin Landfill on the outskirts of Kuala Lumpur in 2004 and it required 90 firemen and volunteers to put out the blaze and two to three additional weeks to completely extinguish the fire beneath the garbage heap.
- *Leachate treatment*: Only one landfill site has a leachate-collection mechanism. It consists of aeration in the leachate ponds and recirculation of the effluents into the landfill.
- *Location of landfill sites:* Many landfills are located in coastal areas or near rivers, resulting into leachate pollution and health hazards. For example, the landfill in Beranang is located near the Beranang River, which in turn is a tributary of the Semenyih River and supplies water to Selangor. The leachate from the landfill resulted in the pollution of Semenyih River. Due to the contaminated water, the water supply to millions of residents in Putrajaya had to be disconnected. This resulted in closure of the landfill site by the Selangor state environmental committee.
- *Proximity to landfill sites*: Due to urbanization and urban expansion in the last two decades, the landfill sites that used to be away from communities are now surrounded by housing estates. In addition, poor management has resulted in an increase in complaints from the nearby residents.
- *Shortage of land*: The government is now considering the use of incinerators, but it is largely practiced in isolated places such as island resorts. Each incinerator costs about MYR2.5 million. It also costs about MYR600 for daily operation in order to incinerate 5–10 tons/day.[12] The federal government is now proposing to build a big incinerator in Broga on the outskirts of Kuala Lumpur to burn waste from and around the city. The proposed incinerator, estimated to cost about MYR150 million, is to have the capacity to incinerate 1,500 tons/day. The Environmental Impact Analysis report for this project was recently approved by the Department of Environment. Although there are protests against incineration technology and the costs of incineration and its related operations, the federal government is convinced of the usefulness of incinerators. The government is taking many steps to win over the people toward incinerator technology by way of

[12] *New Straits Times*, 10 April 1999.

arranging trips for the village and community leaders to Japan (the technology supplying country) and advertisements about the safety of incineration and its usefulness for recycling.

As part of the privatization process, more and more landfills are being managed by private companies. In the Central Zone, Alam Flora now manages most of the landfills built by the local authorities. For instance, the Selayang Municipal Council in Selangor has appointed Alam Flora to manage the Kundang Landfill for MYR60,000 per month. Even though a landfill is privately managed, there are still problems at the landfill sites.

In some cases, the landfills are built and managed by private companies. These are the better-managed landfills. For example, in Penang, the 33-hectare Pulau Burong Landfill, which receives about 1,800 tons of waste a day, is a Level 3 facility. The operator, Idaman Bersih, is building a leachate treatment plant so as to upgrade it to a Level 4 landfill. The Air Hitam Landfill in Puchong, the biggest and reputedly best-managed landfill in the country, was built and operated by Worldwide Landfills, a subsidiary of a conglomerate in Malaysia. This MYR40 million (USD11 million) 42-hectare landfill was commissioned in 1995 to accommodate solid waste from the Klang Valley, which incorporates Kuala Lumpur and the surrounding satellite towns. It receives about 3,000 tons of waste a day.[13]

Disposal Cost

Generally the cost of disposal is MYR30 per ton of waste in privately built and operated landfills.[14] For example, the owner of the Pulau Burong Landfill in Penang charges MYR27 per ton for municipal waste and MYR32 per ton for nonhazardous industrial waste.

Privatization

Privatization of SWM is not a recent practice in Malaysia. Some local authorities have contracted out the collection and transportation of waste since the late 1970s. The practice has been to appoint several contractors in each local authority to do the job and keep a skeleton crew to continue to collect and transport waste.

The present policy is to appoint one private company for each zone consisting of 30 to 45 local authorities. Since the local authorities are still responsible for SWM, the companies have to sign agreements with the local authorities to take over waste management. In addition, since the local authorities in Malaysia are under the charge of the state governments, the state government must also agree to the appointed company before anything can happen. This might explain why privatization is in full swing in the Central Zone. Even in this zone, however, only 23 out of 42 local authorities have entered into agreements with Alam Flora.

Even in states where the state governments are in agreement, there are local authorities that do not want appointed contractors to do the job or to privatize SWM. For instance, Taiping Municipal Council, the second biggest authority in Perak, voted to reject privatization. The reason was that it would cost the council too much, from MYR8 million to MYR10 million.[15]

Even local authorities that originally agreed to the private company have changed their minds. For instance, in December 2000 the Ampang Jaya Municipal Council in Selangor terminated the service of Alam Flora on the grounds of poor performance. It also meant that all the

[13] John, 2004.
[14] *The Star*, 10 February 2003.
[15] *The Star*, 29 September 2003.

services of the subcontractors appointed by M/S. Alam Flora were terminated. It was only after the intervention of the federal government that the service was reinstated.[16]

Other problems of privatization include the right of whom to employ to do the actual work on the ground. This is largely because many local authorities already have contractors to do the job. For instance, in the Central Zone, Alam Flora has to appoint these contractors in order to continue to collect and transport the waste.

Many local authorities are also having trouble paying the private companies. For instance, in 2002 some local authorities collectively owed M/S. Alam Flora MYR66 million. Some of them are: Kajang Municipal Council (MYR8 million for more than two years), Sabak Bernam District Council (MYR6.2 million for more than two years), Kuala Selangor District Council (MYR2.4 million for eight months), and Temerloh Municipal Council (MYR2.6 million for more than two years).[17]

The company reported that it needed MYR30 million a month to manage the waste of 8.1 million residents. Payment problems were not only encountered in 2002. In 2000, the federal government had to allocate MYR37.49 million to help 33 local authorities pay their SWM bills.

GP Practices and Other Proactive Measures

Malaysia is committed to minimizing waste as well as instituting organized management and disposal. However, so far the main emphasis has been on recycling and little has been done to popularize reuse and reduce.

Recycling

In recycling, concerted government programs began only in the early 1990s and the first official recycling campaign was launched in October 1991 in Shah Alam in Selangor by the Minister of Housing and Local Government. Twenty local authorities were identified as the lead agencies to promote recycling. This recycling campaign was to be part of the "Clean and Beautiful Program" launched by the ministry earlier. In the following year, the minister announced that all city and municipal councils would be required to launch recycling programs. The smaller district councils would still be exempted.

On 2 December 2000 the government relaunched the national recycling campaign with 29 local authorities participating.[18] The second phase of the new recycling program was launched on 11 November 2002 with 95 local authorities participating. The target was "to reduce waste generation to a minimum rate of 22% by the year 2020."[19] The present recycling program also involves waste management companies, waste recycling firms, Non-Governmental Organizations, shopping mall management companies, schools, hospitals, and religious organizations.

During 2001–03, the government spent MYR25 million on awareness campaigns and another MYR11 million purchasing and building an infrastructure to support the program. There is now a Recycling Secretariat at the Ministry of Housing and Local Government. Its has established a website (www.kitarsemula.com) to propagate recycling and provide information.

The local authorities are required to submit reports on the status of recycling in their areas. Unfortunately, according to the ministry, the response has been poor, and unreliable data has

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[16] *New Strait Times*, 16 April 2001.
[17] *The Sun*, 9 July 2002.
[18] Engku Azman Tuan Mat. "Partnership between Government, Waste Management Companies, Recyclers, and Communities in the Context of the 3Rs," in *Waste2001 Management*, 2001.
[19] Huszain Huzin. *National Waste Recycling Program*. Power-Point presentation at the Seminar for the Study on National Waste Minimization in Malaysia, Ministry of Housing and Local Government, 16 September 2004.

been used.[20] Recycling campaigns carried out by the local authorities include printing flyers and brochures and holding public briefings. They also provide recycling bins for paper, glass, and aluminum in strategic places, such as shopping centers, schools, and transport terminals. For instance, in 2002 alone the federal government purchased 2,360 recycling bins to be distributed nationwide at the cost of about MYR13 million.

Altogether, about 14,700 recycling bins have been bought. This was part of the MYR40 million budget allocated to recycling campaigns.[21] As part of the annual recycling campaign, the Prime Minister also directed that all government offices, departments, and agencies must have recycling bins.[22]

After more than ten years, the official recycling figure is just 3%, although there are reports of higher than 3% recycling. For example, in 2003 Penang Island's recycling rate was 9.8%, up from 3% in 2000.[23] However, there is little doubt that recycling in Malaysia has not been successful. Almost all the recycling bins contain all sorts of waste. Many Malaysians seem to treat recycling bins as an ordinary waste-disposal bin. Indeed, it was so bad that the Penang State government has taken back most of the bins.

Other Initiatives

Local authorities, with assistance from international bodies, conducted pilot projects on recycling. For example, the Penang Island Municipal Council, with assistance from United Nations Development Programme (UNDP) and participation from the Socio-Economic and Environmental Research Institute (SERI), undertook a waste-recycling project from August 2003 to January 2004. The Japanese International Cooperation Agency (JICA) together with the Ministry of Housing and Local Government conducted a study on waste minimization in 2004.[24] On the whole, most recycling projects were successful. The problem is that there have been no follow-up activities.

Malaysians now understand the need for and benefits of recycling. A survey of 2,010 respondents on two separate occasions revealed that their level of awareness was 100% in 2003, up from 79% in 2002.[25] More importantly, the campaign to recycle has motivated many recycling companies. They not only buy recyclable materials from rag pickers, but also approach industries and hotels to collect their material at a minimal charge or even free of charge. They then divert all recyclable materials and dispose of those that cannot be used.

In addition, the recycling campaigns have also spurred religious organizations to set up recycling centers and activities to collect recyclable materials and use the proceeds to fund their religious and charitable activities. The best example is the recycling project of the Kuala Lumpur branch of the Buddhist Tzu-Chi Merit Society. It began recycling activities in 1996 with the slogan "Turn Trash into Gold." It has been very successful— the society now collects more than 1,000 tons of recyclable materials a year. Table 5.6 shows the types and amounts of materials collected by the society.

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[20] Ibid.

[21] *New Strait Times*, 22 October 2002 and Huszain Huzin. *National Waste Recycling Program*. Power-Point presentation at the Seminar for the Study on National Waste Minimization in Malaysia, Ministry of Housing and Local Government, 16 September 2004.

[22] *New Strait Times*, 10 November 2003.

[23] *The Sun*, 31 December 2003.

[24] SERI, 2003.

[25] *New Strait Times*, 23 July 2004.

Table 5.6: Recycle Materials Collected by the Buddhist Tzu-Chi Merit Society

Materials	2000	2001	2002	2003
Paper	594.8	663.5	689.6	835.7
Metal	33.1	55.6	65.7	87.9
Aluminum	5.1	7.0	8.2	9.6
Glass	40.8	71.4	73.9	110.9
Clothes	117.1	140.0	168.0	252.5
Batteries	—	—	0.5	1.4
Plastics	—	42.7	10.1	23.2
Total	790.9	980.2	1,016.0	1,321.2

Source: Buddhist Tzu-Chi Merit Society. *Involvement of NGOs in Waste Minimization Program in Malaysia*. Power-Point presentation at the Seminar for the Study on National Waste Minimization in Malaysia, Ministry of Housing and Local Government, 16 September 2004.

CASE STUDY: PENANG ISLAND

City Profile/Regional Profile

Penang Island, part of Penang State, is located at the northwest corner of the Malaysian Peninsula. It covers 299.65 sq km, including one nautical mile offshore, largely to allow the municipal council to be responsible for the waste floating on the sea. Settlement on the island was officially recorded in 1786 when Francis Light, an English sailor in the employ of the British India Company, founded a settlement at the northeast end. Since then, despite the vagaries of economic fortune, the population has steadily increased from a few hundred inhabitants to about 0.66 million today, making it the second largest urban entity in the country, second only to Kuala Lumpur.

The urban character of Penang as a whole can clearly be seen in the sectoral share of the Gross Domestic Product (GDP). In 2002, service and manufacturing accounted for 53.8% and 41.3% respectively, making a total of 95.1% of the total GDP. Activities like agriculture, construction, and fishing are relatively unimportant.[26] The bulk of the population is located on the northeast part of the island. Population and economic growth in the last four decades has expanded the urban areas from the northeast corner to the north and east coasts of the island and the Paya Terubong Valley.

The island is administered by the Penang Island Municipal Council (PIMC) which is headed by an appointed president and 24 councilors. Like all local authorities in Malaysia, the PIMC is infra-sovereign and does not enjoy generalized competency, meaning that it can only do those things that are allowed by law. The annual budget of the council is about MYR170 million and the bulk of its income comes from assessment rates. There is no financial assistance from the state government, although the federal government does allocate a small grant and often provides specific grants for development projects.

[26] SERI, 2002.

The municipal council has about 3,000 employees and 10 departments, one of which is the Urban Services Department. This department is responsible for "the management of the collection, transport, and disposal services of solid waste." Its objectives are to ensure "proper solid-waste management and public cleanliness throughout the island." For 2003, it had a budget of about MYR80.3 million, which is about 47% of the total budget of the council.

Solid-Waste Generation

Municipal Solid Waste

Until 2001, quantification of solid-waste generation in Penang Island was based on the amount collected and disposed of in the Jelutong Landfill, as this was the only place where a weighbridge was available. As of 2001, data have been collected at the transfer station before the waste is shipped in containers by barges to the Pulau Burong Landfill. Waste that is not collected and discarded at random is not accounted for.

The amount of solid-waste generation is increasing rather quickly even after excluding the uncollected waste. The Urban Service Department of the PIMC records show that the island collected only an average of 198 tons/day of waste in 1974 after the merger of two local authorities in Penang. For the next decade (1974 to 1984), the amount of solid waste fluctuated around 200 tons/day. It suddenly increased in 1984 and peaked in 1994 when the daily average was 637 tons/day. The amount gradually decreased until 1998 when the collection was only 479 tons/day, 159 tons lower than the 1994 figure. Since then it has increased rather drastically to more than 600 tons/day in 2002. The fluctuations in the amount of solid-waste generation until 2002 are shown in Figure 5.2.

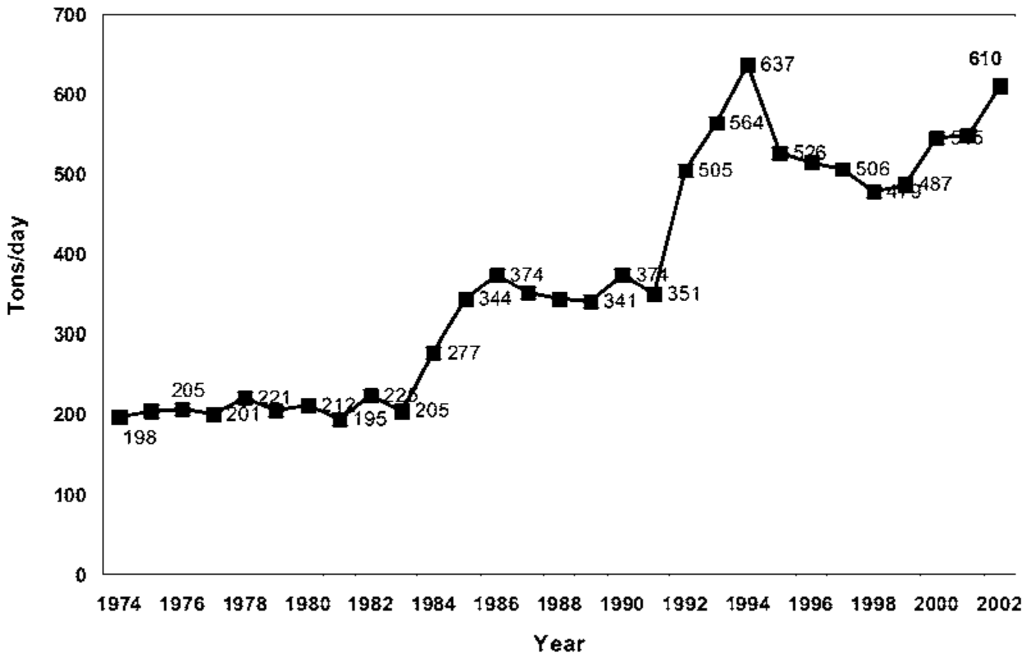

Figure 5.2: Solid-Waste Generation on Penang Island
Source: MPPP Urban Service Department. *Annual Report*, 1995 and 2002.

Even today, no serious evaluations of the waste generation data have been done. Still, it can be believed that the method of payment and the selection of contractors have had an important impact on the amount of waste collected. For example, it can strongly be correlated that the sudden increase in the amount of waste collected between 1984 and 1986 was due to the fact that the council paid the contractors on a per-ton basis. When the payment mode was shifted to a fixed amount per month, the amount of waste collected gradually dropped from 1987 to 1990. One of the possibilities could be that when payment was on a per-ton basis, some contractors were adding stones and water to increase the weight.

Solid-Waste Characteristics and Quantification

The records at the Batu Maung Transfer Station show that about 650 tons/day of solid waste is collected. However, it should be noted that bulk waste such as used furniture, construction waste, and garden trimmings are disposed of at the officially closed Jelutong Landfill. Together with the uncollected waste, it is fair to believe that Penang Island generates about 800 tons/day of solid waste. This works out to about 1.2 kg/capita/day.

The sources of solid waste consists of residential units, commercial units, industries, construction industries, shopping complexes, vegetable markets (wet markets), wholesale establishments, hotels and restaurants, and a floating population.

In terms of the waste composition, a study to prepare for the privatization of solid-waste management in 1996 showed that biodegradable waste formed the biggest category, accounting for about 45.1% of the total amount of waste. Demolition/construction debris and paper accounted for 12.7% and 13.6% respectively, while plastic goods accounted for 10.7%. The remaining 17.9% was made up of metal, wood, textiles, rubber, glass, and other.

A study conducted for the Japanese International Cooperation Agency (JICA) in 1995 had similar results. It found that biodegradable waste accounted for 45%, paper and cardboard another 21%, plastics and rubber accounted for 17%, and glass and stone together accounted for 6%. The rest were textiles 4%, wood and board 4%, and metal 3%. Figure 5.3 shows the composition of solid waste on Penang Island.

The same study looked at three residential areas on the island as part of a recycling project and found some differences in the composition of waste. In two out of the three areas, biodegradable waste accounted for between 52.0% and 59.3% of the total waste. However,

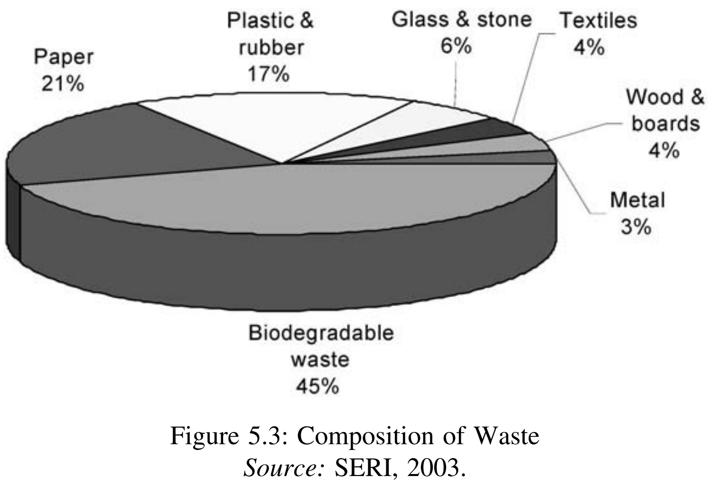

Figure 5.3: Composition of Waste
Source: SERI, 2003.

Weld Quay, an area occupied by low-income families in stilt houses along the coast and adjacent to the heart of the city, had only 34.6% biodegradable waste.

The amount of plastic waste also varied among the three study areas. In the Weld Quay area, it accounted for 32.7%, compared to 13.1% and 15.1% in the other two areas. The details of the other types of waste are shown in Table 5.7. It is important to note that each area does have slightly different proportions of waste composition.

The PIMC was one of the local authorities that contracted for the collection and transport of waste to private companies rather early. In 1984, it appointed six contractors to collect waste from a large part of the island. The reason for appointing more than one contractor was to ensure that if one should fail, others could be called upon to help out. For a similar reason, the council also maintains a small collection and transportation crew to collect waste from the rural part of the island.

Key Elements of Solid-Waste Management

Similar to all local authorities in Malaysia, the principal legal instrument for the management of solid waste in Penang Island is the Local Government Act. Among other things, it authorizes the local authority to establish, maintain, and carry out sanitary services for the removal and destruction of rubbish, litter, dead animals, and all kinds of refuse and effluent. It also enables the council to pass by-laws giving it specific powers to carry out its responsibilities. In solid-waste management, the main by-law is the Public Cleansing and Safety By-laws of 1980.

These by-laws require the owners or occupiers of buildings to provide sufficient and suitable refuse containers with tight fitting lids and to locate them in places that facilitate easy rubbish collection. (See Box 5.3.)

Other by-laws, such as the Hawkers By-laws (See Box 5.4), Trade, Business and Industry By-laws, and Food Handlers By-laws also have provisions for the council to regulate cleanliness and the disposal of waste.

In all the by-laws, there are maximum penalties for those who violate them. For example, any person who breaks any provisions of the Public Cleansing and Safety By-laws is liable to maximum fine of MYR1,000, or a jail term not exceeding six months, or both. The maximum fine for a person who continues to break the law after conviction is MYR200 per day. The

Table 5.7 Waste Composition in Selected Areas of Penang Island (percentages)

Material	Kg. Seronok	Alor Vista	Weld Quay	Overall
Organic waste	59.3	52.0	34.6	52.2
Plastics	13.1	15.0	32.7	17.8
Paper and board	13.5	7.3	12.0	11.6
Metal	4.3	4.8	6.9	5.0
Glass	2.6	9.5	7.7	5.5
Textiles	0.4	0.4	2.1	0.8
Construction waste	3.5	0.8	0.0	2.1
Special waste	3.3	10.1	4.0	5.2

Source: SERI. *A Review of the Community Waste Recycling Situation in Penang.*

Box 5.3: The Public Cleansing and Safety By-Laws of 1980 and Provisions
The do's and don'ts of the by-laws are clearly stated. For example, one of the by-laws states: "No person shall throw or deposit or cause to be thrown or deposited any earth, sawdust, rubbish, refuse, night soil, urine, corpse or carcass, or any part thereof into or upon any street, backside lane, footway, or arcade, or into or upon any ground or open space to which the public have access, or into or upon the banks of any river, canal, drain, or watercourse or into or upon the foreshore."

actual penalties are to be decided by the courts. It is very seldom that the council takes a person who breaks municipal by-laws to court as excessive paperwork is involved. Furthermore, the process can take years since the court calendar is always full. There is no municipal court on Penang Island.

There are provisions for the council to issue compound fines, which are usually only a fraction of the maximum penalties. For instance, although the maximum fine for littering is MYR1,000, the compound fine is as low as MYR30. Furthermore, appeals to municipal councilors or the director of the financial department can reduce the fines to half the amount.

In solid-waste management, rules and regulations are only one part. The other is compliance. Unfortunately, in Penang and for that matter in Malaysia and most cities in developing countries, noncompliance with municipal rules and regulations is common.

One of the main causes of such a state of affairs is the lack of civic values among Penang residents and Malaysians. Their lack of civic consciousness is not only reflected in the way they handle waste, but also in other aspects of life, such as parking their vehicles, driving, and building renovations and usage.[27]

Box 5.4: The Hawkers By-Laws of 1980 and Provisions

The provisions of this by-law state the following.

- Every hawker shall provide adequate refuse bins or receptacles as necessary for the reception of refuse.
- All putrefiable or wet solid refuse shall be placed in plastics bags or other suitable containers before it is deposited in refuse bins.
- All refuse in the refuse bins shall be disposed of by the hawker in such manner as may be directed by the Licensing Officer.

There are even provisions that specifically forbid the hawkers from disposing of waste into the drains. More specifically, there is a provision that states the following.

- No hawker shall cause or permit to be deposited, spilled, scattered, or thrown any blood, brine, waste liquid, any offensive matter, or any refuse into any drain or on any other public place.

[27] Goh Ban Lee. *Non-compliance: A Neglected Agenda in Urban Governance*. Skudai: Sultan Iskandar Institute, 2002.

Box 5.5: Complaint against the Improper Maintenance of Collection Vehicles
According to a complaint to a newspaper, "Take a bike tour around George Town and the suburban areas in the morning. The smelly liquid emitting or dripping from the garbage trucks tends to make the whole town stink as they go around the collecting garbage."*   **The Star*, 31 January 2004.

Part of the blame of the lack of cleanliness in Penang and the poor SWM is the inability to enforce the cleanliness laws. Many actions that are considered a lack of civic consciousness, such as throwing rubbish indiscriminately and misuse of recycling bins, are institutionalized as actions that also break the municipal laws. As such, the municipal council has the power and the responsibility to take actions against those who contribute to the lack of cleanliness.

I have discussed the factors contributing to the lack of enforcement by the municipal council in detail elsewhere.[28] It is sufficient to say that urban management on Penang Island, like that of other local authorities in Malaysia, is weak. Factors for such a state of affairs include: lack of personnel, lack of expertise, weak finance, poor planning, and political interference (perhaps the most important of all).

The last refers to interference by politicians in the affairs of the administration of the local council. The problem is that politicians erroneously believe that protecting taxpayers, even if they were wrong, is a service to the people. Indeed, even a former prime minister believes that the reason why Penang Island is dirty is interference by politicians when the council wants to take actions.

Collection

The weakness in enforcement is compounded by failure to provide good service. There are complaints of missed collections. There are also allegations of collection workers demanding extra payments from apartment managers to ensure that their apartments are not "forgotten." In areas such as wet markets, missed collections result in nearby residents suffering from odors (rotten chicken, fish entrails, etc.). Even casual observers notice the litter on the streets and around bus stops, despite the presence of garbage bins. Most drains are clogged with rubbish, while many back lanes and even some road pavements have bags of garbage.

Storage and Transport

Poor collection systems and vehicle maintenance are also problems. There is also the problem of the council's not taking responsibility even when there are complaints from the public. For example, when local residents from a housing estate complained about an illegal dumpsite in the middle of an open space, no actions were taken for more than a month. The residents had to invite a councilor to visit the site. The explanation was that, "There has been a lot of confusion over who is responsible for maintaining the area and the matter has been shifted between [sic] the management company [Pedeco], the council, and Chaya Delima Enterprise [the appointed waste collector]."[29]

Many cleanliness campaigns have been launched. Unfortunately, they quickly vanish. Since the beginning of 2006, the PIMC has had another "Ops Sinar" (Operation Shine) to

[28] Ibid.
[29] *The Sun*, 19 February 2004.

bring back the shine to the Pearl of the Orient, the nickname of Penang Island. As part of the operation, it now has a squad of about 60 to 100 workers to clean up a specific area if there is a need.

Disposal

There are illegal dumps all over the island, especially on isolated roads and in vacant plots of land, despite the large amount of money spent by the municipal councils on waste collection.[30] These illegal dumps are not only unaesthetic, they also attract stray animals and vermin.

River Pollution

The Sungei Pinang River that runs through the city was declared by the Department of Environment to be the most polluted river in the country. The water is blackish, and rubbish and bags of garbage can be seen on its banks. In response, in the last few years the government has promised to spend tens of million to "beautify" the river. But such promises are yet to be fulfilled.[31]

Although other rivers on the island are not as badly polluted as the Sungei Pinang, they are polluted and laden with rubbish. In fact, the State Drainage and Irrigation Department of Penang stated in 2003 that there were 12 rivers in Penang that could be classified as "highly polluted." These 12 rivers were classified as Class 4 and 5, which under the Department of Environment classification means "not habitable by any living creature."[32]

As a result, not only is the drainage system an ugly sight, it has become an inefficient means of discharging water when it rains. A main contributor to the frequent flash floods in Penang, including in the city of George Town, is rubbish-choked drains and rivers. The municipal council has resorted to placing log booms to trap the rubbish so as to facilitate its removal. It spends MYR0.35 million a year to clear floating rubbish from the eastern coast of Penang Island.[33]

Coastal Water Pollution

As a result of solid waste in the rivers and illegal dumping, the coastal waters around the island are also polluted. The council has to employ fishermen to remove the rubbish. Together with the leachate pollution in the eastern part of the island, the rubbish and floating waste in the waters has caused many parts of the island to be unattractive to visitors. Unfortunately, despite campaigns to "bring back the shine to the pearl" and the promises of state and municipal leaders, things have not improved in the recent past.

GP and Other Waste-Minimization Approaches

Before going on to discuss Green Productivity measures, it is useful to identify the existing problems in the management of solid waste on Penang Island. First, although it is known that a substantial amount of waste is not properly collected and disposed of in designated landfills, very little is known about the amount of such waste and more importantly, the culprits who have been discarding their waste indiscriminately. Furthermore, the reasons for such indiscriminate disposal of waste are not well understood, especially in view of the daily collections in the commercial areas and alternate-day collections in the housing estates.

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[30] *The Star*, 21 April 2003.
[31] *The Sun*, 4 July 2001; *The Star*, 27 August 2003; *New Straits Times*, 17 April 2004.
[32] *The Star*, 19 March 2003.
[33] *The Star*, 30 April 2003.

Secondly, very little is known about the effectiveness of the collection, transportation, and disposal of waste. Is the reason a lack of cleanliness which is the result of poor collection and disposal, or is it the lack of civic consciousness among the people? The search for effective strategies can only be made after the underlying cause or causes are known.

Finally, there is still little information on landfill management. While there are complaints, are they legitimate or just false complaints to extract compensation from the contractors?

As such, an overall study of SWM employing Green Productivity methodology and techniques will be useful. It will provide a systematic survey of the various processes of SWM and identify the problem areas. More importantly, it will also identify strategies to reduce the environmental degradation and at the same time increase productivity.

It is useful to note that the few studies on SWM on Penang Island were for specific objectives, such as recycling or the privatization program. Though useful, these studies have not identified the weaknesses in the chain of events of solid-waste disposal on Penang Island. The holistic methodology employed in Green Productivity will ensure that every process of SWM will be investigated with a view to protecting the environment and at the same time increasing productivity.

The application of GP methodology in each phase of solid-waste management, such as storage, collection, transportation, and final disposal in landfills, will be useful. For instance, an analysis of the storage of solid waste at the sources using GP methodology will not only identify the problem areas, but will help formulate strategies to improve the process.

It is strongly believed that the present lack of success is due to the absence of attention to those who generate waste and store it improperly.

Similarly, the application of GP methodology on the collection and transportation of solid waste will also be very useful. The relatively low application of technology in waste collection and transportation results in an inability to understand the problems related to this phase of SWM and to find sustainable strategies for improvement.

Furthermore, in view of the high organic content of the waste on Penang and in the whole country, there is a Green Productivity Demonstration Project on composting. At present, such a project is being undertaken on Penang Island. One part of the project is to compost biodegradable waste from the canteens at the University Sains Malaysia. The other is to do the same for organic waste from hotels and food courts.

Recycling

Penang Island was one of the local authorities that responded positively to the call by the federal government to promote solid-waste recycling. As early as 1993, it launched a pilot recycling project in a housing enclave in Tanjong Bungah, a popular tourist coastal resort. Here, 1,004 houses were identified and facilitated to separate paper, plastics, glass, and metals from the rest of their waste. These materials were collected once a week.

Apparently, the project was a success. For example, in 1996, collections from the 1,004 houses resulted 218.85 tons of paper, 71.11 tons of metal, and 10.45 tons of glass and plastics.[34] Unfortunately, the enthusiasm has since subsided although it “is still surviving, but hardly living.” Part of the problem, as identified by the municipal officer, was that there was little private-sector participation apart from the residents of the project area and the council.

As part of the national recycling programs, the PIMC has also placed recycling bins at strategic places. Unfortunately, these bins were found to be largely misused. As a result, many

[34] MPPP, 1996.

have been recalled and are only supplied on requests from schools and the managers of complexes.

Since the mid-1990s, the PIMC has actively encouraged businessmen interested in collecting recyclable materials to join in a vendor program in which registered recycling vendors are linked up with hotels and factories that are also interested in participating in recycling programs. Through this program, the council does not need to collect and market the accumulated materials, but it can still promote a healthy recycling business. It also allows the council to concentrate on education and promotion programs. Today 20 vendors are registered with the council under this program.

At present, there is a Non-Governmental Organization with financial aid from the government to promote and facilitate recycling on the island. This is the Penang Environmental Working Group (PEWOG), which operates under the support of the Penang Local Government Consultative Forum (PLGCF). This body is under the chairmanship of an executive council member of the Penang state government in charge of local government, environment, and traffic management. PEWOG is made up of community leaders and recycling vendors. It implements the Community Recycling Program in Penang. Its activities include a pilot recycling project, awareness campaigns, and information collection and analysis. So far, PEWOG's activities have involved about 150 communities.

The PIMC is planning to begin a pilot project to promote the separation of dry and wet recyclable waste in the same area where it began its 1993 recycling program. The objective is to be able to establish a composting program to reduce the amount of organic waste that is currently disposed of in landfills.

OBSERVATIONS AND RECOMMENDATIONS

There is awareness concerning solid-waste management, at least among government leaders, and the serious problems confronting Malaysia because of it. Most Malaysians are also aware of, and fed-up with, the lack of cleanliness in the towns and cities.

Unfortunately, there is the simplistic belief that the problems can be solved easily. The government seems to think that privatization of solid-waste management is the cure. So far, the process of privatization is still not completed and the government is averse to explaining the reasons for its slow implementation. More importantly, there is no clear evidence that privatization, as implemented in the Central and Southern Zones, is effective, efficient, and cost-effective.

The government has also recognized that there must be a reduction in waste quantity before it is brought to the landfills for final disposal. So far, however, it has only promoted recycling. Little has been done to promote the other two Rs, that is, reduce and reuse. Even in the recycling programs, not much has been done except to provide recycling bins and urge the people to use them. The official figure of 3% waste recycling is testimony that a more systematic and innovative program is needed.

There is no doubt that the application of Green Productivity principles and methodology will go a long way toward identifying the problem areas and sustainable strategies. The only difficulty is to convince the national, state, and local government leaders to adopt them.

6. NEPAL

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INTRODUCTION

Solid waste is an inevitable by-product of human activities. With rapid urbanization, improved living standards, and changing consumption patterns, solid-waste management has become a major challenge in many Asian countries. If solid waste is properly organized, it can be a valuable resource, but if it is not managed effectively, it can result in seriously adverse impacts related to the environment and public health.

This study was done as part of an Asian Productivity Organization (APO) project to gather solid-waste management information from member countries to develop a combination of processes and innovative approaches to manage and treat solid waste.

The main objective of this study is to analyze the current waste-management practices in Nepal and recommend improvements. The specific objectives are as follows.

- Assess the current situation of solid-waste management in Nepal.
- Study the prevailing technologies and practices associated with waste collection, transfer/transportation, recycling, and disposal.
- Analyze existing policies and programs on waste management.
- Explore ways to maximize waste minimization and recycling.
- Prepare a case study for waste management in Kathmandu.
- Recommend policies and actions for effective waste management.

Activities associated with solid-waste management normally include waste generation, on-site storage, reduction, reuse, recycling, collection, transfer, transportation, treatment, and disposal. An effective, integrated waste-management system includes appropriate systems to manage each of these activities.

This report introduces solid-waste management in the Nepalese context and then focuses on solid-waste management in Kathmandu. It ends with an action plan for improving Kathmandu's solid-waste management system.

COUNTRY PROFILE

Physiography and Climate

Nepal is a small, landlocked country with an area of 147,181 sq km. The average north-south length of the country is 193 km and average east-west width is 850 km. It is surrounded by India on the south, east, and west, and China on the north. The country, even though small, exhibits tremendous variation in geography and ecology.

The topography is rugged, as the elevation climbs up and down across some of the world's highest peaks and deepest valleys. The country can be broadly divided into three physiographic regions: mountains, hills, and Terai (plains). The physiographic division of Nepal is presented in Figure 6.1.

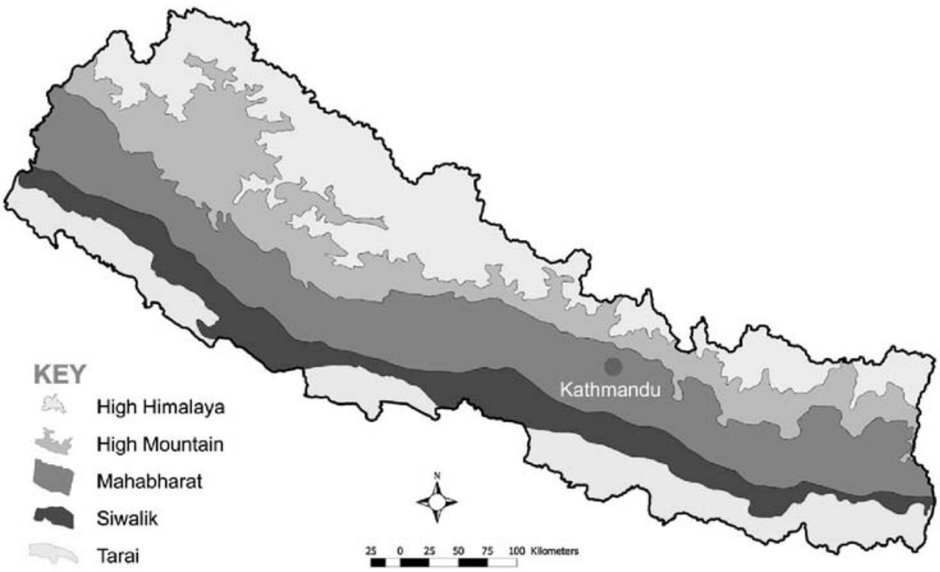

Figure 6.1: Physiographic Division of Nepal

The mountainous area covers about one-third of the total land. The elevation ranges between 2,200 m to 8,848 m (the height of Mt. Everest, the tallest mountain in the world). The mountain region can further be divided into the High Himalayas and the High Mountains. Similarly, the hills can further be divided into Mahabharat and Siwalik hills. The hill region, which is located between the mountains and the plains at an altitude of 500 m to about 3,000 m above sea level, comprises 42% of the country. About 50% of Nepal's land is under some kind of vegetation cover: 29% (4.2 million ha) forests, 10.6% shrubs, and 12% grasslands. The type of forest in the country ranges from tropical and subtropical in the south to alpine in the north. Although loss of forest has been a major problem in the past, more recently community forestry has been a major success story in Nepal. The annual deforestation rate is estimated to 1.7%.[1] Overall, a major portion of the land area comprises forests, followed by agriculture.

Although the country occupies only 0.03% of the world's landmass, it has 8.5% of the world's total bird species, 4.2% of its mammals, 4.2% of the butterflies, 2.2% of freshwater fish, and 2.2% of the world's flowering plants.[2]

The Tarai has substantial groundwater resources, which can be used for irrigation, the drinking water supply, and industry. The water table is generally about 15 m below the surface in the northern Tarai and close to the surface in the southern Tarai. The middle Tarai consists of high-pressure artesian areas.

The topographic diversity is reflected in the variation in the climate. The mountainous region has a very harsh climate, making life inhospitable.

Demography

The total population of Nepal is 24.2 million (2003). More than 85% of the people live in villages. The population density of Nepal is 157 per sq km and population growth rate is 2.2%

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[1] DFRS, 1999 as quoted in MoPE, 2000.

[2] T. B. Shrestha. *Nepal Country Report on Biological Diversity*. Kathmandu: IUCN, 1999.

for the decade 1991–2001. Scattered within this diverse landscape is an equally diverse population with many different, unique languages and cultural practices.

As only 2% of the 35% of the area of Nepal covered by mountains is suitable for cultivation, this area is sparsely populated and shows the lowest growth rate. In the hilly region, although the terrain is rugged, there are many communities scattered throughout. Many of the villages located on the ridges and river valleys are used for agriculture. Most of the villages are small settlements or administrative centers. The fertile Terai area in the south consists of about 23% of the land area but accommodates almost 50% of the total population. Due to migration taking place from the hills in this area, many of the towns are developing rapidly. Due to very little development in terms of infrastructure, institutions, and social services, the literacy rate is only about 53.7%.

Governance

The country has a constitutional monarch as the head of state. The people elect 205 representatives to the Parliament (Lower House), which then selects the cabinet and prime minister, who heads the government. The country also has a 60-member Upper House.

Administratively, the country is divided into five development regions, 75 districts, 58 municipalities, and 3,912 Village Development Committees (VDC). Out of the 75 districts, 16 are located in a mountainous area, 39 are in the hills, and 20 are located in the Terai.

At the local level, the people elect five ward members, including a ward chairman and a female ward member for their local wards and municipality/VDC, as well as a mayor and deputy mayor in the municipalities. The local representatives then elect members for the District Development Committee. A chief district officer, appointed by the central government, heads the district administration. Most government agencies have district level offices that implement government programs at the local level.

Economy

Being one of the least developed countries in the world, Nepal faces numerous challenges. The literacy rate is only 53.7% and the average life expectancy is less than 60 years. The economy is still dominated by the agriculture sector, which accounts for 40% of the total GDP. Because of population pressure, even marginal land in the hills is cultivated, in spite of its rather low productivity. Most of the Terai plains are used for agriculture.

Natural beauty is a resource for the tourism industry. However, very little of the tourism potential has been exploited. The industrial base is very weak with only a few large manufacturing industries and many small cottage industries contributing 20.7% of the GDP in 2003. The GDP per capita is USD241, with a growth rate of 2.6%. The main export items include carpets, garments, and handicrafts.

Although Nepal has very few mineral resources, it does have a large hydropower potential due to its more than 6,000 rivers. The hydropower potential in Nepal is estimated to be 83,000 MW, out of which about 50% is considered to be economically feasible. So far, however, only about 600 MW of power-generating capacity has been established. Traditional energy or biomass has always been, and continues to be, the main source of energy in Nepal. In 2002, over 75% of the total energy consumed came from firewood and about 10% consisted of agricultural residue and dung. Petroleum products, which make up about 9% of the total energy supply, are mainly used in the transportation and industry sectors. Electricity is used mainly for lighting. Because of the low level of industrialization, the main consumer of energy is the residential sector, where almost 90% of the energy is consumed.

Environmental Profile

The Constitution of Nepal (1990) clearly states the need for environmental conservation in the Directive Principles of the State by saying, "The State shall give priority to the protection of the environment of the country and also prevent damage due to physical development activities by making the people conscious of environmental cleanliness and by making special arrangements for the protection of rare animal species, forest, and vegetation."

National Environmental Regulatory Framework

The National Conservation Strategy of 1988 was Nepal's first environment-related policy. It was followed by the Nepal Environmental Policy and Action Plan in 1993. Both of these policies mention the need for pollution-control activities. Several of the country's Five-Year Plans, including the latest, Tenth Five-Year Plan (2002–07), have also highlighted the need for environmental protection.

The Ministry of Population and Environment (MoPE), which was formed in 1995, is the primary government organization responsible for environmental issues in Nepal. The MoPE is responsible for formulating environmental policies and standards and monitoring environmental quality. It also reviews environmental-impact assessment reports and gives environmental clearance for major development projects.

Legislation

The Environmental Protection Act of 1996 and the Environment Protection Regulations of 1997 are the main environment-related legislation in the country. They emphasize environmental conservation and management through the internalization of the environmental assessment system, pollution control and prevention, conservation of the natural heritage, and the operation of environmental funds. The regulations also specify projects that need to prepare environmental-impact assessments. Besides these, several other pieces of legislation have environment-related provisions. Some of these are presented in Table 6.1.

In addition to national legislation, Nepal is also a signatory to several environment-related international conventions. This includes the Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and Their Disposal, 1989. Figure 6.2 shows the timeline of laws and regulations in Nepal.

Environmental Situation Analysis

Natural Resource Degradation and Utilization

Human activities and natural processes change the land-use pattern and increase land degradation. Heavy monsoon rains pounding on steep areas with little or no vegetation result in erosion and landslides. This is compounded by human activities such as forest depletion, overgrazing, and the construction of infrastructure such as roads without adequate protection measures. Soil loss from agriculture and grazing results in a reduction of soil fertility, which in turn leads to conversion of more forest and marginal land into agricultural land. Although the loss of forests has been a major problem in the past, community forestry has recently been a major success story in Nepal.

Because of its unique location and diverse topography, Nepal is rich in biodiversity. In order to conserve the country's biological resources, the government has established national parks and conservation areas covering 18% of the total land and has taken special measures to protect rare and endangered species. As a result, the population of some rare animals such as rhinos and tigers has increased in recent years.

Although Nepal is rich in water resources with over 6,000 rivers and streams, many of

Table 6.1: Key Legislation with Environment Related Provisions

Legislation	Environment-Related Provisions
National Parks and Wildlife Conservation Act, 1973	Declare and manage national parks, wildlife reserves, and conservation areas
Soil and Water Conservation Act, 1982	Ensure soil conservation through land-use regulations
Solid Waste (Management and Resource Mobilization) Act, 1986	Regulate solid-waste management through effective collection, transportation, recycling, and disposal
Pesticide Act, 1991	Regulate the use, production, and distribution of pesticides
Labor Act, 1991	Measures for occupational health and safety
Forest Act, 1992	Conserve and manage forest and biodiversity
Water Resources Act, 1992	Promote conservation of water resources and water quality standards
Vehicle Transport and Management Act, 1992	Regulate vehicle exhaust and promote clean vehicles
Industrial Enterprises Act, 1992	Promote industrial-pollution control
Local Self-Governance Act, 1999	Mandate local governments to conduct local-level environmental planning, natural resource management, and pollution-control related activities, including solid-waste management

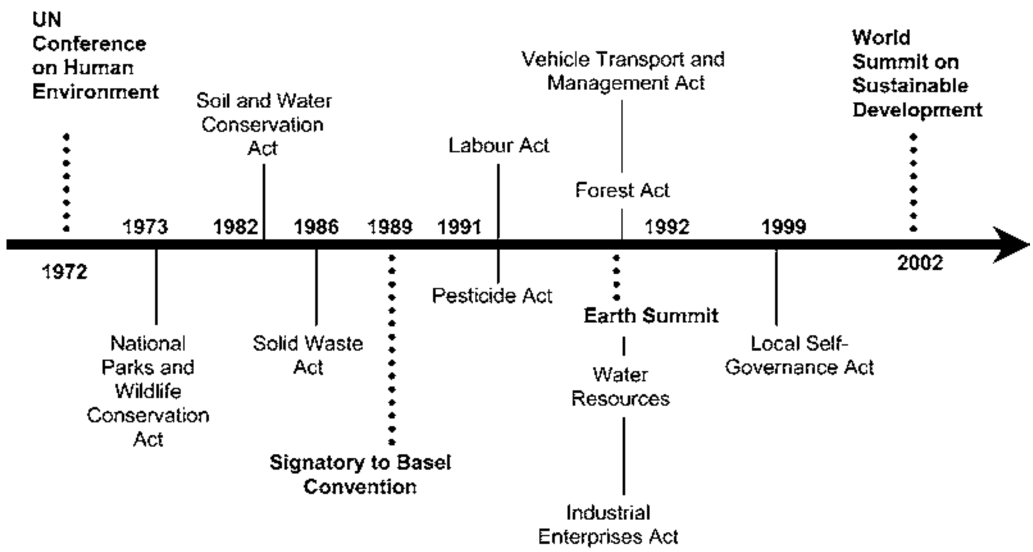

Figure 6.2: Timeline of Laws and Regulations in Nepal

which flow from the glaciers in the Himalayas, it faces many environmental problems related to water. Floods and landslides induced by heavy rainfall and river cutting are common during the monsoons. In addition many communities lack an adequate water supply and irrigation facilities. In urban areas, water pollution is also becoming a major problem because of the disposal of untreated wastewater and solid waste into the rivers.

The Terai has substantial groundwater resources that can be used productively for various purposes. However, in Kathmandu Valley, the existing groundwater resource is being extracted at a rate of more than twice the recharge rate.

According to the 2001 census, 82% of the population has access to an improved water supply from pipelines or tube wells. As for sanitation, however, only 46.8% of the households have toilets.

Air Pollution

Indoor air pollution is a major problem in rural households because of the extensive use of biomass for cooking and space heating. Although the exact extent and impact of this problem is not documented, it is probably responsible for respiratory problems in a large number of people, particularly women and children from poor families.

Urban areas, particularly in Kathmandu Valley, suffer from poor ambient air quality. In Kathmandu, air pollution, particularly the concentration of suspended particulate matter (SPM), is higher than national and international standards, especially in the dry winter months. Vehicle emissions and brick kilns are the main sources for this pollution. Recently, the government has taken steps to ban polluting brick-kiln technology as well as two-stroke vehicles from Kathmandu Valley and to promote cleaner technologies such as electric vehicles.

Currently the government and several NGOs are involved in promoting biogas and improved cooking stoves to tackle indoor air pollution. So far, more than 150,000 improved cooking stoves and more than 130,000 household biogas plants have been installed in the country.

Although Nepal's greenhouse gas emission is very low compared to other countries, the country is vulnerable to the adverse impacts of climate change. An average Nepali produces only 0.14 tons of CO_2 per year. However, the global rise in temperature is resulting in the rapid melting of glaciers as well as other impacts. Because of Nepal's limited capacity to adapt to a changing climate, the impacts of climate change could be quite severe in the future.

Urban Environment

According to the 2001 census, 14.2% of the Nepalese population lives in municipalities, and in the next 10 years this figure is expected to increase to 24%.[3] Although urbanization is a relatively new phenomenon in Nepal, and the percent of total population living in cities is still small compared to other countries, the rate of urbanization is very high. At present, there are 58 municipalities in Nepal, out of which Kathmandu is categorized as a metropolitan city and four are categorized as submetropolitan cities. Additionally, there are more than 132 small towns and market centers that function as service centers for rural areas. Kathmandu is the largest city in Nepal. The next largest city is Biratnagar. The other major cities in Nepal are Lalitpur and Pokhara, located in the Terai plains.

[3] NPC. *Tenth Plan (2002–07)*. Kathmandu: National Planning Commission, 2003.

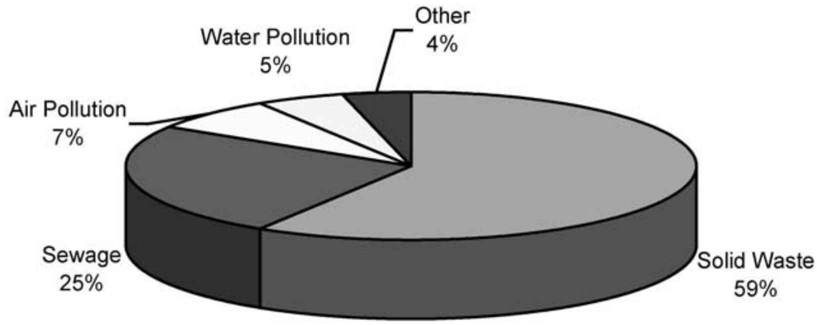

Figure 6.3: Public Opinion on Main Environmental Problems in Urban Areas
Source: CBS. *Urban Population 1996*. Kathmandu: Central Bureau of Statistics, His Majesty's Government of Nepal, 1997.

Since 2001, the rate of urbanization has probably increased further because of the escalating violence in many rural areas. In some towns (Dhankuta, Nepalgunj, Birendranagar, Tansen, and Tribhwannagar) the growth rate was found to be higher than 7%.[4]

The rapid and haphazard increase in urbanization is exerting immense pressure on urban environments and municipal corporations which often do not have sufficient expertise and resources to deal with the rapid growth. As a result, many cities in Nepal are facing environmental problems. The problems are more critical in larger municipalities. Figure 6.3 shows the results of a survey done by the Central Bureau of Statistics (CBS) in 1996 concerning public opinion on main environmental problems in urban areas. Kathmandu, for example, is suffering from extremely poor air quality, severe degradation of the rivers, and improper management of waste.

Environmental Institutions

The environmental-regulatory-framework implementation is vested with various government agencies. A responsibility matrix of the organizations is presented in Table 6.2. Besides these organizations, academic institutions, NGOs, and private companies are involved in activities such as research, public education, and providing environment-related services.

OVERVIEW OF SOLID-WASTE MANAGEMENT

In Nepal, the haphazard disposal of solid waste is probably having the maximum adverse environmental impact in many areas. According to the CBS (1996), only 17% of urban households have their waste collected by waste collectors. Furthermore, in low-income households (houses having no toilets), only 2% of the households have their waste collected. The encouraging thing is that in these houses with no toilets, 35% of the households compost their waste. Hence it can be concluded that traditionally most people recycled waste at home but as societies become modern, waste management starts to become a major problem. The challenge is to modernize waste-management practices while keeping the old values of waste recycling. Figure 6.4 summarizes the methods of household waste disposal.

[4] GTZ. *Discussion Paper.* Kathmandu: Urban Governance Support Programme, 2003.

Table 6.2: Key Government Institutions Involved in Environmental Management

Institution	Environmental Responsibility
Ministry of Population and Environment	Environmental policies, standards, monitoring, and assessments
Ministry of Industry, Supply, and Commerce	Industrial pollution control
Ministry of Forests	Forests and wildlife conservation
Ministry of Works and Physical Planning	Urban planning, water supply, sanitation
Ministry of Health	Environmental health
Department of Transport Management	Vehicle emission control
Municipalities	Urban environment management
Solid-Waste Management and Resource Mobilization Center, Ministry of Local Development	Formulate policies and standards related to waste management and provide technical assistance to municipalities

National SWM Regulatory Framework

The National Conservation Strategy (1988), a step toward Nepal's first environmental policy, states that His Majesty's Government of Nepal (HMGN) will develop and implement policy and legislation related to pollution, including the treatment and handling of solid waste, but the Nepal Environmental Policy and Action Plan (NEPAP) is silent on the issue of solid-waste management.[5] The Tenth Plan (2002–07) does not specifically mention any plans regarding SWM except the construction of a landfill at Okharpauwa for Kathmandu.

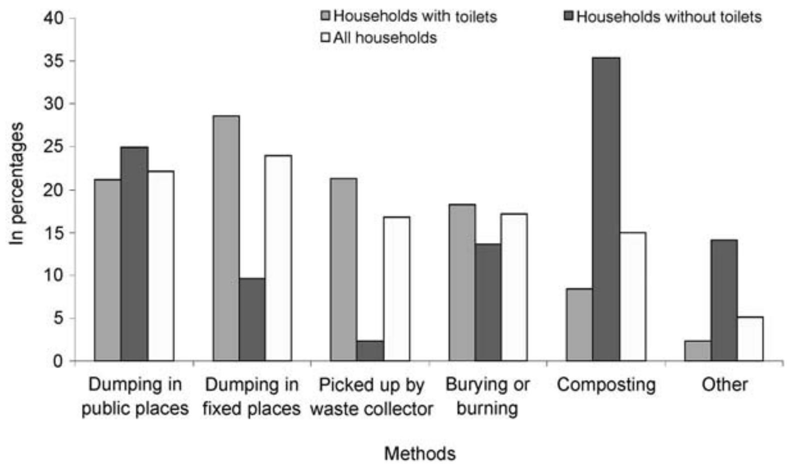

Figure 6.4: Methods of Household Waste Disposal
Source: CBS. *Urban Population 1996*. Kathmandu: Central Bureau of Statistics, His Majesty's Government of Nepal, 1997.

[5] EPC. *Nepal Environment Policy and Action Plan*. Kathmandu: HMGN Environment Protection Council, 1993.

In 1996, HMGN adopted a solid-waste management policy for Nepal, but this must be followed up with appropriate plans and programs. The main objectives of the National Waste Management Policy (1996) are as follows: make waste management simple and effective, minimize pollution and the public-health effects from waste, mobilize waste as resource, privatize waste management, and raise public awareness and people participation.

The Solid Waste (Management and Resource Mobilization) Act of 1987 was the first legislation related to waste management in Nepal. The act was promulgated to form the Solid-Waste Management and Resource Mobilization Center (SWMRMC) and to facilitate the implementation of the GTZ supported SWM project in Kathmandu. However, the act is not functional now because the SWMRMC is no longer involved in managing Kathmandu's waste.

The main legislation governing the activities of municipalities is the Local Self-Governance Act (1999). The act makes municipalities responsible for waste management, but does not say how this is to be done. Some municipalities, such as Dharan and Itahari, have formed their own guidelines on SWM. These guidelines define responsibilities and set the amount of fines to be collected from people who litter.

Institutional Aspects of Solid-Waste Management

According to the Local Self Governance Act of 1999, municipalities are responsible for SWM within their jurisdictions. The organizational capabilities of municipalities in dealing with waste management, however, vary significantly. While many municipalities have separate SWM units, new municipalities such as Khandbari do not have a waste-management unit within their organizational structure and are not involved in waste-management related activities. In some cases, two or more departments from one municipality have SWM related functions. For example, Itahari municipality has a SWM unit under the planning and urban development section and it also has an environmental health and sanitation unit under the community development section. Overall, few municipalities have been able to develop appropriate institutional mechanisms for waste management.

All municipalities fall under the Ministry of Local Development (MoLD). Within MoLD, there is a Solid-Waste Management and Resource Mobilization Centre (SWMRMC), which was created in 1987 to reorganize waste management in Kathmandu Valley. SWMRMC is no longer responsible for waste management in Kathmandu Valley, but it is assisting the municipalities in constructing a sanitary landfill. SWMRMC is responsible for assisting municipalities in SWM related activities, but so far it has not been able to do much because of a lack of financial and human resources. Nepal also has provisions for the National Council for Solid-Waste Management, a high level policy-making body under the chairmanship of the Minister of Local Development. However, in spite of its obvious importance, the council has not met for more than five years and is not functioning now.

Although SWM is a very important service that requires substantial human and financial resources, many municipalities are not able to provide adequate resources due to financial constraints. Furthermore, often due to technical and managerial limitations, the available resources are not efficiently utilized.

The amount of resources allocated by municipalities varies significantly. Even within Kathmandu Valley, well established municipalities such as Kathmandu, Lalitpur, and Bhaktapur have invested substantial resources in SWM, while smaller and newer municipalities such as Madhyapur Thimi and Kirtipur have very limited operations. Table 6.3 shows the resource allocations for SWM in five municipalities in Kathmandu Valley. Kathmandu, Lalitpur, and Bhaktapur collect more than 75% of the waste generated in their cities, Madhyapur Thimi and Kirtipur collect less than 40% of waste generated in their cities.

Table 6.3: Resource Allocation for SWM in Five Municipalities in Kathmandu Valley

Municipality	Population (2004)	Waste Generated (ton/day)	Waste Collected (ton/day)	Expense on SWM (million NPR/year)	Expense per Person (NPR/year)	Size of SWM staff	Persons Served per Staff Member
Kathmandu	741,008	308	250	149.0	201.0	1,262	586
Lalitpur	178,987	75	52	25.0	140.0	211	848
Bhaktapur	80,476	26	19	16.0	199.0	217	371
Madhyapur Thimi	53,853	14	5	0.5	9.3	23	2,341
Kirtipur	43,424	12	4	0.20	4.6	6	7,237

Source: JICA. *Study on Solid-Waste Management for the Kathmandu Valley: Interim Report (1).* Kathmandu: Japan International Cooperation Agency and His Majesty's Government of Nepal, 2004.

Although there are no standards on how much resource allocation is necessary for effective waste management, one staff for over 7,000 residents and less than NPR5 per resident a year is clearly inadequate.

SWM Situation Analysis

Quantification and Characterization

Households are the main source of municipal waste in Nepal. Other sources include agricultural activities, industries, institutions, commercial areas, construction sites, and medical facilities. Since about 85% of Nepal's population are farmers, agricultural activities probably result in a significant amount of waste. However, most of this waste is recycled to produce compost, animal feed, and other products and does not end up as waste that needs to be disposed of. Similarly, the amount of waste generated by industries and other sources is probably small because of the low level of industrialization in the country. UNEP (2001) estimated that about 83% of all waste generated in Nepal is municipal waste, while about 11% is agricultural waste and 6% is industrial waste.

There have been very few studies on waste generation rates and management practices in Nepal and most of these have been limited to Kathmandu. Based on one study,[6] it was estimated that the average waste-generation rate in municipalities is between 0.25 to 0.50 kg per person per day, depending on the size of the municipality. This is probably an over estimate because more recent studies done in Kathmandu by the Kathmandu Valley Mapping Programme (KVMP) and Japan International Corporation Agency (JICA) indicate that the waste generation rates of 0.25 to 0.50 kg per person per day seem a little high. Even in Kathmandu the per capital waste generation is only about 0.3 kg per person per day.

A survey of waste management practices in all 58 municipalities in Nepal conducted by SWMRMC in 2003 found that the household-waste generation rate in the municipalities varied from 0.08 (in Putali Bazar) to 0.7 (in Birgunj) kg per person per day, with the average being 0.25 kg per person per day. It was assumed in the study that household waste constituted 75% of the total municipal waste and therefore the total average generation rate for municipal waste

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[6] S. B. Mishra, and R. P. Kayastha. "Solid Waste Management," in *A Compendium on Environmental Statistics, 1988 Nepal*. Kathmandu: CBS, 1988.

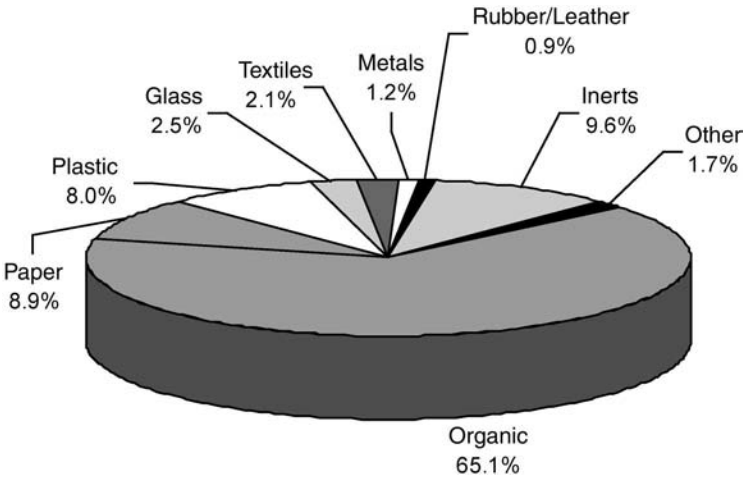

Figure 6.5: Waste Composition of Household Waste in Nepalese Municipalities
Source: SWMRMC. *Diagnostic Report on the State of Solid-Waste Management in the Municipalities of Nepal*. Lalitpur: Solid-Waste Management and Resource Mobilization Center, 2004.

was calculated to be 0.34 kg per person per day. The total municipal waste generation in Nepal in 2003 with an urban population of 3,487,000 was calculated to be 1,369 tons per day or approximately 500,000 tons per year.[7]

As in most other developing countries, biodegradable waste is the main component of the waste stream. According to the SWMRMC (2004) the amount of biodegradable matter in household waste varies from 39% (Lekhnath Municipality) to 95% (Kirtipur Municipality). Normally, smaller municipalities tend to have a higher biodegradable content in their waste. The survey, however, showed that in some cases of waste samples collected in small municipalities, the biodegradable content was lower than average and the proportion of inorganic materials such as plastics was higher than average. This may be because much of the biodegradable waste was probably not included in the waste sample since it was recycled at the source, whereas the inorganic waste is not recycled at the source and enters into the waste stream. On average, about 65% of the household waste generated in Nepalese municipalities was found to be biodegradable matter, while about 20% consisted of recyclable materials such as paper, plastic, and metal, and about 10% was inert materials. The waste composition is described in Figure 6.5.

Due to changing consumption patterns in Nepalese society the amounts of nonbiodegradable waste such as glass and plastic are probably increasing. Waste composition surveys done in Kathmandu have shown that the percentage of plastic waste has increased from 0.3% in 1976 to almost 10% today.

Key Elements of Solid-Waste Management

Waste collection is generally the most important component of any waste management system because it is generally the most expensive and visible part of the system. Therefore,

[7] SWMRMC, 2004.

properly designed and executed waste-collection systems can result in significant savings and an effective SWM system. In Nepal, however, waste-collection systems are not properly planned. Street sweeping, waste collection, and transportation are done on an ad-hoc basis, resulting in ineffective and inefficient services.

Collection

The total amount of waste collected by the municipalities in Nepal is not known because most municipalities do not keep records about it. The waste-collection rate is normally higher in the older and bigger municipalities, which have been involved in waste management for a longer time and therefore have developed better systems.

Since dumping waste on the roadside or other public places is a very common practice in Nepal, street sweeping is an important activity in the waste-management system. Most municipalities employ sweepers who manually sweep the city streets. Brooms made from bamboo with long handles are the most common equipment used. Sweepers tend to collect the waste in small piles along the streets as they sweep. If these piles are not picked up immediately, the waste is scattered by the wind or animals such as stray dogs, causing pollution. Kathmandu has a mechanical broomer with a vacuum suction device, but it is rarely used because of its high operating cost.

Some municipalities have set up communal containers, or even tractor trailers at different places in the city, for the people to dispose of their waste. Once a container is filled, the municipality picks it up and transports it to the disposal site. Other municipalities are practicing on-time collection and door-to-door collection. On-time collection is a system where the waste generator puts the waste directly in the collection vehicle, when the vehicle announces its arrival by giving a signal such as bell or siren. In door-to-door collection, the waste collector goes door-to-door to collect waste from the households.

According to the SWMRMC (2004) all municipalities except Putali Bazar practice street sweeping and 47 municipalities (82%) sweep major streets on a daily basis and sometimes more than once a day, while other streets are swept less frequently.

Storage

In Nepal, very few households have provisions for on-site storage. Many waste generators simply throw away the waste as soon as it is generated. Some modern facilities and large waste generators have containers for on-site waste storage. In recent years, some municipalities have distributed waste collection bins to a limited number of households.

Transportation

Most municipalities use nonmotorized vehicles such as handcarts and rickshaws for waste collection and transportation. The biggest advantage of handcarts and rickshaws is that they are inexpensive and easy to use and maintain. The designs of these vehicles differ from place to place and their capacities normally range from 0.1 m^3 to 0.4 m^3. The waste is directly loaded onto these vehicles manually and when filled, they are emptied by tipping the collected waste onto the ground. It is subsequently loaded onto other vehicles using shovels, an inefficient process that causes pollution. Some studies in Kathmandu have indicated that placing containers or sacks with about 60-liter capacity in these handcarts or rickshaws can make waste transfer a lot more efficient.

Among the 58 municipalities, 50 (86%) use tractors with trailers with a capacity ranging from 1.5 m^3 to 3 m^3 for waste collection and transport. The use of tractors is popular because it is relatively inexpensive, powerful, and versatile, it can be used with several trailers, and is appropriate for rough roads as well. Similarly 14 municipalities (24%) use trucks or tippers for waste collection and transportation. Trucks normally have higher waste-carrying capacity and can travel faster. Only two municipalities, Kathmandu and Lalitpur, use trucks with detachable containers, and only Kathmandu uses hydraulic compactor trucks.

Transfer Stations

Waste transfer involves transferring the waste from a small, primary-collection vehicle, such as a handcart, rickshaw, or tractor trailer, to a larger truck for secondary transport. In most Nepalese municipalities, there is no need for waste transfer since the waste is collected in a tractor trailer or truck, which when full, is taken directly to the disposal site. In cases where there is a need for waste transfer, the most common method for transfer is the platform method, where the waste is dumped from a small vehicle onto the ground and is then moved manually into a larger vehicle for secondary transport. In most cities, this type of waste transfer takes place along a road or in a vacant plot.

Kathmandu is the only municipality with a permanent transfer station because it has different vehicles for primary collection/transportation and secondary transportation. However, even in Kathmandu, transfer is done by unloading waste from the primary collection vehicles onto a platform and then using a loader to place the waste in a secondary transport vehicle. The Teku Transfer Station in Kathmandu has facilities for split-level transfer where the primary collection vehicle is taken up a ramp and the waste is directly unloaded onto a secondary transport vehicle or container that is placed at a lower level. However, this facility is rarely used because of the incompatibility of vehicles and equipment.

Few municipalities have separate vehicles for secondary transport. Kathmandu uses 14 m^3 multicompactors and 20 m^3 roll-off tippers as secondary transport vehicles. The compactors are not very suitable because loading them is not easy. The roll-off tippers are better because they are less expensive and easier to operate. Waste compaction before secondary transportation is not very necessary because the waste density is already fairly high and compaction can be difficult and expensive. It is a sensible decision that Kathmandu is planning to purchase 16 additional 13-ton-capacity roll-off tippers for secondary transport.

Disposal

The haphazard disposal of waste in makeshift dumping sites is the most common practice for the final disposal of collected waste in Nepal. Most municipalities simply find sites that are close by and will not be objectionable to anyone. Usually these sites do not have any precautionary measures such as cover material, a leachate collection mechanism, drainage facilities, and fencing to prevent unauthorized personnel. Figure 6.6 shows the disposal practices followed by 58 municipalities in Nepal.

The area of the disposal sites varies from 0.025 hectare to 19 hectare. In a small municipality like Malangwa, a small low-lying area of about 9 m^2 is used as a dumping site. When this site is filled, the municipality finds another site. None of the municipalities is involved in closing or rehabilitating the old dumpsites.

None of the municipalities is currently operating a sanitary landfill site. Kathmandu and Lalitpur municipalities disposed of their waste at the Gokarna landfill from 1986 until the landfill closed in 2000. Now all the waste is dumped in large trenches along the Bagmati River. The Gokarna landfill did not have liners, but it had a leachate collection system and gas vents, although these were not functioning. The landfill was closed down due to opposition from the local people.

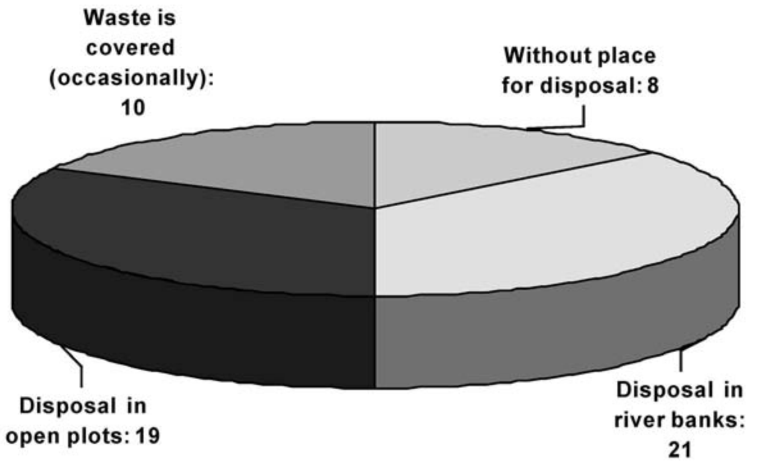

Figure 6.6: Solid-Waste Disposal Practices in Municipalities in Nepal
Source: SWMRMC, 2003.

The search for new landfill sites has been a long frustrating process for Kathmandu, because of the Not in My Backyard (NIMBY) syndrome. Most communities do not trust the government to do a good job managing a landfill site and they often oppose construction of a new one in their locality, even when the government promises a compensation package in return. Over the past decade more than 20 potential sites have been identified but none of them has been studied in detail.

Finally, a new sanitary landfill is being constructed at Sisdol, with assistance from JICA, for Kathmandu and Lalitpur municipalities. The landfill, which is designed according to the Fukuoka semi-aerobic principle, is equipped with a clay liner and a system for leachate recirculation. The landfill was expected to be complete in early 2005. The main problem with the landfill is that it is located 28 km north of Kathmandu. This will result in increasing the cost of secondary waste transport by almost nine times. In addition, the design life of the landfill is only 2 to 3 years. Therefore, Kathmandu will have to start the process of developing a new site immediately. This could be a difficult and expensive task.

A sanitary landfill was recently constructed in Pokhara with loan support from the ADB, but it is not being used because of a lack of required equipment. All waste from Pokhara is currently being dumped in the Seti River, which flows through the city. Pokhara's sanitary landfill is spread over an area of 10 hectare and has an estimated life span of 14 to 15 years. It is equipped with a 1 mm thick geo-membrane liner, 13 gas vents, and a reed-bed leachate treatment system. Pokhara Municipality plans to use the landfill soon.

Many municipalities have expressed their desire to construct landfills, and several have even identified potential sites. The lack of technical expertise and financial resources, however, is preventing them from developing the sites.

Special-Waste Management

In the case of Nepal, special-waste management includes managing biomedical waste, industrial waste (hazardous waste), construction debris, and dead animals. This waste is generated in smaller quantities than household waste, but it needs special consideration because it may be hazardous or difficult to handle. At present this type of waste is normally dumped with ordinary waste. Due to low industrialization and the limited use of hazardous chemicals, the amount of hazardous waste generated in the country is probably very low.

Obsolete pesticides and used pesticide containers can also be hazardous. An estimated 75 tons of hazardous obsolete pesticides are stored in unsafe conditions at various locations in the country. They need to be disposed of safely. Similarly, a survey conducted in 1995 indicated that 25% of the farmers threw old pesticides in open dumps while 10.8% still used them.[8] The survey also indicated that 46% of the farmers threw away used containers and 10% reused them, which is a dangerous practice.

Biomedical Waste

Tuladhar (1999) estimated that 6,521 hospital beds in Nepal generated approximately 500 tons/year of biomedical waste. The generation may have increased slightly by now. Although some hospitals have incineration facilities, most biomedical waste is mixed with ordinary waste and dumped. Hetauda is the only municipality with a separate biomedical waste-collection system. The collected biomedical waste is burned in a locally made incinerator. Kathmandu has installed a small, modern, double-chambered incinerator to manage medical waste, but it has not yet been used mainly because of problems in operating the incinerator and objections from the local community about the incinerator. KMC has also developed a set of guidelines for medical-waste management and provided some training.

GP Practices and Other Proactive Measures

Waste composition studies have shown that most of the waste generated in Nepal can be recycled using simple technologies, and much of this can be done within the country.

Recycling

Using waste as a resource and recycling it to add value is the preferable way of managing waste because it is cost effective and environmentally friendly. However, in spite of the importance of waste recycling, very few municipalities have taken initiatives to promote it. Some municipalities, such as Bhaktapur and Kathmandu, have started composting programs and a few municipalities, such as Hetauda, are involved in plastic-recycling activities.

The private sector, however, has seen the potential profits that can be made from treating waste as a resource and invested in waste recycling activities. Hundreds of scrap dealers who are scattered throughout urban Nepal, collect recyclable inorganic waste such as metals, plastics, paper, and glass and convert them into raw materials by processing them. This process includes sorting, cleaning, size reduction if necessary, and packaging. The materials are then sent to factories in Nepal and India for recycling. Almost 3,000 tons/month of recyclable materials are exported from Kathmandu Valley alone, contributing about NPR371 million annually to the national income.[9]

Households are also involved in recycling, particularly organic waste. In the old days and even today in rural communities, most waste is composted and used in agriculture. In Kathmandu Valley, houses used to have a *Saaga*, which literally means “compost pit” in the Newari language. Household waste, most of which was organic in nature, used to be deposited in the *Saaga*s. Once every six months or so, the *Saaga*s were emptied to harvest the compost. This

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[8] L. Dahal. *A Study of Pesticide Pollution in Nepal*. Kathmandu: IUCN, 1995.

[9] JICA. *Study on Solid-Waste Management for the Kathmandu Valley: Interim Report (1).* Kathmandu: Japan International Cooperation Agency and His Majesty’s Government of Nepal, 2004.

practice indicates that people understand the value of waste, and waste recycling was a standard practice that had been ingrained in the local culture. Today, however, many people in Kathmandu and other major cities have forgotten traditional recycling practices and simply dump their waste. Recently some municipalities, including Kathmandu, have started promoting household composting.

Organic-Waste Recycling

Organic waste, which is the main component of the waste stream, can be recycled by converting it into animal feed, compost, or energy. Different technologies can be used to produce each of these products. The existing and potential uses of these recycling technologies are described below.

Animal feed: Agricultural waste is often used to feed cattle, while household waste and food waste from hotels and restaurants can be fed to pigs. This usually requires little or no processing and can be an effective way of recycling some types of organic waste in rural communities and small municipalities. Nepal also has some factories that use animal bones from slaughterhouse waste to produce bone meal, which is mixed with chicken feed as a source of calcium. This is a simple technology to recycle bones and should be promoted.

Waste-to-Energy: In order to convert waste into energy, it can either be burned directly or processed to produce a solid or gaseous fuel. Burning solid waste directly is usually not an efficient process since most of the energy is lost. It also results in air pollution. Certain types of organic waste can be converted in to fuels such as briquettes, biogas, or producer gas.

Briquettes: Briquettes are produced by applying mechanical pressure and occasionally temperature to the organic material. The simplest and most common type of briquette is the dung patties or *guithaa* made mostly in rural households by compacting cow dung. Some Nepalese organizations are now promoting the use of beehive briquettes, which are made from agricultural or forestry waste. In this process the organic waste is first burned in a controlled environment to produce char, which is then mixed with clay in a 70:30 ratio and compacted in special equipment to produce briquettes with holes in between. The beehive briquettes can then be used for cooking and space heating. This technology is a bit more complicated than using dung patties but it utilizes low-grade organic waste and produces briquettes that are significantly more efficient and eco-friendly. Some factories use industrial waste such as sawdust and rice husks to produce briquettes. There are also technologies to use municipal waste to produce small pellets to be used as fuel in industrial applications. This technology, however, has not been used in Nepal and there have been few studies on the feasibility of this technology in the Nepalese context.

Biogas: Biogas is a product of the anaerobic digestion of organic waste. The gas, which is approximately 60% methane, 30–40% CO_2, and small amounts of other gases, can be used for cooking. If the methane can be separated, the gas can also be used to power vehicles or generate electricity. Currently Nepal has more than 130,000 household biogas plants with capacities ranging from 4 m^3 to 10 m^3. Most of these plants are located in rural areas and most of them use cow dung and toilet waste as their feedstock. Over 97% of these plants are operating and they are making significant environmental contributions by utilizing waste to produce gas for cooking and lighting, reducing deforestation and indoor air pollution, improving hygiene, and producing slurry, which can be used to make high-quality organic fertilizer.

Although the production of biogas from municipal organic waste is not very common because anaerobic digesters require a homogeneous type of waste, some experiments are being done. However, household biogas plants have been very successful in rural areas and need to

Box 6.1: Examples of Composting Plants in Nepal
• In Kathmandu, a 30-ton/day composting plant was set up in 1986 with support from GTZ. Although the composting plant operated for four years, it was closed in 1990 because of complaints from the neighborhood. The plant had a concrete platform for piling the waste in long windrows and the degraded material was screened in a mechanical plant. • GTZ also assisted in setting up a smaller composting plant at Bhaktapur which had windrows and manual screening. Bhaktapur municipality is still operating the plant, which has a capacity of processing about 6 tons/day, but it is currently processing only about 1 ton/day. • Thimi Municipality has set up two small compost chambers, but they are not functioning very well because of technical problems. • Small-scale composting is also being done in some other municipalities such as Kathmandu and Hetauda.

be promoted further. This technology can also be useful for some types of industrial waste and waste from commercial establishments.

Aerobic Composting: Composting is the most feasible technology for recycling organic waste in Nepal because the technology is simple, inexpensive, and robust, and the product is useful for agricultural applications. Different types of composting technologies can be used based on the amount of waste and space available. Simple aerobic composting can be done in piles, windrows, pits, or vessels. Many people, particularly in rural areas, are involved in composting their waste by placing it in piles or pits and letting it degrade. Even in urban areas, about 15% of the people compost their waste in the traditional methods.[10] This usually takes a long time because of the lack of aeration.

In recent years, some municipalities have started composting municipal solid waste, but this is being done only on a small scale and the total amount of waste being composted is still very small. The cities of Kathmandu and Hetauda are promoting household composting by distributing compost bins with capacities ranging from 60–100 liters. Four years ago KMC signed an agreement with a private company to set up a 300 tons/day composting plant, but it has not yet been implemented due to the lack of suitable land for the plant.

Vermi Composting: KMC started conducting experiments in vermi composting a few years ago by importing earthworms of the species *Eisenia foetida* from India. It is now selling vermi compost kits for NPR500. Experiments done in Kathmandu indicate that vermi compost has higher amounts of nutrients than ordinary compost. Some rural households are also starting to use this technology because of the production of high-quality fertilizers. This technology therefore has a great potential in Nepal. Although it is simple and effective, the main drawback is that it is not very effective for treating mixed waste.

Inorganic Waste Recycling

Paper Recycling

All types of paper, such as office paper, newsprint, old magazines, and cardboard boxes, can be recycled in Nepal. Most of the scrap paper is converted to pulp and paper in large paper

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[10] CBS, *Urban Population Survey 1996.*

mills such as the Bhrikuti Paper Factory. Some small handmade paper-recycling units are also in operation. These plants take small amounts of scrap paper and produce specialty paper.

Although Nepal has paper recycling facilities and there is a market for scrap paper, not all paper waste is recycled because there is no system for collecting paper waste separately. Waste paper that is generated in bulk quantities is usually bought by scrap dealers and then sold to paper factories, but paper waste produced in smaller quantities is often not picked up for recycling. Some waste buyers go door-to-door to buy scrap paper, primarily old newspapers, from households and institutions, but municipalities do not provide such services.

Metal Recycling

Most metal waste, such as scrap iron and aluminum, is collected and recycled since the price of metal scrap is usually quite high. As a result very little metal waste ends up in the solid waste stream.

Plastic Recycling

Nepal has factories for recycling some common types of plastics such as polyethylene (PE) and polyvinyl chloride (PVC). Some other types of plastics, such as PET bottles, can be sent to India for recycling. However, much of the plastic waste is still not being recycled because of the lack of a proper system for collecting plastic waste separately and the relatively low value of plastic waste, particularly if it is not clean.

With increasing amounts of plastics in the waste stream, it is important for municipalities and the public to support the efforts of the private sector in recycling plastics. Plastic bags made from high-density polyethylene (HDPE) and low-density polyethylene (LDPE) are the most common types of plastic waste and their consumption will increase in the future. These bags do not degrade and they cause problems such as litter and clogging drains if they are not managed properly. This is a common problem in many cities. On the other hand, several plants within Nepal that can recycle HDPE and LDPE to make plastic sheets and pipes are suffering from the lack of adequate quantities of scrap plastic.

Glass Recycling

Beer and soft-drink bottles are generally collected and reused, but recycling other glass waste is low because of the low price of glass waste in the scrap market. Although Nepal had a glass recycling plant at Simara, it is now closed and all glass waste has to be sent to India for recycling. Since this is expensive, much of the glass waste is not recycled. Although the amount of glass in the waste is relatively small, it can cause problems in producing compost if it is not separated properly. One of the main problems at the Bhaktapur composting plant is that small glass pieces occasionally end up in the compost. Therefore, more efforts are required to develop collection systems that can ensure uncontaminated separation of plastic at source and transport to recycling facilities. The municipality of Hetauda has encouraged households to store plastic waste separately. The municipality then collects the plastic separately and pays people NPR4/kg of plastic. Other municipalities also need to initiate such innovative measures.

CASE STUDY: KATHMANDU CITY

Prior to the rapid urbanization and modernization that started after the 1950s, waste management was probably not a major problem in Kathmandu because the amount of waste produced was not very significant and the society had developed its own system of managing waste, which was an integral part of the culture and life style in the Valley (Tuladhar, 1996).

At that time, almost all the residents in the Valley were farmers and the waste they generated consisted of agricultural waste, kitchen waste, sewage, and waste from religious activities and festivals. Because of the absence of sophisticated materials and excess packaging, the volume of waste was probably minimal. People used to dump their waste, which was all organic in nature, in pits called *Saaga* near their houses to produce compost, which they applied in the fields as a soil conditioner.

In 1917, the then Prime Minister Chandra Sumsher created the "*Safai Adda*," which means "Cleaning Department." This later became the Kathmandu Municipality. The *Safai Adda* was responsible for cleaning the streets and later, for managing public toilets.

City Profile

Since 1992, the role of the Kathmandu Municipality in solid-waste management has increased continuously. In 1998, Kathmandu Metropolitan City (KMC) took over all SWM responsibilities from the SWMRMC and developed a new SWM strategy that focused on making SWM more effective by involving the local communities and the private sector.

The Environment Department (ED) of the Kathmandu Metropolitan City is the main agency responsible for managing Kathmandu's waste. The ED is one of 13 departments within the organizational structure of KMC. It is one of the most important departments in the municipality because it is responsible for addressing a priority issue and has more than half of KMC's total staff and the biggest budget among all the departments. The department has a Mechanical Section which is responsible for the maintenance of all vehicles and a Solid-Waste Management Section (SWMS), which is responsible for waste management.

The ED has a total staff of 1,262 involved in waste management. Out of these 1,050 are sweepers (822 in the wards and 228 in the central office). Each ward has a head sweeper and a supervisor who monitor the sweeping and collection activities. The ward-level staff report to four zonal supervisors who in turn report to the Chief of the Operations Unit. The Chief of the Operations Unit also supervises the 100 drivers who operate the collection vehicles. The Operations Unit is the largest among the seven units in the Solid-Waste Management Section. The organizational structure of the Environmental Department is presented in Figure 6.7 and the number of staff in each category is presented in Table 6.4.

Solid Waste Generation

Municipal Solid Waste

Several attempts have been made to estimate the per capita waste-generation rate in Kathmandu. Lohani and Thanh (1978) estimated the waste-generation rate to be 0.25 kg/person/day. In 1989, the waste-generation rate in Kathmandu was estimated to be 0.4 kg/person/day.[11] Another study done in 1993 estimated the rate to be 0.46 kg/person/day.[12]

In 2001 KMC, with support from the KVMP, collected waste from about 1,000 households

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[11] D. Mutz. "Technical Choice and the Economies of Compost Production," in B. B. Adhikary and E. Spreen (eds.), *Solid-Waste Management and Resource Mobilization*, pp. 10–29. Kathmandu: SWMRMC, 1990.

[12] R. K. Khanal. *Solid-Waste Management in Khatmandu, Nepal*. MSc Thesis, Asian Institute of Technology, Bangkok, 1993.

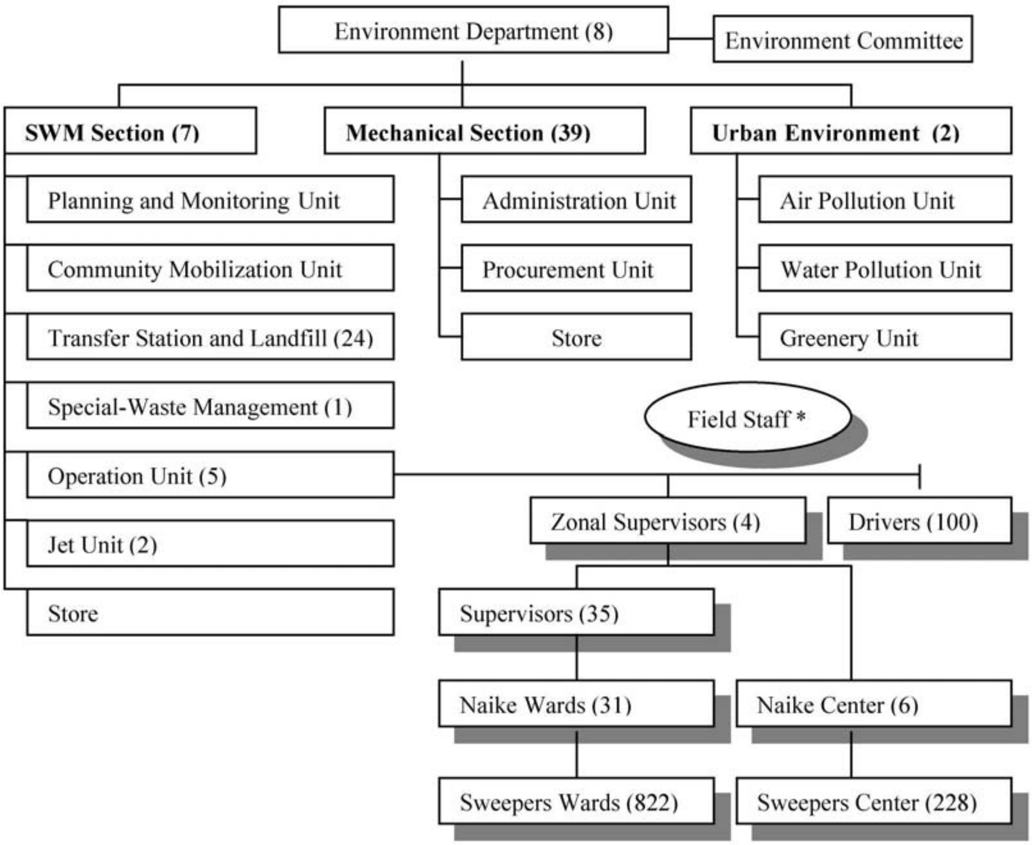

Figure 6.7: Organization Structure of the Environment Department
Note: The numbers in parentheses are the number of staff members.

Table 6.4: KMC Environment Department Staff

Staff Category	Number
Sweeper	1,050
Driver	100
Mechanics	50
Administrative	50
Community Motivator	4
Engineer/Officer	8
Total	1,262

at 10 different locations and found the average household waste-generation rate to be about 0.23 kg/person/day. The average per-capita waste-generation rate for low-income, middle-income, and high-income areas were 0.19, 0.23, and 0.30 kg/person/day, respectively. These figures are only for household waste and do not include waste from commercial establishments, market centers, and industries. KMC estimates that industrial/commercial waste and street waste are approximately 20% of the total household waste. In addition, KMC estimates that waste from surrounding VDCs, equivalent to approximately another 10% of the household waste, enters KMC's waste stream. Based on these assumptions, the total waste generation in Kathmandu is estimated to be about 243 tons/day or about 1000 m^3 per day.

JICA (2004) surveyed waste from various sources and found that the waste-generation rate varied from 0.159 kg/person/day in low-income neighborhoods to 0.318 kg/person/day in high-income areas. The study also found that the amount of waste generated by restaurants ranged from 2.5 to 7.4 kg/day and that the waste from selected offices ranged from 0.3 to 5.1 kg/day. The study also found that the amount of street waste was about 22.3 kg/100 m of road length. It is important to know that the amount of waste generated by commercial establishments and offices varies significantly depending upon the nature and size of the institution. Similarly, the amount of street waste also varies significantly depending on the nature of the street and the effectiveness of the waste-management service provided in the area.

Biomedical Waste

Medical waste from hospitals and nursing homes is a major source of concern because of its hazardous nature. According to a survey done by ENPHO for KMC, Kathmandu's hospitals generate on average 1.72 kg of waste/patient/day. Out of this, 26% or 0.45 kg/patient/day is considered to be hazardous. Currently only a few hospitals have incineration plants. While a few nursing homes burn their waste in crude incinerators, most of the other hospitals and nursing homes dump their waste in municipal waste containers.

Other Solid Waste

The city of Kathmandu also generates large quantities of solid waste other than those mentioned above, such as agricultural waste, commercial waste, industrial waste, and dead animals. Although much of the industrial and commercial waste is recycled by the private sector because it is generated in bulk and usually contains few contaminants, a significant portion is placed in municipal containers or dumped in public places.

Agricultural/Garden Waste

Agricultural and garden waste are generally recycled by the farmers themselves and is, therefore, not a major concern. Furthermore, farmland in the city is decreasing rapidly. The amount of garden waste is, however, slowly increasing. A survey of 331 households in Kathmandu showed that garden waste comprised 27% of the total waste generated by households.[13] Among these, 48% disposed of the garden waste along with normal municipal waste, 43% burned the waste in the open, and only 37% practiced composting. (The numbers don't add up to 100 because some respondents provided more than one answer.)

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[13] JICA. *Study on Solid-Waste Management for the Kathmandu Valley: Interim Report (1).* Kathmandu: Japan International Cooperation Agency and His Majesty's Government of Nepal, 2004.

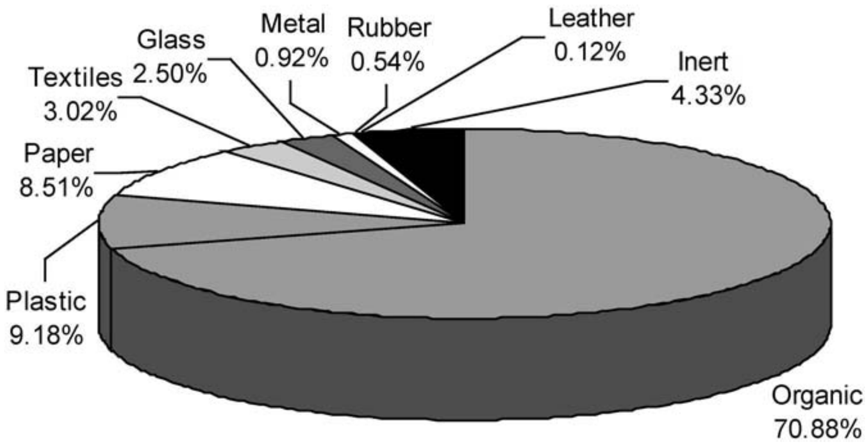

Figure 6.8: Composition of Kathmandu's Waste

Commercial/Industrial Waste

The main sources of commercial/industrial waste in Kathmandu are restaurants, vegetable and fruit markets, slaughterhouses, the carpet industry, and the garment industry. Restaurant waste, which mainly consists of food waste, is usually dumped with municipal waste or taken by pig farmers. Among waste from slaughterhouses, the bones and skin are recycled but the intestinal waste from slaughtered animals usually ends up in the municipal containers or on the riverbanks. Fruit and vegetable market waste is usually disposed of with regular municipal waste. Some of the waste from the carpet and garment industries is recycled and some is dumped in containers or on riverbanks.

Solid Waste Characteristics and Quantification

Composition

Although the nature of waste varies according to standard of living and time of year, municipal waste in Kathmandu can generally be characterized as having high organic content, high density, and fairly high moisture content. The first waste-characterization study done in Kathmandu found that organic waste made up 70.5% of the total waste.[14] Several studies have been done since then and they all found that the organic content in the waste ranged from 60% to 70%. Recent studies also indicate that about 70% of the waste is organic in nature. This shows that even with rapid urbanization and changing lifestyles, the amount of organic material in the waste has remained more or less constant. The studies, however, indicate that the amount of plastic in the waste has increased significantly in a span of 25 years from 3.6% in 1976 to more than 9% in 2001.

The composition of Kathmandu's household waste, according to a study done by KMC in 2001 is presented in Figure 6.8. In this study, 10 different locations representing various house-

[14] I. O. Tabasaran. Expert Opinions on the Reorganization of Solid Waste Disposal in the Kathmandu Valley, especially in the Cities of Kathmandu, Patan, and Bhaktapur. Stutgart: 1976.

Table 6.5: Composition of Kathmandu's Solid Waste

	Percentage of Waste (by weight) in the Last 30 Years					
Component	1976[a]	1981[b]	1985[c]	1988[d]	1995[e]	2001[f]
Organic material	70.5	61.6	67.5	58.6	59.1	70.9
Paper	6.5	19.3	6.0	6.2	6.0	8.5
Textiles	6.5	5.3	2.7	2.0	8.1	3.0
Metal	4.9	3.4	2.2	0.4	4.8	0.9
Glass	1.3	3.4	4.0	1.6	3.6	2.5
Plastic	0.3	3.6	2.6	2.0	5.4	9.2
Rubber/leather	0.0	0.0	0.0	0.4	2.3	0.7
Batteries	0.0	0.0	0.0	0.1	3.6	0.0
Inert Material	10.0	3.4	15.0	28.9	13.2	4.3

Notes:

[a] The mean value of two samplings taken at Thamel on 30 July 1976 and at Bhonsiko Street on 3 August 1976 (Tabasaran, 1976).

[b] I. O. Tabasaran, and W. Bidlingmaier, *Report on the Possibility of Composting Municipal Waste in Kathmandu Valley* (Mutz, 1990).

[c] *Survey on Waste Generation in Households and Smaller Shops in Kathmandu and Patan* (Mutz, 1990).

[d] Survey of waste from six different sites in Kathmandu conducted in May 1988 by the Compost Section of SWMRMC (Mutz, 1990).

[e] Survey conducted by Nepal Environmental and Scientific Services Pvt., Ltd. (NESS, 1995).

[f] Survey conducted by Kathmandu Valley Mapping Programme of KMC in 10 locations in Kathmandu.

hold incomes were selected and approximately 1 m^3 of waste was collected from each location. In total, waste from almost 1,000 households was studied. Table 6.5 also shows the changes in the composition of waste from Kathmandu over last 30 years.

Lohani and Thanh (1978) estimated the density of Kathmandu's waste to be 600 kg/m^3. A survey conducted by the SWMRMC in May 1988 found that the density varied between 330 and 430 kg/m^3. The average density for waste from six locations was found to be 390 kg/m^3. According to the KVMP (2001), the density of waste at the source was 231 kg/m^3 but the on-truck density was closer to 400 kg/m^3. The SWMRMC survey also calculated the moisture content of the waste from the six locations to vary between 39% and 58.7%. The average moisture content was 45.8%.[15]

Key Elements of Solid-Waste Management

Collection and Storage

KMC's ward offices, SWMS, some private companies, and some NGOs are involved in waste collection. Each ward office, except in wards 1, 4, and 13, are assigned a tractor or a

[15] D. Mutz. "Technical Choice and the Economies of Compost Production," in B. B. Adhikary and E. Spreen (eds.), *Solid-Waste Management and Resource Mobilization*, pp. 10–29. Kathmandu: SWMRMC, 1990.

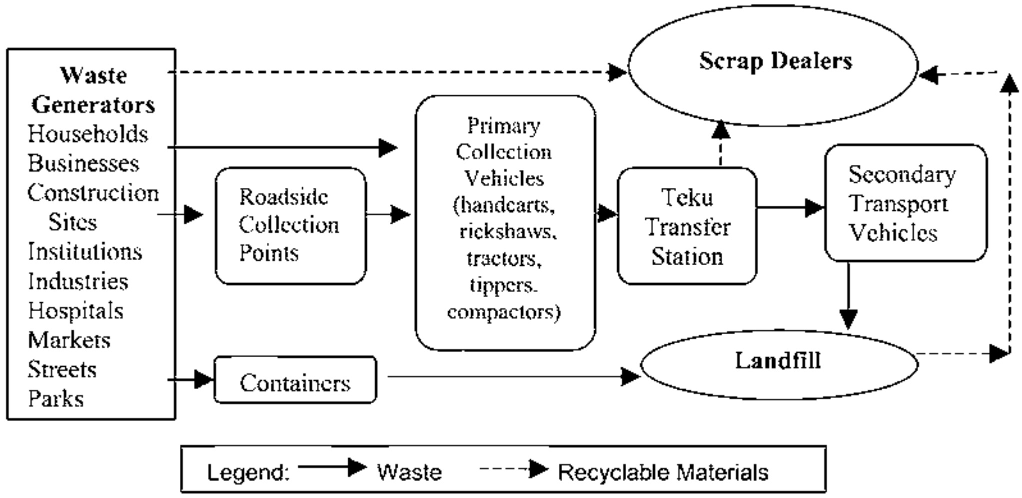

Figure 6.9: Waste Flow in Kathmandu

tipper, 20 to 30 sweepers, and a supervisor to sweep the streets and collect waste on a daily basis. Street sweeping and waste collection are done in two shifts, 6 a.m. to 11 a.m. and 1 p.m. to 4 or 5 p.m. Street sweeping and waste collection are done by private companies in wards 1, 4, and 13. In addition, sweepers from the SWMS are involved in sweeping some of the major streets.

Residents normally deposit their waste at a designated location on the roadside, directly into a waste collection vehicle, or into a community container. The waste at the roadside is cleaned by sweepers and loaded into tractors or tippers and taken either to the Teku Transfer Station or directly to the landfill site. The community containers are picked up by the SWMS and taken to the landfill site. If the waste is collected by a small vehicle such as rickshaw or handcart, it is usually transferred to a bigger vehicle before being taken to the transfer station or landfill. This transfer operation takes place on the roadside or in vacant plots.

Recyclable materials in the waste such as metals, plastic, and paper are either sold to waste buyers by the waste generators or picked up by rag pickers from the roadside piles, Teku Transfer Station, or the landfill site. These materials are taken to a scrap dealer, who sells them to factories that use recycled materials.

The area surrounding the community containers is often very dirty because people tend to dump waste not just inside the container but outside as well, and the containers often overflow when the municipality is unable to pick up the filled container on time. As a result, most people do not want to have a community container in front of their houses. Because of this problem, Kathmandu now has few public containers. The flow of waste and recyclable materials in Kathmandu is shown in Figure 6.9.

According to a survey of 331 households in Kathmandu, 65% of the respondents said they gave their waste to a door-to-door collection service. This shows that door-to-door waste collection has become quite popular in Kathmandu (see Figure 6.10). The survey also indicated

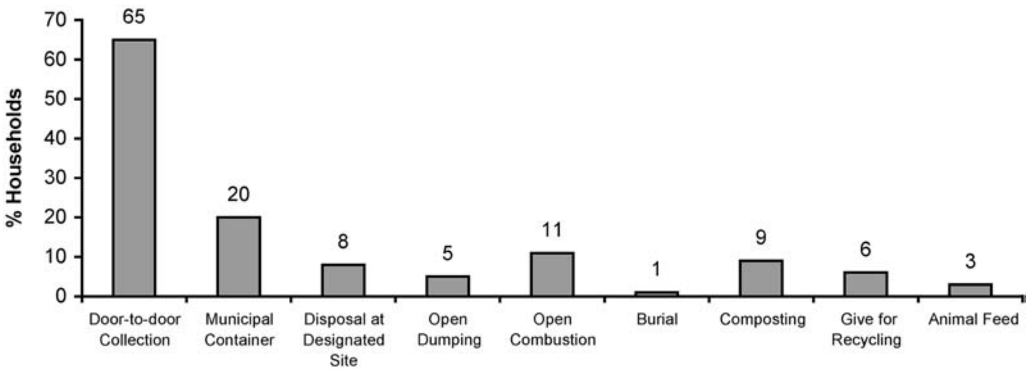

Figure 6.10: Waste-Management Practices of Households in Kathmandu

that 89% of the people have some kind of waste-collection service and are using the service on a regular basis.[16]

Some people, however, still dispose of their waste in vacant lots or other public areas such as river banks. These waste dumpsites are usually in areas that are hidden or difficult to access and as a result, the waste usually does not get picked up. Occasionally the KMC and local people organize campaigns to clean up these isolated waste dumps.

Transport

A wide variety of equipment and vehicles are used for waste transfer and transportation in Kathmandu. These range from simple handcarts to hydraulic compactors. Table 6.6 describes the infrastructure available in KMC for solid-waste management.

Handcarts and rickshaws are the simplest type of vehicles. They are used to transport relatively small quantities of waste (0.06 m^3 to 0.4 m^3) for short distances (100 m to about 2 km) from the source to a larger vehicle or a temporary transfer point. Although KMC does not use rickshaws directly, many of the private companies or NGOs involved in waste collection do. The advantages of these vehicles are that they are inexpensive and useful in narrow lanes. The main disadvantage is their limited capacity and range. Sometimes rickshaws are used to transport waste over long distances which is inefficient. The working range for a rickshaw should be limited to about 2 km.

Most ward offices use tractors for waste collection and transportation. These vehicles are old but useful because they can go into narrow lanes and the trailers can be detached and used as containers, although this is rarely done. The main disadvantages of the tractor are that the capacity is fairly low (about 1.7 m^3), it is slow (about 10 km/hour), and it causes pollution. Because the tractors are very old, it is time to replace them with tippers or smaller vehicles.

Tippers are often used when the amount of waste that needs to be collected is fairly high and the travel distances are long. The tippers have a higher capacity (3.5 m^3 to 4.5 m^3) and travel faster (about 18 km/hour in city traffic). Its tipping device is also an advantage. Its main disadvantage is the relatively high loading height.

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[16] JICA. *The Study on Solid-Waste Management for the Kathmandu Valley: Interim Report (1).* Kathmandu: Japan International Cooperation Agency and His Majesty's Government of Nepal, 2004.

Table 6.6: Vehicles and Equipment for SWM in KMC

Vehicle/Equipment	Payload (m^3)	Total Units	Model/Year	Remarks
Vehicles Used for Waste Collection				
Tractor with trailer–Chinese	1.7	37	1988	Only 30 are operating
Mini-compactor–Daihatsu	4.0	1	1989	Obtained from Japan in 2002
Mini-compactor–Isuzu	6.0	1	1989	Obtained from Japan in 2002
Mini-compactor–Tata	6	1	1996	Compacting equipment is not working
Hydraulic tipper–Mitsubishi Canter	3.5	12	1993	Donated by the government of India
Hydraulic tipper–Eicher	3.5	2	1993	
Hydraulic tipper–Swaraj Mazda	4.5	10	2002	
Dumper placer	4.5	3	1988	Two operating
Dumper placer–DCM Toyota	4.0	8	1994	Donated by the government of India
Dumper placer–Ashok Leyland	6.0	4	1994	Donated by the government of India
Vehicles and Equipment Used for Waste Transfer and Secondary Transport				
Multi-compactor–Ashok Leyland	14.00	7	1994	Donated by the government of India
Roll-off tipper with container–Miller (German)	20.00	2	1988	One operating
Backhoe loader–JCB	0.75	2	1994	Donated by the government of India
Shovel loader–German	0.75	1	1980s	Very old
Shovel loader–Belarus		2	2003	
Excavator	0.25	1	1986	
Bobcat–Belarus		1	2003	
Equipment Used for Landfilling				
Chain dozer		2	1981–1997	One Working
Sheep-footed compactor		1	1988	
Excavator–Korean		1	2003	

Dumper placers with containers are useful for collecting bulk waste from one location, such as construction sites and large institutions. In the past many areas in Kathmandu had community containers, but now most of these have been removed due to complaints from the local people. Hydraulic compactors look good but they are expensive to buy and maintain. As the density of waste is already about 400 kg/m^3 in an ordinary truck, the need for compacting is minimal. For long-distance haulage, KMC uses multi-compactors and roll-off tippers. The roll-off tipper with 20 m^3 container is very old but it is still useful because it has a large capacity and the containers can be detached and used separately. KMC is planning to purchase 16 more roll-off tippers for transporting waste from Teku to the new landfill site.

Transfer Station

The Teku Transfer Station (TTS) is the only transfer station in Kathmandu and is located in Ward 12 in the southern part of the city. The TTS is spread over a 2-hectare plot, but less than half of it is used for transfer operations. At present the transfer is done by unloading waste from collection vehicles onto a concrete platform and then using a loader to reload the waste onto secondary transport vehicles. Occasionally, when the landfill is closed the TTS is used as a temporary storage for the waste. The TTS receives about 100 tons of waste per day from various parts of the city.

Currently KMC is in the process of improving the TTS to include ramps that will allow split-level transfer where the waste is directly loaded onto a secondary vehicle or container. This will make the transfer operation quicker and more efficient. However, this will prevent rag pickers from going through the waste to pick out recyclable materials.

Treatment

Organic-waste recycling is a major concern. Very few private entrepreneurs are willing to touch this waste as it is difficult to handle and the market value for the finished product (compost) is very low. In addition, because organic waste is the largest component of the waste stream, KMC has to take initiatives to promote composting.

KMC is actively promoting household and community composting. It has also started the process to set up a central composting plant with a capacity of 300 tons/day. However, although a private party was willing to invest NPR100 million (USD1.35 million) in the project, it could not proceed because of administrative and political problems.

In the case of inorganic materials, there are more than 250 scrap dealers operating in Kathmandu. These initiatives from the private sector should be promoted by making it easier for scrap dealers to obtain good quality recyclable waste.

Household Composting

In order to promote household composting, KMC is conducting public awareness campaigns, providing training, and selling compost bins and vermi-compost kits. The compost bin, which is designed and produced by KMC with the brand name *Saaga*, is sold at a subsidized price of NPR750 (USD10) along with necessary accessories that include a set of tools, a screen, and a bottle of effective microorganisms (EM). The actual cost for the complete set is NPR1,032. The 100-liter bin is made of plastic and is divided into two chambers separated by a steel grill. Organic waste is placed in the upper chamber and compost is removed from the lower chamber. The bin has small holes for aeration and an opening at the bottom to remove the compost. The compost bin was designed to be durable, light weight, attractive, effective, and inexpensive. The bin can convert waste into compost within one or two months. So far KMC has sold about 800 compost bins.

A survey of 76 compost-bin users indicated that more than 80% are using the bins regularly and are satisfied with the performance of the bins. Furthermore, 79% of the bins were in good condition. However, there are some problems as well. Although 40% of the respondents said they did not have any problems, 36% said that they have had problems, and 24% said that they have had occasional problems. The most common problems seem to be a bad smell and flies. In addition, leachates come out of the compost bin and there is less output from compost bins than anticipated.

The results of the survey clearly demonstrate that the compost-bin program has been successful and needs to continue. However, there is room for improvement. Proper training for users and regular after-sale service is necessary to ensure that all customers are fully satisfied with the service. The survey also showed that 39% of the users first heard about the bin from friends. This indicates that word-of-mouth publicity is very important in further promoting the compost bins. Therefore, before-sale service is also a very important aspect of marketing the compost bins.

In order to promote vermi composting, KMC provides a kit consisting of a plastic tub; a set of 300 worms of the species *Eisenia foetida*, bed material for the worms, and half-day training for NPR500 (USD6.75). So far, about 100 people have bought the vermi kits and started vermi composting. KMC also buys worms and vermi compost from people who are using this technology to process their waste and then sells vermi compost for NPR25/kg and worms for NPR1 each.

A survey of 32 vermi-compost kit users found that all but one was satisfied with the kit and all the kits were in good or excellent condition. However, 78% of the respondents said that they faced occasional problems. The most common problems were flies and leachate, while some people experienced problems with rats and ants.

The promotion of household composting through the use of compost bins and vermi-compost kits is a very good initiation and the survey results indicate that it is working well. The challenge is now is to expand the number of people using these systems. A recent survey of 276 households in Kathmandu who are not composting their waste indicated that 47% were willing to make compost.[17] The survey also indicated that 46% of the people in Kathmandu have knowledge of composting but do not practice it, while 37% did not have knowledge about composting and did not practice it. This indicates that programs that provide knowledge on composting, as well as motivate people to compost, are necessary to further promote household composting.

Community Composting

KMC has made several attempts to promote community composting, but as of now only one community-composting plant is operating. KMC had started programs to compost waste from the Kalimati vegetable market, the Kuleshwor Fruit Market, and the Hyumat and Kankeshwori slaughterhouse areas, but these programs were not continued because of a lack of interest from the local communities. All these initiatives involved the use of windrows for composting.

At present one community-composting plant uses an old 3,000-liter tank with aeration holes and grills at the bottom. The plant was set up in 2003 and is being operated by a local NGO, which also has a waste-collection service. An old waste dumpsite under a bridge was used to set up the small plant.

The experience from community composting in Kathmandu suggests that it is difficult to sustain these projects unless there is a genuine interest from the community or an NGO that is managing the waste. Support is needed in the initial stages to set up the plant and to keep it going.

Central Composting Plant

In 1986, a 30 ton/day composting plant was set up at Teku with support from the German-funded Solid-Waste Management Project. The plant operated quite well for four years, although it never utilized its full capacity. The waste was piled in windrows and turned regularly

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[17] JICA. *The Study on Solid-Waste Management for the Kathmandu Valley: Interim Report (1).* Kathmandu: Japan International Cooperation Agency and His Majesty's Government of Nepal, 2004.

with a loader. After about a month, the waste would be screened using a mechanical screening plant and then the compost was allowed to mature for two months. The final product was sold for about NPR250/m^3. In 1990, however, the plant shut down after some local people complained about the odor.

In 2000, KMC signed a memorandum of understanding with a local firm to set up a 300-ton/day plant with technical collaboration from M/S. Excel Industries in India. KMC was supposed to find suitable land (5 to 10 hectare) to set up the plant, but it was unable to do so because land was not available within the municipal boundary and the government was unable to provide the land. Some time later, the Ministry of Local Development called for proposals from private parties to set up a central composting plant and after a long delay signed an agreement with a firm to establish a plant using rotary kiln technology. However, the private party did not initiate the project for unknown reasons.

As household and community composting will only be able to handle a relatively small portion of the waste, a large-scale facility is needed to significantly reduce the amount of waste that needs to be landfilled. Experience from Indian cities demonstrates that a large-scale composting plant is technically and economically feasible. However, this requires serious commitment from the government and a reliable private partner. As municipalities cannot operate a large-scale composting facility, they should support the private sector in setting up the plant and pay a small tipping fee to attract private investment. Because the development and operation of a landfill is very expensive and difficult, KMC should make an extra effort to set up a central composting facility.

Disposal

The lack of a suitable landfill has been a major problem in Kathmandu for a long time. Gokarna landfill, located about 5 km northeast of Kathmandu, was established in 1986 with support from the German project. Problems started appearing at Gokarna in 1993, when the local people complained about the poor state of the landfill and closed it down. It was later reopened, following negotiations and some compensation. In the years that followed, the process of the locals shutting down the landfill and the government entering into frantic negotiations with the public was repeated several times until the landfill finally closed down in 2000.

Since 2000, KMC has been landfilling all the waste it collects (about 250 tons/day) along with the waste from the neighboring Lalitpur Municipality on the banks of the Bagmati River, which flows through the city. Trenches that are 2–3 m deep and 5–10 m wide are dug on the banks and then filled with waste and covered. After final cover, the site is used as a public road. KMC is spending about NPR2 million per month to operate this site. KMC realizes that this is not a good practice but says that it has no other options for now.

The main problems associated with the current practice are as follows.

- The waste is polluting the river.
- Nearby houses are being affected by odors and scattered waste.
- There is no provision for gas management at the landfill.
- Access to the site is not restricted.
- Since KMC does not have a separate system for managing hazardous waste such as biomedical waste, it is mixed with ordinary waste and landfilled.
- Since the site is a flood plain, there is a danger of the waste being washed out.
- The river width has been narrowed thus altering the river hydrology.
- A valuable material that could have been converted into compost is being wasted.

The process of finding a new landfill started in 1989 with the feasibility study of a site in Lubhu. Since then, about 20 potential sites have been identified by various committees and researchers, but none has been seriously studied. The government is finally constructing a landfill at Sisdol, which is located 28 km north of the Teku Transfer Station. However, there are several problems associated with this site as well. These include the following.

- The distance of 28 km is very long. This will significantly increase travel time and costs. JICA[18] estimates that the transportation cost for KMC will increase by 8.5 times once the site is operational and about 40% of the total waste-management cost will be spent just on travel. KMC will also require at least 16 new large-capacity trucks to carry the waste to the new site.
- The road connecting the site is a narrow hill road, which could cause traffic jams.
- Hill roads in Nepal are very vulnerable to landslides. If there is any damage on the road, the SWM activities in Kathmandu will be disrupted.
- Since the road passes through several villages, the potential for social problems is high.
- Since the site is located next to the Kolphu River, the potential for water pollution is high.
- The capacity of the site is only two to three years. This means that the process of finding a new site has to begin immediately.

In spite of these problems, the site is being developed. JICA is currently assisting the government in identifying a new site. A few sites such as Taikabu (east of Bhaktapur) and Phasidol (south of Lalitpur) have been identified, but they need to be studied in more detail.

Special-Waste Management

KMC does not currently have any systems for managing special waste. KMC has installed an incinerator to manage biomedical waste and also prepared guidelines for this purpose, but the separate collection and treatment of biomedical waste has not yet started. As a result, most biomedical waste generated in the city, estimated to be approximately 1 ton/day, is mixed with regular waste and sent to the landfill.

Similarly, KMC does not have any system to collect industrial waste and construction/ demolition debris. Some industries are supplied with containers for waste collection, but the contents of the container are mixed with municipal waste. KMC could use its 4.5 m^3 dumper-placer to collect construction waste separately and use it as a filler material, but has not yet started to do so.

Cost Economics of the SWM Services of KMC

Currently KMC is spending approximately NPR149 million (approximately USD2 million) annually on SWM. This is equivalent to approximately NPR200 (USD2.7) per citizen/year or about NPR1,000 per family/year. The amount spent by KMC on SWM per person is quite high compared to most other municipalities in Nepal (see Table 6.3). Besides KMC, many other private and community organizations are involved in waste collection. The expenditure of these organizations is not known.

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[18] JICA. *The Study on Solid-Waste Management for the Kathmandu Valley: Interim Report (1).* Kathmandu: Japan International Cooperation Agency and His Majesty's Government of Nepal, 2004.

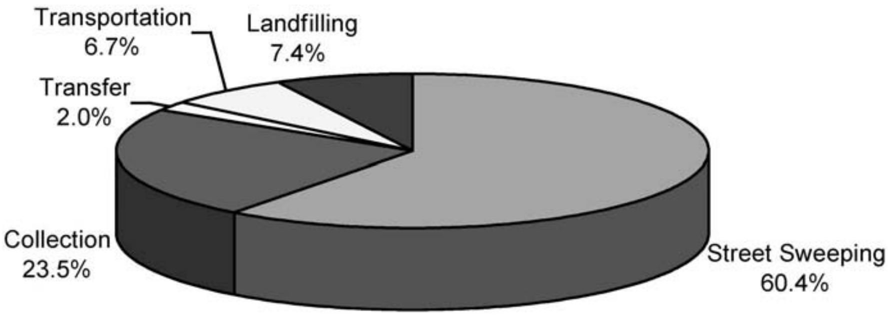

Figure 6.11: KMC's Expenditure on SWM
Source: KMC Environmental Department, 2004.

KMC spends about 35% of its total expenditure on SWM. This indicates that SWM is a very important task for the municipality. Effectiveness in SWM can result in significant financial benefits. KMC estimates that street sweeping and waste collection account for almost 84% of the total cost of SWM, while transfer and transportation account for approximately 8.7% and landfilling about 7.4% (see Figure 6.11). The relatively low cost of transportation and landfilling compared to the total SWM cost is because the waste is currently being landfilled along the Bagmati River, which is only about 3 km from the city, and the landfilling process is relatively crude and inexpensive. The high cost of street sweeping and collection compared to the total cost also reflects the need to make the collection process more efficient and cost effective.

After the completion of the Sisdol landfill site, KMC will have to transport its waste 28 km to the landfill site and also manage the site. This will significantly increase KMC's transportation and landfilling costs. JICA is assisting KMC in procuring 16 secondary transport vehicles with a capacity of 13 tons each for taking the waste to the landfill site, but KMC will need to cover the operation and maintenance cost, which is estimated to be about NPR60 million per year.[19] KMC is also planning to procure some equipment for the new landfill. This will probably increase the cost of landfilling as well. This means that KMC's total cost for SWM will probably increase by approximately 40% next year unless it reduces waste-collection costs. KMC's estimates indicate that about 74% of the SWM cost is spent on personnel, while about 15% is spent on fuel and maintenance, and 10% on materials. Table 6.7 and Figure 6.12 show the itemized expenditure.

The cost of fuel and maintenance will probably increase significantly next year when KMC starts transporting the waste to the Sisdol landfill site. The main reason for the high personnel cost is the large number of sweepers. At this point, it may not be possible to reduce personnel costs significantly because most of the sweepers are permanent staff who cannot be removed easily. KMC has already stopped hiring new staff and if it uses some of the existing staff to provide other municipal services, the personnel cost can be expected to come down.

With operation costs expected to rise significantly next year and the difficulties in removing existing staff, KMC has to initiate innovative measures quickly to make its SWM system more efficient and to reduce costs. Some of the major areas for cost reduction are mentioned below.

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[19] JICA. *The Study on Solid-Waste Management for the Kathmandu Valley: Interim Report (1).* Kathmandu: Japan International Cooperation Agency and His Majesty's Government of Nepal, 2004.

Table 6.7: Itemized Breakdown of Expenditure (in percentages)

Item	Street Sweeping		Collection	Transfer	Transport	Landfill	Total
	Ward	Central					
Personnel	55	5	11	1	1	1	74
Maintenance	—	—	4	—	1	2	7
Fuel			3	1	2	2	8
Materials	6	4	—	—	—	—	10
Administration	1	—	—	—	—	—	1
Total	62	9	18	2	4	5	100

Note: The estimates exclude hidden costs such as depreciation and interest.
Source: KMC Environmental Department, 2004.

- As secondary transportation is expected to be a major cost center after operation starts at the Sisdol landfill, serious efforts need to be made to reduce the amount of waste that needs to be landfilled. This means increasing recycling rates.
- Street sweeping and waste collection are the most expensive activities. They need to be made more efficient and cost effective.

So far, KMC has initiated very few measures to raise revenue from special services. These include container service for the generators of bulk waste, a septic tank cleaning service, and a jet cleaning services. The total amount of revenue raised is, however, negligible compared to total SWM expenses. KMC does not charge a service fee to households but it allows private collectors to collect such fees. In the future, KMC should try to increase its revenue collection by expanding its container service.

KMC is allocating 35% of its total spending on SWM and with the cost of SWM expected to increase significantly next year due to the operation of the Sisdol landfill, it will be difficult to depend only on KMC for financing waste-management related activities. Although reducing the cost of waste management will be very important, KMC will also have to increase the revenue it receives from providing waste-management services.

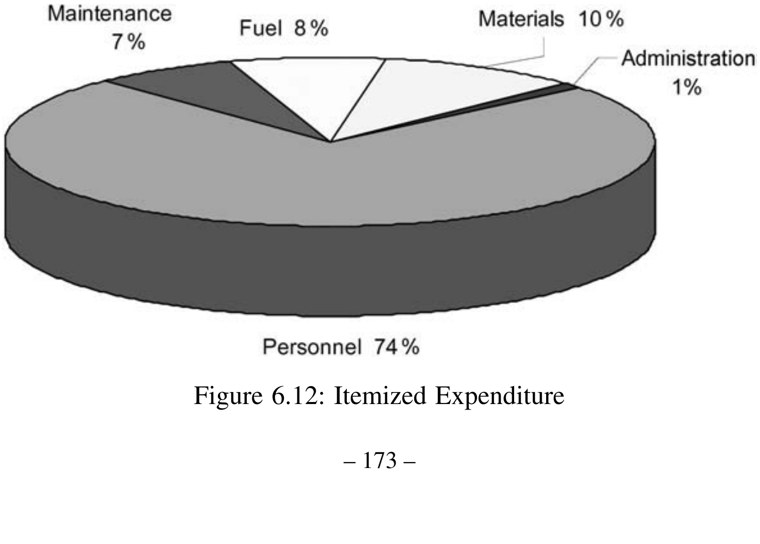

Figure 6.12: Itemized Expenditure

GP and Other Waste-Minimization Approaches

Although most of Kathmandu's waste can be recycled and KMC's policy is to maximize recycling, very little is actually recycled. The recycling rate is particularly low for materials whose market value is low. This includes organic waste, some types of plastic, and broken glass.

KMC has established a Community Mobilization Unit (CMU) within its Environment Department and initiated several innovative programs to raise awareness of SWM and mobilize local communities, especially women and children, to participate in waste-management related activities. Composting and recycling have been given special emphasis. The CMU's programs include the following modules.

Children and the Environment—The CMU is working with 50 local schools to establish nature clubs, build the abilities of club members, and organize various activities within the school and the surrounding community.

City Volunteers—About 100 youths have been trained to become "City Volunteers" (CV) who work as a link between the municipality and the community.

Community Participation and Training—The CMU is working with several community groups and providing them with technical and financial assistance wherever necessary. It has also formed and supported Ward Environment Committees in several wards.

Demonstration of Environmental Technologies—The CMU is promoting technologies such as compost bins and vermi-compost kits.

Community Recycling Centers—A few Community Recycling Centers have been established to encourage and assist people in recycling their waste.

Mass Education—CMU is reaching out to the general public through two weekly radio programs, message boards, and regular exhibitions.

Environmental Awards—Annually, KMC gives out the Kathmandu Environmental Awards to individuals and organizations that have made exemplary contributions toward improving Kathmandu's environment. It also gives the Nature Club of the Year Award to one outstanding nature club and the City Volunteer of the Year Award to the most active CV.

These programs are good, but they need to be expanded in order to reach out to more people.

Major Issues and Challenges

Some of the major challenges faced by KMC are as follows.

Collection System—As street sweeping and collection are by far the most expensive activities in KMC's waste-management system, the collection system needs to be made more effective and efficient. The practice of roadside pick-ups should be stopped, and door-to-door collection service, with private-sector participation (PSP), should be provided throughout the city. KMC should also introduce alternate-day collection to reduce cost.

Medical Waste Management—At present all biomedical waste is mixed with ordinary municipal waste, which is a dangerous practice. KMC has already initiated some work on biomedical-waste management. It should immediately start a separate collection system for biomedical waste.

Central Composting Plant—In order to handle a large quantity of waste it is essential that Kathmandu set up a large-scale central composting plant. This should be done with private-sector participation.

Landfill Site—Since KMC does not have a proper landfill, it is disposing of all its waste on the banks of the Bagmati. A new landfill is being built, but it is very far and its design capacity is only two to three years. Therefore, KMC urgently needs to find and develop another site.

Community and Private Sector Involvement in SWM—The active involvement of local communities and the private sector is essential for an effective waste-management system. Although KMC has started to involve local communities and the private sector in waste management, this has been a slow process. This process needs to be accelerated in a well planned manner.

Future Strategies and Action Plan

The Action Plan for SWM of the KMC has an SWM strategy (Figure 6.13) with the following goal: "Establish an integrated waste-management system that is environmentally sound, cost effective, and suitable to local conditions, with maximum involvement from the private sector and local communities."

Outputs

In order to achieve this goal, the strategy has outlined the following eight outputs, which can be viewed as components of an effective waste-management system.

- Increase collection efficiency
- Improve the efficiency of waste transfer and transportation
- Maximize recycling
- Landfill only nonrecyclable waste
- Manage hazardous and special waste effectively
- Formulate and enforce appropriate policies and regulations
- Expand public education and participation
- Strengthen the institutional capacity for management and monitoring

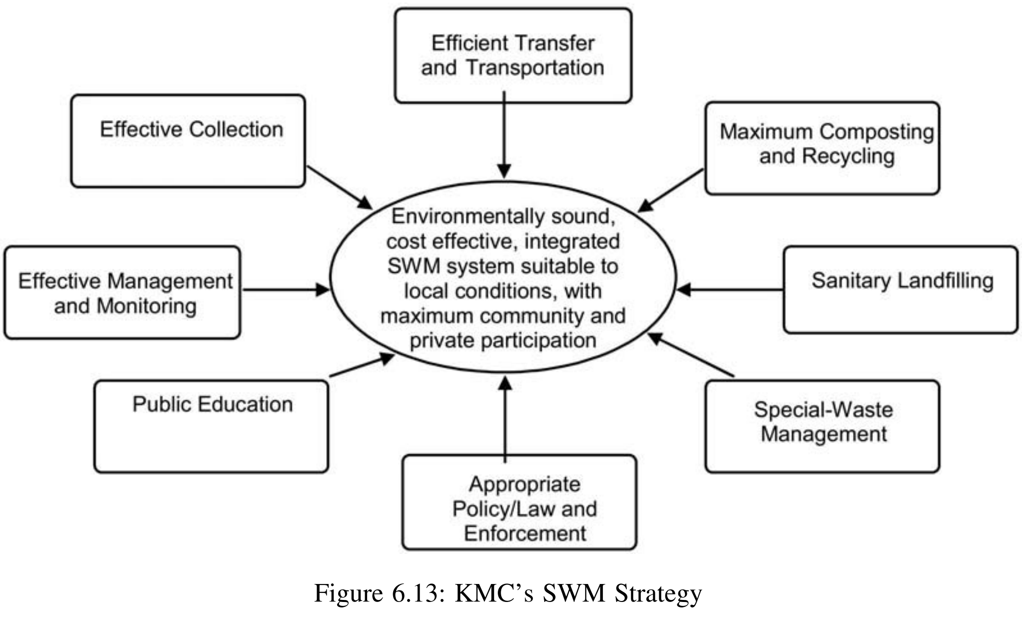

Figure 6.13: KMC's SWM Strategy

This action plan is based on KMC's waste-management strategy and is therefore organized into eight components as defined in the strategy. For each component, the plan identifies strategies to adopt in order to achieve the desired outcome and lists activities that need to be done in the short term (1 to 2 years), in the medium term (3 years), and in the long term (5 years). The planning period has been set for 5 years because it is difficult to predict the situation beyond five years. It is better to prepare rolling plans. Therefore, the action plan can be expanded later based on past experience and new information.

In the next five years, Kathmandu's population is expected to grow at 3.32% per year and by the year 2010 the population is expected to reach 0.9 million. Similarly, the waste-generation rate in Kathmandu is expected to grow at approximately 1% per year and reach 0.44 kg/person/day in 2010. This will increase the total waste generation in Kathmandu to 398 tons/day in 2010.

The plan is designed to be ambitious yet flexible. It is comprehensive and integrated, incorporating the technical as well as organizational and social aspects of solid-waste management. Yet it is kept short and simple so that it can be easy to read and comprehend. As this is not an operational plant, it is not meant to address all the problems related to SWM, but it should provide a guide for the Environment Department of KMC, based on which annual plans can be developed.

This plan has been prepared based on the consultations of key KMC staff and other key stakeholders. The plan also incorporates the preliminary findings of the JICA-supported Clean Kathmandu Valley Study. The Five-Year Action Plan is presented in Table 6.8.

Monitoring the Action Plan

The action plan will have to be reviewed at least once a year and modifications will be made based on the progress and the lessons learned. Depending on the situation, KMC should not hesitate to change the action plan as long as the actions are in line with the overall waste-management strategy and its goals.

The following indicators can be used to monitor the progress made by KMC to implement the solid-waste management strategy and action plan.

- Task completion rate compared to fixed targets
- Records of amount of waste collected
- Amount of waste recycled
- Performance of private companies
- Percentage of cost recovered through service fees
- Regular consumer surveys

The planning and monitoring unit of the Solid-Waste Management Section should be responsible for regularly monitoring the progress of the action plan and should revise the plan if necessary with participation from the key stakeholders.

OBSERVATIONS AND RECOMMENDATIONS

Some of the key findings and observations of this study are as follows.

- Although the urban population in Nepal is relatively small, it is growing rapidly. This rapid growth is causing major environmental problems including the improper management of solid waste in urban areas, particularly the bigger cities.

Table 6.8: SWM Action Plan for Kathmandu Metropolitan City

Goal: Establish an integrated waste-management system that is environmentally sound, cost effective, and suitable to local conditions, with maximum involvement of the private sector and local communities.				
		Activities		
Output	Strategies	Short-Term (2005–06/7)	Medium-Term (to 2007/8)	Long-Term (to 2010)
Collection efficiency is improved	Fixed collection schedule, preferably three times a week for households Door-to-door collection system or on-time collection system throughout the city Separation of organic and inorganic waste at the source Involvement of the private sector in waste collection Volume-based service fees for all waste generators	Introduce alternate-day collection in trial areas Expand door-to-door collection system with PSP to cover 9 wards or serve about 25% of the population Introduce a source-separated collection system in a trial area Develop policies and plans to expand PSP Develop plans to replace tractors and pilot test a few new vehicles Source-separated trash bins in tourist areas Initiate route planning for efficient collection	Expand alternate day collection in 25% of the city Expand door-to-door collection system with PSP to cover 15 wards or serve about 40% of the population Source-separated collection from 25% of the population Replace 25% of the tractors with more efficient vehicles Improve collection routes Install garbage bins in major public places	Expand alternate-day collection in 50% of the city Expand door-to-door collection system with PSP to cover 25 wards or serve about 70% of the population Source-separated collection in 50% of the city Replace 50% of the tractors with more efficient vehicles Install garbage bins in all public places

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Goal: Establish an integrated waste-management system that is environmentally sound, cost effective, and suitable to local conditions, with maximum involvement of the private sector and local communities.				
		Activities		
Output	Strategies	Short-Term (2005–06/7)	Medium-Term (to 2007/8)	Long-Term (to 2010)
Efficiency of waste transfer and transportation is improved	Improve transfer efficiency at Teku Transfer Station Establish new transfer stations at appropriate locations Ensure effective maintenance of vehicles and equipment Replace old vehicles with new, efficient, and cost-effective vehicles on a regular basis	Use split-level transfer at Teku Identify potential land for a new transfer station in the northern or western part of the city Procure new vehicles for secondary transport Establish a system for preventive maintenance for vehicles and equipment Formulate a plan for replacing old vehicles	Develop new transfer station Start replacing old vehicles Renovate existing mechanical workshop Institutionalize system for the effective operation and maintenance of vehicles and equipment	Operate new transfer station Replace old vehicles

Goal: Establish an integrated waste-management system that is environmentally sound, cost effective, and suitable to local conditions, with maximum involvement of the private sector and local communities.

Output	Strategies	Activities		
		Short-Term (2005–06/7)	Medium-Term (to 2007/8)	Long-Term (to 2010)
Recycling and composting is maximized	Promote home composting Initiate a source-separated waste collection system Set up a central composting plant with private-sector participation Establish community recycling centers Encourage the use of recycled products Develop and enact policies and market-based instruments to encourage recycling	Household composting in at least 1,000 additional households Finalize plans and sign an agreement with a private company to set up a central composting plant Identify a site for a central composting plant Conduct an EIA for a central composting plant Establish at least two community recycling centers Start small vermi-composting facility Develop a policy for the procurement of recycled products by KMC	Household composting in at least 3,000 additional households Start operating a central composting plant with private-sector participation Establish new vermi-composting facility Establish new community composting facility Establish community recycling centers in 20 wards in close collaboration with Nepal Recyclable Products Association (NEREPA)	Household composting in a total of 10,000 households Fully operational central composting plant Operate at least five community composting facilities Establish community recycling centers in all wards Assist in marketing recycled products and compost

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Goal: Establish an integrated waste-management system that is environmentally sound, cost effective, and suitable to local conditions, with maximum involvement of the private sector and local communities.				
		Activities		
Output	Strategies	Short-Term (2005–06/7)	Medium-Term (to 2007/8)	Long-Term (to 2010)
Nonrecyclable waste is disposed of in a sanitary landfill	Close existing dumpsite Operate a short-term landfill Develop a new landfill	Develop a plan for closing the existing dumpsite and implement the plan Develop an operation plan for Sisdol Landfill and implement it Identify a new landfill site by conducting a feasibility study and an EIA of potential sites	Landfill only rejects from composting and recycling (50 to 100 tons per day) Develop a new long-term landfill Environmental monitoring of the Sisdol landfill	Operate a long-term landfill for nonrecyclable waste Close Sisdol landfill
Special waste (including hazardous waste) is properly managed	Establish a central medical-waste management system Collect and use construction and demolition (C/D) waste Ensure the proper management of industrial waste	Start separate medical-waste collection and management system Initiate medical-waste training facility Start separate collection for C/D waste and use it as landfill cover Study industrial-waste management practices	Expand medical-waste collection and management system to all hospitals Study new types of waste Fully manage C/D waste Initiate industrial-waste management	Fully operative medical-waste management system with additional incinerator and autoclave Develop systems for managing new types of waste Ensure proper management of all industrial waste

Goal: Establish an integrated waste-management system that is environmentally sound, cost effective, and suitable to local conditions, with maximum involvement of the private sector and local communities.				
		Activities		
Output	Strategies	Short-Term (2005–06/7)	Medium-Term (to 2007/8)	Long-Term (to 2010)
Appropriate legislation is formulated and enforced	Formulate and implement new SWM legislation Introduce market-based instruments to promote recycling Strengthen the enforcement of anti-littering law	Lobby for removal of scrap tax Urge the government to enact legislation regarding solid and hazardous waste Expand the city police involved in the enforcement of anti-littering laws	Formulate municipal by-laws on SWM Study market-based instruments for promoting recycling Regular monitoring to stop illegal dumping	Initiate market-based instruments for promoting recycling
Public education and participation in SWM is enhanced	Expand the school-level Children and the Environment program (BABA) Expand the City Volunteer (CV) Program Promote household composting and recycling Support community initiatives Expand mass education program	Expand the BABA program to a total of 60 schools Add 50 CVs Develop training materials for SWM and recycling Market household compost bins and vermi-composting kits Prepare a database of community groups Establish 3 WECs Develop demonstration plants for community composting and vermi-composting (about 1 ton per day) Organize two public exhibitions per year Continue "Ankur" radio programs	Expand the BABA program to a total of 75 schools Provide regular training on SWM and recycling Add 100 CVs Establish 5 WECs Market household compost bins and vermi-composting kits Operate demonstration plants for community composting and vermi-composting Regular interaction with journalists Organize two public exhibitions per year Continue "Ankur" radio programs	Expand BABA program to a total of 100 schools Regular training on SWM and recycling Add 200 CVs Establish 10 WECs Market household compost bins and vermi-composting kits Operate demonstration plants for community composting and vermi-composting Organize two public exhibitions per year Continue "Ankur" radio programs

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Goal: Establish an integrated waste-management system that is environmentally sound, cost effective, and suitable to local conditions, with maximum involvement of the private sector and local communities.				
		Activities		
Output	Strategies	Short-Term (2005–06/7)	Medium-Term (to 2007/8)	Long-Term (to 2010)
Capacity of SWM section is enhanced and effective management systems are institutionalized in KMC	Appropriate organizational structure with adequate staff Effective management practices Proper planning, management, and monitoring	Reorganize SWM section Clearly define the responsibilities of all staff Establish monitoring mechanisms Develop management systems Develop HRD strategy	Operate management-information system Recruit staff to activate all units fully Implement an HRD strategy with an adequate budget Develop feedback mechanism	Fully activate all units in SWM section with adequate staff and resources Establish an effective staff performance evaluation system Regular capacity enhancement for staff

• The average per-capita waste-generation rate in Nepalese cities is estimated to be 0.34 kg/person/day. At this rate, the total municipal waste generation in Nepal in 2003 with an urban population of 3.5 million became 1,369 tons/day or approximately 0.5 million tons/year. Of this amount, municipalities collect about 600 tons/day. Most of this waste is generated in the city of Kathmandu because it is the largest city in the country.

• Most of the waste generated in Nepal is organic in nature. On average, about 65% of the household waste generated in municipalities consists of organic matter, while about 20% consists of recyclable materials such as paper, plastic, and metal, and about 10% is inert materials. With increasing modernization and changing consumption patterns, the percentage of modern materials such as plastic will probably increase in the future, but organic waste will continue to dominate the waste stream. Therefore, the focus of solid-waste management should be on recycling organic waste.

• In most cities, waste generators dump their waste in the streets or other public places whenever they wish. Municipal sweepers then sweep the streets using traditional brooms with long handles and load the waste onto collection vehicles. This is an inefficient and environmentally unfriendly way to collect waste. Some cities are experimenting with door-to-door collection, which is more effective since the waste goes straight from the source to the collection vehicle, thus reducing handling requirements and chances for pollution. Disposal of waste in public places should be banned and door-to-door collection should be encouraged.

• Tractors with trailers are the most common vehicles used to transport waste in Nepal. Although tractors are appropriate for most municipalities, big cities like Kathmandu need more specialized vehicles.

• As much of the organic waste produced in urban areas is not currently recycled, municipalities need to promote household composting and also assist in setting up community or city-level composting plants. In large cities, the private sector should be encouraged to set up large-scale composting plants based on successful examples from neighboring countries.

• Since the private sector is already involved in recycling most inorganic waste, the government and municipalities should support the private sector by making arrangements to collect these types of waste separately. Simply separating waste into its organic and inorganic components at the source will significantly reduce the contamination of inorganic waste and thus increase its value.

• The SWMRMC and District Development Committees currently charge a scrap tax on all recyclable materials that is collected for recycling. This is a very regressive tax that discourages recycling and should therefore be abolished immediately and replaced with market-based instruments that encourage recycling.

• None of the municipalities in Nepal is currently operating a sanitary landfill site. Almost all municipalities dump their waste in a crude manner at a location where there are no complaints from the local people. Several municipalities, however, want to construct a landfill but require financial and technical assistance. The experience from Pokhara and Kathmandu has shown that a landfill is usually an expensive and difficult method for managing solid waste. Therefore, more focus needs to be given on efforts to maximize waste recycling.

• The practice of a separate collection system for special and hazardous waste is nonexistent, except for a medical-waste collection system in Hetauda. As a result almost all special waste, including hazardous biomedical waste, is disposed along with the municipal waste. This is a dangerous practice. Cities need to have a separate system to manage hazardous waste. The city of Hetauda presents a model for a simple and cost-effective medical-waste management system that can be replicated in other municipalities.

• Although most municipalities do not have regular programs to encourage public participation in waste management, some municipalities such as Kathmandu and Hetauda have initiated innovative programs for community mobilization. As public participation is essential for an effective SWM system, similar programs need to be organized by all municipalities.

• Most municipalities, especially the new ones, do not have adequate institutional mechanisms and resources to manage the waste generated in their cities. Therefore, the government needs to support municipalities to strengthen their institutional capacity.

• Some municipalities, such as Biratnagar and Kathmandu, have started to work with private companies to improve waste management. Although this is still in the initial stages and there is plenty of room for improvement and expansion, the initial results are good. Since the private sector can be more efficient, more municipalities should forge partnerships with the private sector to manage solid waste, especially because the municipalities themselves have limited ability to do so. However, even with private-sector participation, the municipality needs to be actively involved in planning and monitoring.

• Nepal does not have an adequate policy and legal framework for solid and hazardous waste management and private-sector participation. Although the country has a National Solid-Waste Management Policy, it has not been followed up with plans and programs.

• The problem of waste management is most critical in the city of Kathmandu, which generates about 308 tons of waste per day. The municipality collects about 250 tons of waste per day and dumps it in a site along the banks of the holy Bagmati River which flows through the city.

• KMC has initiated door-to-door waste collection with the participation of private companies. This is a very good initiative and needs to be expanded throughout the city. In the future, the collection of segregated waste at the source and alternate-day collection also need to be introduced.

• Because about 70% of the waste in Kathmandu is organic, there is an urgent need to convert it into valuable compost instead of dumping it. This requires a combination of household composting, community composting, and central-level composting plant.

• The practice of dumping waste along the Bagmati River is not acceptable and needs to be stopped immediately. KMC can use the Sisdol landfill site for a few years, but since the site is very far from Kathmandu, the process for developing a new site should be started immediately.

• KMC's initiatives to mobilize local communities in waste management are excellent and need to be expanded. The main requirements for effective SWM in Kathmandu are: a sanitary landfill, a central composting facility, an efficient collection system, a separate biomedical-waste management system, and an expansion of private sector and community involvement in SWM.

• A five-year action plan for SWM in Kathmandu based on KMC's SWM strategy has been prepared. According to the strategy, the goal of SWM in Kathmandu is to "Establish an integrated waste-management system that is environmentally sound, cost effective, and suitable to local conditions, with maximum involvement of the private sector and local communities." In order to achieve this goal, the action plan has eight key outputs, strategies for each output, and a list of activities to be done in the short-term (1 to 2 years), medium-term (3 years) and long-term (5 years). The implementation of the action plan is important for integrated solid-waste management in Kathmandu city.

The following recommendations are made based on the findings of this study.

• As the institutional capacities of municipalities, especially the new ones, are weak, the SWMRMC should assist them in developing effective, integrated SWM systems.

• Municipalities need to prioritize SWM and allocate adequate resources for it.

• Municipalities should ban the practice of dumping waste on roadsides or in public places, and provide door-to-door waste-collection service wherever possible.

• Since most of the waste generated in Nepalese municipalities is organic in nature, priority should be given to recycling organic waste.

• The practice of haphazard waste disposal should be replaced by at least controlled dumping where the waste is covered with soil, provisions are made for adequate drainage, and access to the site is restricted.

• Several municipalities have initiated innovative systems such as private-sector participation at Biratnagar, composting and recycling at Hetauda, central composting in Bhaktapur, and community mobilization in Kathmandu. These need to be expanded and replicated in other municipalities.

• Household composting should be promoted in all municipalities by conducting public awareness campaigns and providing technical assistance to the people who are interested in composting. Providing compost bins at subsidized rates, as it is done in Kathmandu, can be helpful. Community composting should be promoted in areas where land is available and local communities are willing to cooperate. City-level composting plants should be set up with the involvement of the private sector.

• Windrow composting with aeration provided by turning the piles manually is probably the most appropriate method for city- and community-level composting. In the case of small plants, manual screening or simple trammels will be more effective, but for large-scale plants (more than 20 tons/day) more complex screening plants will be necessary.

• The government should formulate and implement legislation for solid- and hazardous-waste management and also develop programs to implement the National Solid-Waste Management Policy.

• In Kathmandu, door-to-door waste collection with private participation should be expanded throughout the city, composting and recycling should be encouraged, and dumping waste along the Bagmati should be stopped.

• The Action Plan for waste management in Kathmandu should be implemented and its progress should be monitored regularly.

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7. PHILIPPINES

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INTRODUCTION

Background of the SWM Survey

This survey of solid-waste management (SWM) is a very timely endeavor, especially for a developing country like the Philippines. To say the least, SWM in the country's major urban centers is in dire need of change. A good example is Metro Manila (MM), the premiere urban center where 9.9 million people reside, work, and generate waste. Given this population, MM generates 6,700 tons of solid waste every day. Of this, approximately 720 tons is recycled or composted.[1] However, estimates have shown that as much as 27% is uncollected and ends up in rivers, canals, and estuaries.[2] The rest is collected, but it ends up in open dumpsites around the metropolis. Because of the new Republic Act 9003, the Ecological SWM Act of 2000, some local government units, e.g., Makati City and Marikina City, have instituted waste minimization and recovery programs to mitigate the garbage problem. Other urban centers like Baguio (northern Philippines), Cebu (central), and Davao (south) are likewise in a similar bind, although to a lesser degree in terms of quantity and manageability and are undergoing similar transformation.

This survey on SWM is an occasion to reflect on the current situation of SWM in the participating countries, to see what the challenges are and where improvements are needed. It is also an opportunity for these countries to learn from each other, share experience and ideas, and hopefully come up with appropriate (doable, effective, and sustainable) action plans.

Objectives

As provided for in the Terms of Reference, the objectives of the survey are as follows.

- To study the current situation and major problems in the member countries in the generation, reduction, reuse, recycling, handling, collection, transfer and transport, transformation (e.g., recovery and treatment), and disposal of solid waste.
- To gain information on the prevailing technologies and practices of solid-waste management on collection, transformation, and disposal.
- To study ways and means to manage solid waste for reduction, reuse, recycling, and recovery.
- To explore policy measures and industrial actions to minimize the undesirable impacts generated by solid waste.

Methodology

The national SWM survey entailed various activities to meet its objectives. These include the following.

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[1] Asian Development Bank. *Garbage Book 2004.*
[2] MMDA Briefing Paper, SWM in MM 1999.

- Identify the major sources of data, persons, groups, organizations, and institutions from the government and private sectors.
- Review the related literature from various sources, e.g., various government agencies, especially the Department of Environment and Natural Resources (DENR), National Solid-Waste Management Commission (NSWMC), and the Department of Interior and Local Government (DILG); NGOs, like the Solid-Waste Management Association of the Philippines (SWAPP) and the Centre for Advanced Philippine Studies (CAPS); and the donor community, among them the Asian Development Bank (ADB), the World Bank (WB), and Japan Bank for International Cooperation (JBIC).
- Conduct in-depth interviews or focus group discussions involving key personalities from the various organizations, institutions, and agencies mentioned above involved in or with knowledge about SWM in the country.
- Search and gather relevant, current, and latest statistics about population, waste generation, recovery, recycling, composting, collection vehicles and capacities, open dumpsites and landfills, plans and programs, etc.
- Conduct interviews and meetings with key officers and staff at the Development Academy of the Philippines (DAP), the country's National Productivity Office.

COUNTRY PROFILE

Physiography and Climate

The Philippines is an archipelago of 7,107 islands. The country is divided into three geographical areas: Luzon, Visayas, and Mindanao. It has 17 regions, 79 provinces, 115 cities, 1,499 municipalities, and 41,969 barangays.[3] The Philippines covers an area of 299,764 sq km, geographically located between 4° 23′ and 21° 25′ N latitude and 116° and 127° E longitude. Its length measures 1,850 kilometers, starting from the point near the southern tip of the Republic of China and ending close to northern Borneo. Its breadth is about 965 kilometers.

The total land is divided into arable land (19%), permanent crop cover (12%), permanent pastures (4%), forest and wetlands (46%), and the remaining land (19%) used for other purposes. The Philippines is surrounded by prominent water bodies like the Pacific Ocean on the east, the South China Sea on the west, and the Balintang Channel on the north, and the Sulu and Celebes Sea from the south. The Philippine coastline comprises nearly 17,500 km. The country has a tropical climate with relatively abundant rainfall and gentle winds. There are three pronounced seasons: the wet or rainy season from June to October, the cool, dry season from November to February, and the hot, dry season from March to May.

Demography

The population of the Philippines was 76.5 million as of May 2000. (The estimate for 2004 was 82.7 million.) The Filipino is basically of Malay stock with a sprinkling of Chinese, European, and Arab blood. The population is divided according to geographical locations and each group is recognizable by distinct traits and dialects, e.g., the sturdy and frugal *llocanos* of the north, the industrious *Tagalogs* of the central plains, the carefree *Visayans* from the central islands, and the colorful tribesmen and religious Moslems of Mindanao. Tribal communities can be found scattered across the archipelago. Out of the total population, 56.9% of the

[3] The smallest local-government unit in Philippines.

people live in urban areas. The literacy percentage of the country is 94.6%. The population growth rate is 2.36%. The life expectancy at birth is pegged at 67.4 years.

Filipino, which is based on the Tagalog dialect, is the national language. English is also widely used and is the medium of instruction for higher education. The Philippines has more than 111 dialects, of which the eight major ones are Tagalog, Cebuano, Ilocano, Hiligaynon or Ilonggo, Bicol, Waray, Pampango, and Pangasinense.

Governance

The Philippines is a republican country governed by a constitution enacted in February 1987. The executive branch of government is led by a president, who also serves as the head of state. The president is elected by popular vote, without reelection, to a six-year term of office. The president appoints a cabinet. The bicameral legislative branch consists of the Senate and the House of Representatives. The Senate consists of 24 members, serving six-year terms while the House of Representatives consists of a maximum of 250 members, each serving a three-year term of office. The judicial branch is headed by the Supreme Court, which is composed of a chief justice and 14 associate justices, all of whom are appointed by the president. Other judicial bodies include a Court of Appeals and trial courts distributed by regions, cities, and municipalities.[4]

Economy

The economy of the Philippines is dominated by the agriculture sector. Agriculture, fishing, and forestry account for the highest employment, which is 11.155 million, followed by the manufacturing industry with 2.892 million people employed. The construction sector accounts for 1.747 million people, mining, quarrying, electricity employ 105 million, and gas and water services employ 116 million people. Overall in the Philippines, 31.520 million people are employed and 4.989 million persons are unemployed.[5] The reported GNP is 1170.4 billion (Q1 2004) and the median family income as per the 2000 reports was PHP88,782 (USD1,614.22).

Environmental Profile

The terrain of the Philippines consists mostly of mountains with narrow to extensive coastal lowlands. It has a tropical climate with monsoon seasons between November and April in the northeast and May and October in the southwest.

National Environmental Regulatory Framework

The Department of Environment and Natural Resources (DENR) is the principal government agency responsible for maintaining the quality of air, water, and land at levels conducive to health and productive work. It is mandated to enforce the following laws.

- The Clean Water Act, Republic Act 9275 for water-quality management and water-pollution permits and charges
- The Clean Air Act, Republic Act 8749 for air-pollution control and air-quality management
- The Pollution Control Law, Presidential Decree (PD) 984 for water-pollution control and river classification and monitoring

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[4] Antonio A. Oposa, Jr., *A Legal Arsenal for the Philippine Environment*. The Philippine Islands: Batas Kalikasan, 2000.

[5] Q1 2004; April 2004, as cited in *Labstat*, vol. 8, no. 9, July 2004.

- The Ecological Solid-Waste Management Act, Republic Act 9003 for garbage and other solid waste
- The Toxic Substances and Hazardous and Nuclear Waste Control Act, Republic Act 6969 for chemical and hazardous waste
- The Environmental Impact Assessment System, Presidential Decree 1586 for environmentally critical areas and projects

Other Environmental Laws, Regulations, and Standards

In the 1970s during the preparation of the Material Law, several laws relating to environmental protection and solid-waste management came into force. Table 7.1 presents a list of

Table 7.1: Laws and Regulations on the Environment

Year Enacted	Summary of Laws and Regulations on the Environment
1976	Presidential Decree No. 600 as amended by PD 979. Marine Pollution Control Law of 1976 Provides and controls pollution of the seas by prohibiting the dumping of waste and other matter that create hazards to human health or harm living resources and marine life.
	Presidential Decree No. 1151. Philippine Environmental Policy Recognizes the right of the people to a healthy environment and the duty of everyone to contribute to the preservation and enhancement of the environment. Section 4 requires the preparation of Environmental Impact Statements for any project or undertaking that may significantly affect the environment.
	Presidential Decree No. 1152. Philippine Environmental Code Requires the preparation and implementation of waste-management programs by all provinces, cities, and municipalities.
1990	Executive Order No. 432 Orders the strict implementation of PD 825 by all law enforcement agencies and officers. Enjoins the Metro Manila Development Authority to do so for Metro Manila.
	Republic Act 6969. Toxic Substances and Hazardous and Nuclear Waste Control Act Regulates the importation, use, movement, treatment, and disposal of toxic chemicals and hazardous and nuclear waste in the Philippines.
1991	Republic Act 7160. The Local Government Code Mandates LGUs to exercise power and discharge functions and responsibilities as necessary or appropriate and incidental to the efficient and effective provision of services and facilities related to general hygiene and sanitation, beautification, and solid-waste collection and disposal systems.
1992	DAO 92-29. The Implementing Rules and Regulations of R.A. 6969
2003	DAO 2003-26. Revised Industrial Eco-Watch System Amending Guidelines of DAO 98–51 Series of 1998 Promotes mandatory self-monitoring and compliance with the environmental standards and encourages voluntary self-regulation among establishments for improved environmental performance.

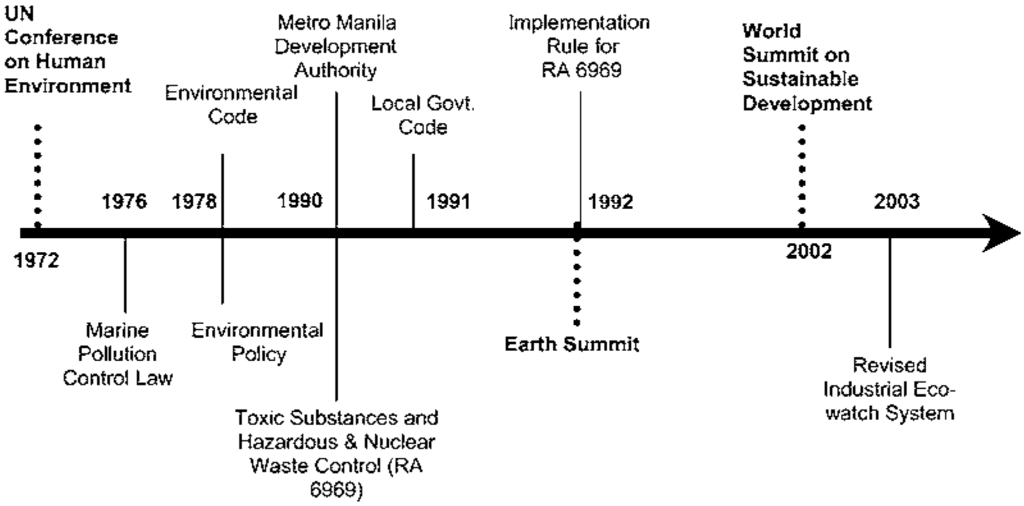

Figure 7.1: Timeline of Environmental Rules and Regulations in the Philippines

environmental regulations and the years of their endorsement. A summary of environmental regulations related to solid-waste management is covered below in the section entitled "The Environmental Impact of MSW."

Multilateral Environmental Agreements

The Philippines has also ratified MEAs on climate change, endangered species, hazardous waste, maritime dumping, nuclear test ban, ozone layer protection, biodiversity, wetlands, and whaling. The timeline of environmental rules and regulations is presented in Figure 7.1.

Status of Environmental Compliance

Air and water-quality monitoring is a function of the Environment Management Bureau (EMB), a line bureau under the DENR. Under the Clean Air Act and the Ecological SWM Act, mass burning is prohibited due to very high capital and operational costs and to prevent air pollution from this source. PD 984 (Pollution Control Law) provides the regulatory framework for water-pollution control. Its implementation is specified under the DENR Administrative Orders (DAO) No. 24 (1990 series) for water usage, classification, and water-quality criteria, and DAO 35 (1990 series) for effluent regulations. A system of fines and penalties for noncompliance to effluent standards is defined under PD 984 and is in operation. This is currently implemented by the Pollution Adjudication Board (PAB). Figure 7.2 provides data on water-polluting firms in Metro Manila for the year 2001. The classification of firms is based on a Permit to Operate (PTO). In 2003, the EMB reported that of the 1,361 firms monitored, 548 are water-polluting firms and 813 are non-water-polluting firms; 54% of these firms are operating without permits.

Environmental Situation Analysis

General State of Rivers, Lakes, and Coastal Waters[6]

According to the EMB, there are very few rivers and creeks left unpolluted. Box 7.1 presents water-quality monitoring figures and their status.

[6] Based on EMB, *Environmental Quality Report, 2003.*

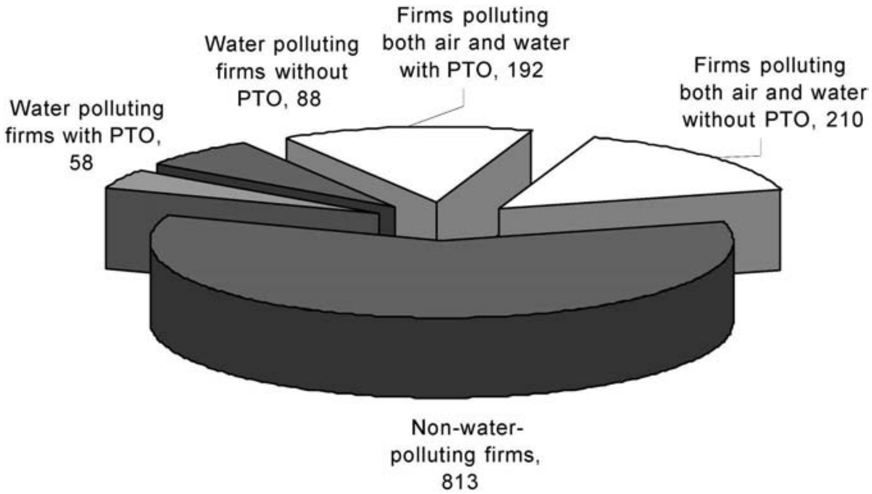

Figure 7.2: Water-Polluting Firms in Metro Manila, 2001
Source: EMB, *Philippine Environmental Quarterly Report* (draft), 1996–2002.

Hazardous Waste[7]

Hazardous waste is generated by a wide range of industrial, commercial, agricultural, and to a much less extent domestic activities. It is in the form of solids, liquids, or sludge and can pose both acute and chronic public health and environmental risks. An estimated 2.4 million MT/year of hazardous waste is generated by industries. Only 1,079 hazardous-waste generating industries are registered with the EMB. These industries produce 278,393 tons/year of hazardous waste. The major waste classes include inorganic chemical waste, alkali waste, putrefiable waste, acid waste, and oils. About 25% of the total hazardous waste from registered industries is recycled, out of which 56% are oils and 49% are inorganic chemicals. There are 28 hazardous waste treatment facilities registered with the DENR-EMB nationwide and 21 units operate full-time. Currently, there are no landfill facilities available for hazardous waste. The hazardous waste generating units store their waste or dispose of them partially treated or untreated. An undetermined portion of hazardous waste ends up in municipal dumpsites and landfills.

Biomedical Waste[8]

There are 18,500 hospitals (with 90,000 beds) in the country that generate about 6,750 tons of biomedical waste per year or 18 tons/day. Of this, 47% is generated in the National Capital Region while Region IV accounts for 12%. Prior to the ban imposed on incineration by the Clean Air Act of 1999, there were 43 incinerators operational in the country, of which 22 were located in Metro Manila. Presently, 50% of the biomedical waste generated is incinerated while the rest is disposed of improperly. It is not uncommon to find biomedical waste in municipal disposal sites.

[7] Ibid.
[8] Ibid.

Box 7.1: General State of Rivers, Lakes, and Coastal Waters
Rivers Out of 662 rivers and creeks, 460 or 69.5% were classified by the EMB according to their water quality. • Only 3 rivers (0.5%) remained in Class AA, the cleanest category that is considered as a source of potable water after simple disinfection. • 151 rivers (22.8%) were in Class A, which need complete treatment to make them potable. • 98 rivers (14.8%) are in Class B and 191 rivers (28.9%) are in Class C, while the remaining 17 rivers (2.6%) are in Class D. • 306 rivers can not be used to supply water for households while 208 rivers are not suitable for washing, bathing, and other activities that involve skin contact.
Lakes Few of the Philippine lakes have been classified as to their water quality. Of the 56 lakes monitored by the EMB offices, only 3 have been officially classified, Lake Lanao, Lake Nauja, and Lake Taal. All are in Class B. The largest lake in the country, Laguna de Bay, has not been officially classified.
Manila Bay Manila Bay remains heavily polluted due to household and industrial waste. This is revealed by the condition of the coral reefs and sea grasses that have been found to be heavily damaged. The few mangrove forests that remain have been converted to aquaculture areas and salt beds. Fishery stocks are dwindling and fish and shellfish growth remain poor. Likewise, the benthos populations are steadily declining and their composition has shifted from a bivalve-dominated community to a polychaete-dominated community. Fecal contamination is very high among the bivalves and exceeds standards.

Environmental Issues

- There is no national compilation of data regarding the monitoring of and compliance with environmental laws, regulations, and standards.
- Incineration is effectively banned under the Clean Air Act. As a result, hospitals are faced with problems of medical-waste disposal.

Incentives/Disincentives for Good Environmental Practices

Table 7.2 presents examples and the status of incentives and disincentives such as *Lason sa Ilog Pasig*, extended producer responsibility, eco-labeling, and the environmental user-fee system. Table 7.3 shows the effluent-discharge fee structure (in USD) based on the hydraulic and organic discharge limits for effluents.

Cleaner Production (CP)

Industries in the Philippines have initiated, developed, and implemented different programs that contribute to CP. Of these, 83 industries are ISO 14001 certified and adopt Cleaner Production approaches. The majority of the industries is aware of and complies with the environmental standards and practices environmental management. Other industry associations set

Table 7.2: Incentives/Disincentives for Good Environmental Practices and Pollution Prevention

Incentives/ Disincentives	Description
Lason (Poison) Award	The *Lason sa Ilog Pasig* (Poison to Pasig River) Awards A mock award is given every April 22 coinciding with the celebration of World Earth Day to the top ten industries that have been found to be polluting the river. During the five years that the Sagip Pasig Movement (SPM) has worked in this area, the majority of the past awardees have installed waste-water treatment facilities as a result of the public pressure created by the awards.[a]
Extended Producer Responsibility	The Extended-Producer Responsibility (EPR) principle is still being studied. Currently, there is no EPR regulation.[b]
Eco-Labeling	R.A. 9003 mandates the Department of Trade and Industry, Bureau of Product Standards (DTI-BPS) to formulate and implement a coding system for packaging materials and products to facilitate waste recycling and reuse. Currently, one product has been given the "Green Choice" label, Pride Laundry Detergent. There are other identified priority products on the list while criteria are developed by the DTI-BPS.[c] DAO 26 (Series of 2003) specifically provides the implementing guidelines for eco-labeling, e.g., standards and requirements established by the Bureau of Product Standards of the DTI for labeling product as "Green Choice."
Environmental User Fee System	In Laguna de Bay, the 900,000 hectare lake near Metro Manila, the polluter-pay principle is being implemented. The Laguna Development Authority (LLDA) introduced the user-fee system (Section 3, E.O. 927) for all industries discharging wastewater into Laguna de Bay. The fees collected are of two kinds: a fixed fee (based on the volume of wastewater discharged) and a variable fee (based on the unit load of pollution, computed as the product of the volumetric rate of discharge and the effluent concentration).

[a] Based on the *Sagip Pasig* Movement: Communities Making a Difference.
[b] Based on an interview with Tony Chong, a member of the NSWMC for the private sector, August 2004.
[c] Based on information gathered from the NSWMC Secretariat, August 2004.

Table 7.3: Volumetric Rate of Discharge Fixed Fee and Effluent-Concentration Variable Fee, Based on Resolution No. 33 (1996 series)

Volumetric Rate of Discharge Fixed Fee	Effluent Concentration Variable Fee
• Within 30 m^3/day: PHP5,000 (USD91) • More than 30 but less than 150 m^3/day: PHP10,000 (USD182) • More than 150 m^3/day: PHP15,000 (USD273)	• Within 50 mg/L BOD: PHP5 per kg BOD (USD0.10) • Above 50 mg/L BOD: PHP30 per kg BOD (USD0.55)

guidelines and promote ecological practices among their members as a constructive tool. Case studies and demonstration projects on CP have also been developed by various stakeholders, particularly the industries.

OVERVIEW OF SWM

The Environmental Impact of MSW

Solid waste and its liquid and gaseous by-products can have serious effects on life, health, and the environment. Recently, a *Philippine Daily Inquirer* (PDI) headline screamed "Garbage a Major Culprit in Floods" in Metro Manila. As per API News, after an abnormally heavy downpour the previous day, the metropolis experienced severe flooding. Solid waste in waterways restricted drainage flow and affected the performance of the MMDA's pumping stations. Six people drowned and thousands had to be evacuated.

Open dumpsites impose severe environmental and health risks on surrounding areas. They become natural breeding grounds for vectors and they produce leachates that contaminate ground and surface water. Worse, they can be a threat to life, as happened in the Payatas dumpsite in July 2000 when a garbage landslide occurred and buried more than 200 people in their sleep. Table 7.4 describes the impacts and threats of existing solid-waste dumpsites in Metro Manila.

Solid waste also contributes to climate change, mainly due to the emission of greenhouse gas in the form of methane gas (from the anaerobic decomposition of organic waste), which is 21 times more potent than the carbon dioxide. According to the calculations of the Inter-Committee on Climate Change in the Philippines, in 1994 an estimated 4,200 kt of solid waste was brought to waste-disposal sites, releasing about 302.73 kt of CH_4. Domestic wastewater (sewage) and industrial wastewater also release CH_4 in the atmosphere.[9] Table 7.5 shows the CO_2 and CH_4 emissions by various sectors.

National SWM Regulatory Framework

The main legal instrument governing SWM in the country is the Ecological Solid-Waste Management Act of 2000 (R.A. 9003), signed into law by President Gloria Macapagal-Arroyo 26 January 2001. This law declares the adoption of a systematic, comprehensive, and ecological solid-waste management program as a policy of the state. It adopts community-based approaches to SWM and mandates waste diversion through recycling and composting, among others. The key features of R.A. 9003 are as follows.

Institutional Arrangements: Establishment of National Solid-Waste Management Commission (NSWMC) that will oversee the implementation of solid-waste management plans and prescribe policies to achieve the objectives of the Act. Creation of a multisectoral SWM Board in each province and local government unit (LGU) responsible for the implementation and enforcement of the Act within their respective jurisdictions.

Strategic Planning and Framework: Preparation of a National Solid-Waste Management Status Report by the NSWMC that will include an inventory of existing solid-waste facilities, waste characterization, waste-generation projections, and other pertinent information. The report is the basis of the National Solid-Waste Management Framework, which will contain the medium- and long-term plans. The Act also requires each province, city, and municipality to

[9] Manila Observatory-ICCC. *Tracking Greenhouse Gases: A Guide for Country Inventories*, 1999.

Table 7.4: Impacts of Dumpsites in Metro Manila

Dumpsite	Impact and Threats
Payatas Dumpsite, Quezon City Opened in 1973 22 hectares Solid waste: 2,200 tons/day	For the past 30 years, the solid-waste dump has most likely been releasing leachates into the ground water and river systems, an amount currently estimated at 2 liters/second or 63 million liters each year. Garbage landslide occurred in July 2000, killing more than 200 residents.
Catmon, Malabon Opened in 1986 5 hectares Solid waste: 210 tons/day	Located in a dense residential area prone to flooding, the site has most likely been generating leachate for the past 17 years with unknown consequences.
Lupang Arenda, Taytay Opened in 1995 40 hectares, expandable to 170 Solid waste: amount unknown	Illegal dumpsite located on the north shore of Laguna Lake. Waste used as fill to raise the surface above flood elevation. Housing resettlement for 25,000 households on dumps. Acute public health and environmental threats.
Rodriguez Landfill, Rodriguez Opened in 2002 14 hectares Solid waste: 1,200 tons/day	Each year, this facility generates over 63 million liters of leachate, enough to fill more than 28 Olympic-size swimming pools, the bulk of which flows into Marikina River system. Along with Payatas, it generates an estimated 26 kg of lead and 76 kg of arsenic annually.
Tanza, Navotas Opened in 2002 11 hectares, expandable to 100 Solid waste: 800 tons/day	Constructed on former fishpond and surrounded by fishponds. Risks seriously contaminating nearby fish and shrimp ponds, a major food resource for Metro Manila.

Table 7.5: CO_2 Emissions by Sector, 1994

Sector	CH_4 Emissions (kt)	CO_2 Emissions (kt)
Solid waste	302.73	6,357
Domestic wastewater	46.00	966
Industrial wastewater	43.81	920
Human sewage	45.43	954
Total	437.97	9,198

Source: Manila Observatory-ICCC, 1999 based on an urban population of 35.58 million in 1994.

prepare a 10-year plan to include reuse, recycling, and composting waste, using the framework as a guide.

Reuse: The Act requires all LGUs to divert at least 25% of all solid waste from waste-disposal facilities to reuse, recycling, composting, and other resource-recovery activities within five years from the implementation of the Act. Segregation of solid waste at the source is also made mandatory.

Recycling: The Act mandates the Department of Trade and Industry (DTI) to prepare an inventory of existing markets for recyclable materials and compost. It also requires the DTI to develop procedures, standards, incentives, and strategies for the local market for recyclable materials and compost. The use of environmentally noncompatible packaging materials is restricted.

Sanitary Landfills and Controlled Dumps: The Act prohibits new open dumpsites for disposal and encourages the conversion of open dumps into controlled dumpsites within three years. Within five years of the implementation of the Act, controlled dumpsites are to have been converted to sanitary landfills.

Fees: The Act states that fees be levied on all waste generators for SWM services. Fines and penalties for any violation of the law are also set. All revenues from the implementation of the law are to be placed in an SWM Fund and will be used for research and development, providing awards and incentives, providing technical assistance, conducting awareness campaigns for information dissemination and education, and monitoring activities.

Participation: The Act also encourages Citizen Lawsuits, where anyone can file a civil, administrative, or criminal case against any person, government agency, or official who violates or fails to comply with the ecological solid-waste management law. It should be pointed out that a number of municipalities and cities as well as localities (barangays) have enacted a localized version of R.A. 9003, which will help them implement the law in their own locality.

SWM Situation Analysis

Quantification and Characterization

Based on the national waste-generation data for 2000–10, the National Capital Region, or Metro Manila, has the highest waste generation (23%), almost a quarter of the country's generated waste as a whole. On the other hand, the Cordillera Region has the lowest generation (1.6%). Table 7.6 shows the status of waste generation in the Philippines.

The waste-production rates are: National Capital Region: 0.71 kg/person/day; urban population: 0.5 kg/person/day; rural population: 0.3 kg/person/day. It was assumed that the urban population would increase its waste production rate by 1% per year due to rising income levels (based on GHK/MRM International Report).[10] This is attributed to the fact that Metro Manila is a major contributor to the national GDP and therefore has the highest consumption rates, and consequently the highest waste generation. This same trend is expected to continue to the year 2010.[11]

Waste generation rates are generally related to modern conveniences and changing lifestyles, increasing population, rapid urbanization, improper waste disposal, and public insensitivity. Other studies show that waste generation varies from 0.30 to 0.70 kg/capita/day, depending on whether the estimate refers to residential or all sources of waste, as presented in Table 7.7.

The waste composition for several cities outside Metro Manila is shown in Table 7.8.

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[10] Urban and rural population and growth rates by region are based on National Statistical Office data from 2000.

[11] World Bank. *Philippines Environmental Monitor 2001.*

Table 7.6: National Waste Generation, 2000–10

	2000		2010	
	Million Tons/ Year	% of Total	Million Tons/ Year	% of Total
Metro Manila (National Capital Region)	2.45	23.0	3.14	22.3
Cordillera AR	0.17	1.6	0.21	1.5
Ilocos	0.50	4.7	0.63	4.5
Cagayan Valley	0.32	3.0	0.40	2.8
Central Luzon	0.96	9.0	1.32	9.4
Southern Tagalog	1.42	13.3	2.11	15.1
Bicol	0.54	5.1	0.65	4.6
Western Visayas	0.82	7.7	1.00	7.1
Central Visayas	0.74	7.0	1.01	7.2
Eastern Visayas	0.43	4.0	0.51	3.6
Western Mindanao	0.40	3.8	0.53	3.8
Northern Mindanao	0.37	3.4	0.47	3.4
Southern Mindanao	0.70	6.6	0.97	6.9
Central Mindanao	0.33	3.1	0.41	2.9
ARMM	0.26	2.5	0.39	2.7
Caraga	0.26	2.4	0.31	2.2
National	10.67	100	14.05	100

Source: World Bank. *Philippines Environmental Monitor 2001.*

Table 7.7: Per Capita Estimates of Waste Generation in Selected Cities and Municipalities in the Philippines

Area	Coverage	Estimate (kg/capita/day)	Study
Mandaluyong City	Residential All sources	0.37 0.76	Soncuya and Viloria (1992)
San Juan Municipality	Residential All sources	0.32 0.57	Soncuya and Viloria (1992)
Olongapo City	Residential	0.30	GHK/MRM (1992)
	All sources	0.39	
Bacolod City	All sources	0.39	EMS/JSD (1995)
Metro Manila	Residential	0.42	MMDA/JICA (1998)
	All sources	0.66	DENR/WB (1998)

Source: Eugene Bennagen et al. *Solid-Waste Segregation and Recycling in Metro Manila: Household Attitudes and Behavior.* EEPSA, 2003. Cited in GHK/MRM 1995.

Table 7.8: Waste-Composition Studies in Other Local Government Units in the Philippines (in percentages)

Waste Composition	Batangas	Olongapo	Baguio	Iloilo City	Tacloban City	San Fernando City, Pampanga	Dinalu-pihan, Batan
Paper	5.92	7.62	9.81	9.4	12.1		6.5
Cardboard	3.59	5.02	3.78				
Food waste	24.04	18.74	27.46	29.0	12.7	17.0	19.0
Plastic	13.21	12.36	6.35	20.0	11.0		9.0
Textiles	2.80	3.44	2.17	5.5	2.2		1.7
Rubber and leather	0.98	2.09	2.12		1.4		2.0
Petroleum products	3.03	5.20	11.18				
Yard/field waste/ wood	29.80	26.32	25.02	9.1	39.4	38.0	6.5
Metals	3.32	5.51	3.86	6.1	3.0		7.0
Glass	2.38	2.94	2.44	1.3	2.7		3.0
Fines/Inert	10.82	9.95	5.51		9.5		15.0
Special waste	0.08	0.81	0.23	3.0	0.4		5.3
Other				16.6	6.0	51.0	
Total	99.97	100.0	99.93	100.0	100.0	106.0	75.0

Sources: World Bank. *Solid-Waste Ecological Enhancement Project* (2000).
Tetra Tech EM, Inc., *Pre-Feasibility Study of the City of San Fernando Ecological Solid-Waste Management Program*, 2002.
Province of Bataan. *Integrated Solid-Waste Management*, as presented in the PEMSEA Investors Roundtable 2003: Environmental Investment Opportunities, May 2003.

There was more garden and field waste/wood (25–39%), followed by food waste/vegetable (18–29%), and plastics (6–20%). The presence of agricultural waste in these areas can account for the high percentage of organic waste.

Key Elements of SWM

Current Methods of Segregation, Storage, Collection, and Transport

Segregation

Under R.A. 9003, LGUs are now requiring their citizens to practice segregation at the source including institutional, industrial, commercial, and agricultural sources. The waste is to be classified in four types: biodegradable, nonrecyclable, recyclable, and special waste. The baronages are now mandated to collect recyclable and biodegradable waste, and the city/municipality is responsible for the residual and special waste. To further encourage segregation at the source, the LGUs have developed specific collection schedules/dates for biodegradable, recyclable, and residual waste. Some LGUs are refusing to collect nonsegregated waste. Waste segregation at the household level, however, is not yet widely practiced. Traditionally, Filipinos only segregate waste according to what they can sell, mainly bottles and papers, to roaming waste buyers.

Storage

The most common practice by households is to store waste in plastic grocery bags, bamboo baskets, drum cans, tire bins, or any available receptacle. Because collection is done only once or twice a week, some communities have put up waste-collection containers to temporarily store their mixed waste until the scheduled waste collection. Often, waste is left to rot or is scattered by stray animals. Worse scenarios are seen in other areas where no infrastructure is available. Piles of waste reeking with foul odors are found on the street and become a habitat for insects and vermin.

The temporary storage of recyclable materials is necessary to consolidate and maximize the volume before delivery to recycling facilities. In most cases, dealers are not concerned or lack the capacity to set up the systematic storage of their materials. Thus the haphazard storage of recyclables becomes unaesthetic and a source of street litter.

Collection and Transport

In the 2001 World Bank Report, the countrywide collection efficiency is estimated at 40%, although major towns and cities show an average collection rate of up to 70%. Many of the poor neighborhoods in the country are underserved owing to the inaccessibility of their areas to the waste-collection vehicles. In the case of the Province of Bataan, the collection system covers about 95% of the 237 baronages (most urban or town center areas) and a collection efficiency of 76%.[12]

Most of the LGUs manage their own collection systems, while some hire haulers to do roadside collection. In Metro Manila, the common types of collection vehicles are open dump trucks (79%) and compactor trucks (21%).[13] The waste-collection trucks also serve other purposes, such as carrying materials for the construction activities of the LGUs. It should be pointed out that the LGUs in Metro Manila are responsible for the collection of waste and the cleanliness of their own jurisdiction as per the Local Government Code, although the MMDA is mandated to formulate and implement policies, standards, programs, and projects for the proper waste disposal of the metropolis. Waste collection is done on a regular basis, with the marketplace being the most frequently visited collection area. In Metro Manila, for instance, the usual types of collection systems and vehicles used are: door-to-door (2–3 times a week, 10-wheeler dump trucks), major thoroughfares (once daily, 6-wheeler dump trucks), and stationary (daily, 1–10 truckloads, compactor trucks).

Garbage containers such as drums and plastic bins are usually placed at strategic points in the community for the collection of waste to be transported by vehicle. In addition to the government collection crew, the roaming waste buyers/collectors (Eco-aides) and the scrap-shop operators also play a major role in the collection and transport of waste. In small communities that are not serviced by regular LGU collection vehicles, homeowners' associations hire one to two Eco-aides to undertake the collection of recyclables around the subdivision. Other communities rely on the roaming waste buyers who go around the community and buy used bottles, paper, scrap metals, and appliances from the households. Collection crews also segregate recyclables to be sold to the scrap shops.

Treatment and Disposal

There is hardly any treatment going on to process solid waste except for small-scale composting in some baronages and municipalities. Based on a study of two baronages, less than

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[12] Province of Bataan. *Integrated Solid-Waste Management*, as presented in the PEMSEA Investors Roundtable 2003: Environmental Investment Opportunities, May 2003.

[13] Metropolitan Manila Development Authority.

Table 7.9: Summary of Waste Disposal Facilities, 2001–03

Region	Existing Open Dumpsites	Open Dumpsites for Conversion to Controlled Disposal Facilities	Existing Controlled Disposal Facilities	Proposed Controlled Disposal Facilities	Sanitary Landfill (SLF)	Proposed SLF
NCR	11		4			
I	29	15	2	5		
II	10	1	2	5		
III			6		1	
IV-A	89		16		1	7
IV-B	21		2			
V	10			3		
VI	15		1		1	2
VII	7				1	
VIII	22			8		
IX	21	6				13
X	25			1		1
XI	37					1
CARAGA	83	3	3	9		
CAR	24					4
TOTAL	404	25	36	31	4	28

20% of the kitchen waste is treated through composting or given as food to animals. The rest is disposed of. On the other hand, garden waste is mostly disposed of (57%) or burned (32%), and only 11% is recovered.[14]

With regard to the treatment and disposal of residual waste, the Philippine Clean Air Act of 1999 (R.A. 8749) prohibits open burning, and "only state-of-the-art, nonburn thermal treatment technologies" are acceptable. R.A. 9003 also mandates the establishment of controlled dumps and eventually a sanitary landfill for waste disposal.

While open dumping is the general method of waste disposal practiced in the country, communities and establishments had a deadline of 2004 to close open dumps or convert them into controlled dumps. About 1,607 LGUs around the country are operating and maintaining temporary or permanent dumpsites.[15] According to the NSWMC, as Table 7.9 shows, 404 open dumps, 36 controlled disposal facilities, and 4 existing landfills were in use in 2001–03.

Infrastructures for Solid-Waste Management

Based on R.A. 9003, LGUs need to put up or establish several waste facilities such as materials-recovery facilities (MRF) for processing recyclable and biodegradable waste and waste-disposal facilities. There are currently 618 MRFs servicing 692 barangays. It should be

[14] Eugene Bennagen et al. *Solid-Waste Segregation and Recycling in Metro Manila: Household Attitudes and Behavior.* EEPSEA, 2003.

[15] Based on the World Bank Study, 2001.

pointed out that these numbers are only from the 52 LGUs that the NSWMC is monitoring. Hence, there may be more MRFs established that are not yet reported to the Commission.

The LGUs have established different types of facilities, since the municipalities/cities constructed MRFs based on their needs. It may be a centralized composting with recycling, or only centralized composting, or only barangay recycling, or market composting, or communal bins at the barangays. Due to lack of set guidelines, the establishment of MRFs is left at the discretion of LGUs. The cost of establishing MRFs varies depending on the LGU budget. Even the type of materials used is not specified. LGUs who have the budget go for concrete materials while those with budgetary constraints construct their MRFs from bamboo or coconut lumber.

In terms of waste-disposal facilities, municipal solid waste is generally disposed of in open dumpsites.[16] So far only a few have facilities for controlled dumpsites or sanitary landfills (see Table 7.9). Section 37, Article 6 of R.A. 9003 mandates that all open dumpsites should have been converted into controlled dumpsites by January 2004, prompting more LGUs to convert their open dumpsites to controlled dumpsites. The Commission, through the Integrated Bar of the Philippines, has started filing cases against LGUs that violate the provisions of R.A. 9003. Around the country, three LGUs have established operating sanitary landfills: Metro Clark Sanitary Landfill, Capas, Tarlac; Cebu City Sanitary Landfill; and Bais City Sanitary Landfill in Negros Oriental.

At present, Metro Manila has ten disposal facilities: Catmon, Malabon; Rodriguez, Rizal; R10 Vitas, Tondo/Pier 18, Manila; Bagumbong (municipal), Caloocan City; Tanza Navotas; Doña Petra, Marikina; Lupang Arenda, Taytay; Pulang Lupa, Las Piñas; and Barangay Lingunan, Valenzuela. The Payatas dumpsite in Quezon City only accepts waste generated by Quezon City while Doña Petra is in the process of closing. Most of these dumpsites, however, were active until 2004. See Table 7.9 for related information.

It is realized that the cost of constructing new waste-treatment and disposal facilities would place an additional burden on the municipal/city budget, so some LGUs have started to develop and implement sustainable funding mechanisms such as garbage-collection fees for households or institutions, fines and penalties, tipping fees for the disposal facilities, sale of recyclables and compost fertilizers, special-waste collection, and leasing MRFs to private individuals. Table 7.10 shows some examples of LGUs that are collecting user fees (funding mechanism). The use of transfer stations is not common in the Philippines.

GP Practices and Other Proactive Measures

Waste Minimization, Reuse, and Recycling Practices:
Initiatives of Various LGUs, NGOs, and Other Groups

Paper, scrap metal, and clean glass bottles and cullets have traditionally been segregated, traded, and recycled. Big companies are actively buying these recyclables, for example, M/S. San Miguel Corporation buys clean glass and cullets and M/S. TIPCO buys paper. Both are mostly monopoly buyers of such materials. Several medium-size companies in Luzon and Cebu melt scrap metal. In addition, the NSWMC is expanding the recycling activities with tire manufacturers and intensifying the buying of polyethylene terapthalate (PET) by the PET Task Force and San Miguel Corporation. Likewise, the NSWMC has set up more redemption centers for recyclable materials like aluminum cans, bottles, tetra packs, polypropylene (PPs), batteries, and others. Various shopping malls, groceries stores, schools, and other large establishments are already serving as redemption centers for these materials.

Plastic recycling is one of the most interesting concerns of environmentally conscious

[16] Ibid.

Table 7.10: Examples of Funding Mechanisms Applied by LGUs

LGU	Funding Mechanism	Remarks/Description
Olongapo City	Garbage collection fee collected monthly and attached to electric bill Disposal fee for transients/visitors to the city who dispose of their waste at specified collection points User fee at the landfill area Service charge for annual inspection of junk shops through the issuance of a decal permit	Variable rate for residential and non-residential, based on land area (sq meters) and/or type of business Rates differentiated according to vehicle, e.g., bus, car, jeep, boat, etc. Volume-based rate (per cubic meter) Decal permits issued to junk shop operators
SBMA	Tipping fees for disposal at USD15 per 15 m^3 Garbage collection fees/monthly billing; bag system of USD1 for commercial and industrial establishments Flat fee of USD10/month for residents Special collection fees at USD30	Collected by SWM office
San Fernando, La Union	Monthly garbage fee at PHP20–30 per household Subsidies from the IRA for collection and disposal	Currently practiced in only 1 barangay
Marikina	Income from MRF lease rental by a private business (PHP75,000/month) PHP600 annual garbage fee for households incorporated into the property tax; 50% discount if paid fully within the first quarter of the year	Originally city administered but was losing money; turned over to a private contractor Revenue generation dependent on the efficient collection of real property tax; does not cover residents who do not own real property
Dumaguete City	Variable waste collection fee using tags or trash bags Dumping fee for biodegradable waste at PHP15 per m^3, nonbiodegradable at PHP30 per m^3	
Silang, Cavite	Flat rate for households Variable rate for business/commercial establishments based on gross income and attached to business permit	Fees not enforced due to failure in defining the collection mechanism Variable rates not pegged on volume of waste generated; therefore does not have any impact on source reduction

(continued on next page)

(continuation)

LGU	Funding Mechanism	Remarks/Description
Tacurong	Monthly garbage collection fee at PHP35 per household Tipping fees at the dumpsite area to be collected from barangays and private contractors Charges for the collection and disposal of bulky waste Environmental management fees for special events such as a fiesta or fair: PHP50 per stall MRF income from recycling and compost Grants and donations from other government agencies, NGOs, civic organizations	Planned for 2004, year 2 of the Ten Year Plan

people, as plastic is considered a major cause of the worsening garbage problems such as flooding due to clogged canals and street litter because it is not biodegradable. The recycling of both scrap and post-consumer plastic products is usually done by the manufacturers themselves such as M/S Moldex Products, Inc., and Marulas Industrial Corp. These companies, however, are not involved in processing the waste into new products, but simply melt the plastic waste and transform it into granules or pellets that are sold to other companies that make toys, bins, containers, etc.

Lead recycling, on the other hand, is something not well known to many people. Several local companies have been recycling lead from used car batteries. One of the leaders in this field, Philippine Recyclers, Inc., recycles scrap batteries to recover the lead which is subsequently used in the manufacture of new car batteries.

Other companies are also involved in specialized recycling. Philippine Moulded Pulp Products, Inc. is a pioneer in the production of egg trays and cartons that are made of 100% recycled paper from way back in 1977. Through the Philippine Polystyrene Recycling Corporation, established by Polystyrene Packaging Council of the Philippines, polystyrene food packs are now being processed into plastic blocks that are exported to China and Hong Kong for recycling. The HMR Group of Companies has set up its own recycling facility, HMR Envirocyle, Inc., that collects and recycles electronic equipment and appliances such as computers, telephones, fax machines, television sets, ovens, etc. Hewlett-Packard of the Philippines collects print cartridges and ships them to a recycling plant in Singapore. Nokia Philippines has launched its collection and recovery of old cellular phone units and accessories and also ships them to Singapore for recycling.

The Role and Significance of Small and Micro Enterprises in Solid-Waste Management

Scrap shops have set up satellite branches even in the remotest barangays. In the 2001 World Bank Report, an NGO, *Linis Ganda* (literally, clean is beautiful) organized the Federation of Multi-Purpose Cooperatives. It is an alliance of more than 500 scrap shops that employ Eco-aides to conduct recycling activities. In 2000, they reportedly purchased 101,850 tons of waste paper, corrugated boards, cullets, plastics, and metals worth PHP132.5 million. But this is only about 4.5% of the total waste generated in Metro Manila. Elsewhere in the Philippines, scrap shop operations have grown rapidly, especially in the commercial business districts. Estimates have shown that trade in waste materials has increased in volume by 39% and in value by 47% in 2000 compared to 1998.

Other efforts on waste recovery initiated by the private sector have also been considered effective. Now in its third year, the annual Earth Day Recyclable Collection Event (RCE) is organized by Philippine Business for the Environment (PBE), Ayala Foundation, Inc. (AFI), and Laguna Industrial Estates' By-Product Exchange Program. More than 26,000 tons of recyclable materials, equivalent to 197 m^3, were recovered. More than 108 companies, organizations, and individuals participated in the RCE at five locations. PBE reported that the activity had a multiplier effect and more private groups and organizations have started planning to organize similar events. Table 7.11 shows the economics of waste recovery in Metro Manila.

Incentives and Disincentives for Waste Minimization, Reuse, and Recycling

The World Bank study revealed that LGUs allocate between PHP12 to PHP250 per person for solid-waste management. LGUs allot about 1.2% to 11.7% of their total budget for SWM. Given the considerable amount needed for the service, LGUs need to look for additional sources for funding. R.A. 9003 specifies that fees shall be levied on all waste generators for SWM services. Fines and penalties are also set for any violations. All revenues from the implementation of the law accrues to SWM funds (both national and local) earmarked to support research and development, provide awards and incentives, provide technical assistance, and conduct training, education, communication, and monitoring activities.

R.A. 9003 offers various incentives for LGUs, enterprises, private entities, and NGOs to encourage their active participation. These include tax and duty exemptions, a tax credit on domestic capital equipment, provisions and grants to LGUs to improve their technical capabilities, and incentives to communities hosting shared treatment and disposal facilities. As an additional support, the Department of Trade and Industry is to prepare an inventory of existing markets for recyclable materials and compost. The ESWM Act also stipulates that procedures, standards, incentives, and strategies should be specified to develop local markets for recyclable materials and compost. The act places restrictions on the use of environmentally nonacceptable packaging materials.

To encourage the participation of the barangays in SWM, the DENR launched the Nationwide Search for the Model Barangay in Eco-Waste Management. More than 500 entries were received in the search which was based on a rating system that determines the degree of compliance with the requirements of R.A. 9003. Cash prizes ranging from PHP100,000 to PHP1,000,000 and presidential trophies were given to the model barangays.

Table 7.11: Economics of Waste Recovery in Metro Manila

Year	Tons Purchased	Value (million PHP)
1998	69,400	95.2
1999	95,600	124.5
2000	101,850	132.5

Source: *Report of the Metro Manila Federation of Environment Multipurpose Cooperative*, Bong Teves, March 2001, as cited in the *World Bank Philippines Environment Monitor 2001.*

Future Strategies

The country's solid-waste management program is now largely based on R.A. 9003. Hence, the plans and policies for the coming years will be guided by that law. Since most LGUs are not yet compliant with the provisions of R.A. 9003, the following provisions will be target goals by them.

- Development of a 10-Year SWM Plan consistent with the National Solid-Waste Management Framework. The plan should emphasize the reuse, recycling, and composting of waste generated within their jurisdictions. It should include a program and implementation schedule indicating the methods and strategies adopted by the LGUs. The LGUs in combination with source reduction, recycling, and composting will also reduce the amount of waste disposed in accordance with the required waste-diversion goal. The plan should also identify existing and proposed disposal sites and waste-management facilities.
- Diversion of at least 25% of all solid waste from waste-disposal facilities through reuse, recycling, composting, and other resource-recovery activities within five years. The waste-diversion goals will be increased every three years thereafter.
- Establishment of a materials-recovery facility (MRF) in every barangay or cluster of barangays.
- Closure of existing open solid-waste dumps or their conversion into controlled dumps, and eventually to a sanitary landfill.
- Development of a sustainable funding mechanism sufficient to pay the costs of preparing, adopting, and implementing an SWM plan.
- Development of procedures, standards, and strategies for promoting the use of recyclable materials and local markets for recycled goods.

National Strategic Plan for Solid-Waste Management

Under R.A. 9003, the NSWMC was created to prescribe policies that will effectively achieve the objectives of the law as well as oversee the implementation of appropriate solid-waste management plans by end-users and local governments. Chaired by the Secretary of Environment and Natural Resources, the NSWMC is composed of 14 members from the government sector and three members from the private sector. The organizational structure of the Commission is shown in Figure 7.3.

Currently, the National Solid-Waste Management Commission has drafted the National Framework for Solid-Waste Management which integrates social, political, economic, and technological aspects toward the development of ecological solid-waste management as provided in Republic Act 9003. The framework is built along three principal dimensions: the scope of waste-management activities (answering the question "What?"), the critical actors and partners to implement SWM activities (answering the question "Who?"), and the means of implementing the SWM activities (answering the question "How?").

The salient features of the framework are: to create the awareness and participation of all sectors of the society in waste management, to establish the National Ecology Center that will provide information, research, database, training, and networking services to the target clients (LGUs), to provide basic information on the current state of the Philippine solid-waste situation, the national policies on solid waste, and the key approaches and actors on solid-waste management. The emphasis, however, is focused on the role of the LGUs in the implementation of the program, and the formulation of SWM plans at the local level.

There are three major aspects in waste handling cited in the national framework. They are as follows.

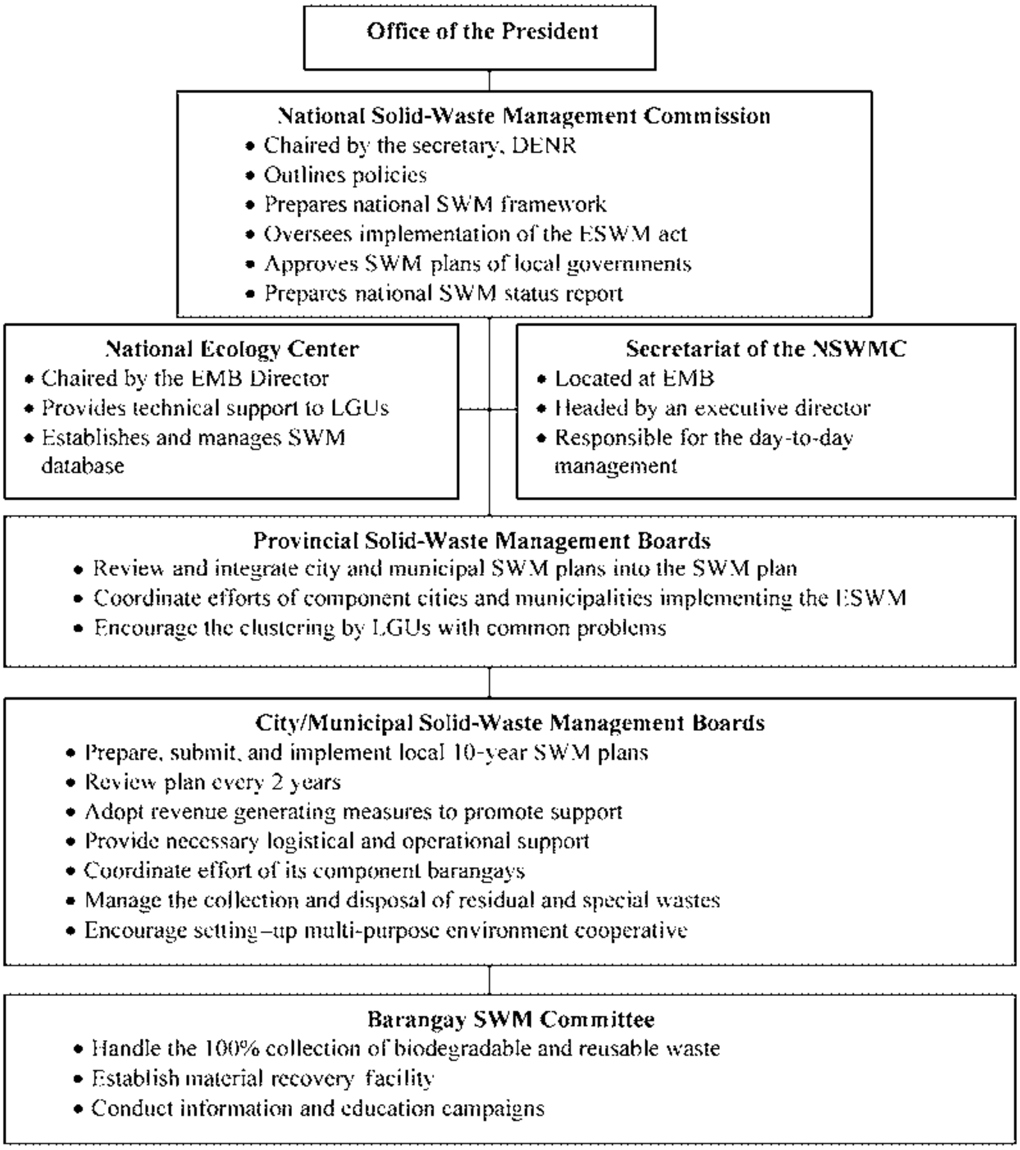

Figure 7.3: Organizational Structure of the Commission
Source: World Bank Philippines Environment Monitor 2001.

- *Recycling and Recovery:* Recycling is important in waste minimization, particularly recovering recyclable waste and composting biodegradable waste.
- *Collection and Transport:* Effective collection and transport will lessen unauthorized dumping which causes flooding.
- *Disposal:* The establishment of appropriate waste-disposal sites such as landfills. LGUs are also one of the main concerns of the framework.

CASE STUDY

The Ecological Solid-Waste Management Program of Makati's Central Business District is an expansion of the Ayala Foundation, Inc. (AFI) Solid-Waste Management Program (SWMP) that was launched in 1993. The SWMP was a component of AFI's four-year Makati Development Program funded by the United States Agency for International Development (USAID) that was initially carried out in 18 villages in Makati City.

After the completion of the Makati Development Program, the Ayala group of companies, through AFI, adopted the SWMP to promote corporate social responsibility for the environment. The SWM Donor-Beneficiary Scheme became one of AFI's mainstay programs until 2001 when the project saw the opportunity to expand in the whole Makati Central Business District (MCBD). MCBD is the country's premier business district established in the 1960s by Ayala Corporation, one of the oldest, largest, most respected, and most widely diversified conglomerate corporations in the Philippines today.

The passage of R.A. 9003 provided the legal framework to push for a full-blown program expansion. In March 2001, the Management Association of the Philippines (MAP), through its subcommittee on SWM chaired by Fernando Zobel de Ayala, the Executive Managing Director of Ayala Corporation, supported the program and endorsed its implementation to its members in MCBD.

City Profile/Regional Profile

The city of Makati is Metro Manila's premier city, being the business and financial capital of the country. It plays host to the headquarters of multinational companies and the Philippines'

Box 7.2: AFI'S SWM Program

AFI's SWMP sought to "Coordinate the efforts of the government, business sector, and NGOs in managing the ecological problems in Makati, focusing on the proper management of solid waste."[a] It encouraged the communities to sort their solid waste at the source and to reuse or sell the materials that could be recycled. Through its information, education, and communication (IEC) campaign, people were informed of the impact of the improper management and disposal of solid waste and trained in ecological solid-waste management and disposal through segregation, recycling, and composting.

A mid-term program review in 1996 opened the opportunity to involve the businesses and commercial establishments in SWM. As generators of a large volume of solid waste that is mostly recyclable materials, these establishments have become partners of the developing communities as donors of recyclable materials. This started the SWM Donor-Beneficiary Scheme that forged the partnership of four Ayala owned and managed buildings and four community beneficiaries. The commercial-establishment complex, Ayala Center-Makati later participated in SWM by adopting the scheme and became a donor to one community. The community beneficiaries were able to find a source of livelihood, and each community beneficiary, with 2 to 4 households as direct beneficiaries, earned a monthly income ranging from PHP8,000 to PHP15,000 (USD145.50–272.70).[b]

[a] *AFI's Vision, Mission, Goal for MDP Environment Program.*
[b] Based on USD1 = PHP55 exchange rate.

Box 7.3: History of Makati
In early 1970, Legaspi Village was created, followed by Salcedo Village. High-rise buildings started to be constructed in 1990 after the restriction on their construction was waived. Since then the area has been popularly known as the MCBD. Corporations there generate almost 100,000 jobs for residents and nonresidents alike. This 118 hectare area, expanding its coverage into three barangays, is composed of 371 buildings: 242 office buildings, 27 residential condominiums, 78 mixed-use (office and residential), 5 churches, 3 schools, 4 embassies, 2 hospitals, 2 hotels, 3 car-park buildings, 2 gas stations, 2 library/cultural centers, and 1 sports club. The district also includes 2 commercial complex/malls consisting of 38 buildings: 2 mixed (office and retail), 30 retail, 6 residential (4 hotels, and 2 service apartments). There are 250 food stores and restaurants, and 700 nonfood retail shops.

top corporations, the Philippine stock exchange, prime banks, five-star hotels, foreign embassies, plush condominiums, and posh villages.

The history of Makati[17] dates back to 1571 when the Spanish expedition leader Don Miguel Lopez de Legaspi first set foot on it and gave it its present name, derived from the Tagalog phrase meaning "ebbing tide." A large portion of Makati used to be grassland, prone to flooding from the Pasig River. When the Ayala family came to own the land in 1834, it was mostly a cattle ranch. Much later, the main airport of Manila was also situated among ranches. The urbanization of the area started in 1962 along the three major arteries of Makati: Ayala Avenue, Paseo de Roxas, and Makati Avenue.

Solid-Waste Generation, Composition, and Quantification

As a business and commercial area, MCBD contributes 4% to Metro Manila's voluminous solid waste. Its population of less than half a million swells by daytime as tens of thousands of people report to work, do business, dine, and shop.

Sources

There are nine categories of sources of solid-waste generation identified. Table 7.12 shows the sources and per capita waste generation.

Composition

Based on the waste characterization of three sample buildings, residential, office, and commercial, conducted by AFI in 2002, the average volume of general classification waste showed that recyclables equaled 27.80%, compostable/food waste equaled 26.47%, and residual waste equaled 45.73%. In the commercial center, with 35% of its merchants food stores or restaurants, the volume of food waste or pig slops was a high 18% in the waste stream. The rest comprised: recyclables, 14%; compostable, 12%; and residual waste, 56%. The waste composition of the commercial center is shown in Figure 7.4. The solid-waste composition of office and residential buildings is shown in Figures 7.5 and 7.6 respectively.

Quantification

The waste-composition survey of Metro Manila in 1997[18] showed that Makati City generated the highest amount of waste at 0.44 kg/capita/day, or approximately 550 to 600 tons/day

[17] www.makati.gov.ph.
[18] WACS conducted by JICA and MMDA, 1997.

Table 7.12: Sources of Waste and Per Capita Generation

Category	Unit	Quezon City	Makati	Parañaque	Average
High income	gm/capita/day	465	553	483	500
Middle income	gm/capita/day	449	432	473	451
Low income	gm/capita/day	372	340	321	344
Restaurant	gm/shop/day	15,824	41,732	6,939	21,318
Other shops	gm/shop/day	1,688	2,150	1,618	1,818
Institution	gm/capita/day	59	101	57	72
Market	gm/shop/day	4,065	3,945	13,774	7,261
Street sweeping	gm/km/day	10,560	19,010	2,535	10,702
River	gm/km/day	41,555	3,595	9,035	18,062

Source: WACS conducted by JICA Study Team in 1997.

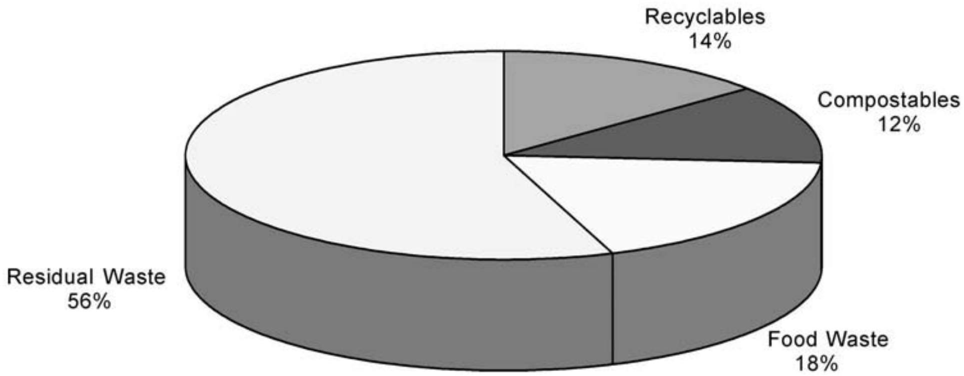

Figure 7.4: Solid-Waste Composition of the Commercial Center

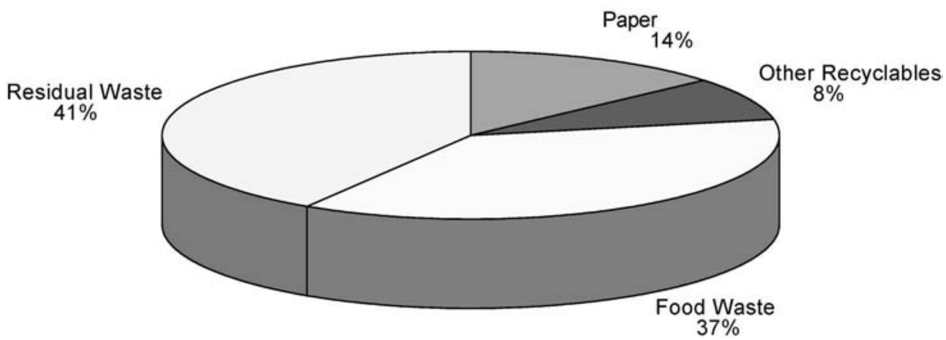

Figure 7.5: Solid-Waste Composition of Office Buildings
Source: Ayala Foundation, Inc. *Waste Characterization Study*, 2002.

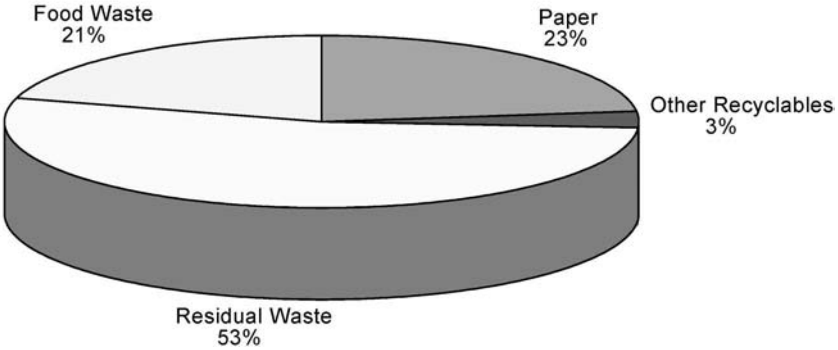

Figure 7.6: Solid-Waste Composition of Residential Buildings
Source: Ayala Foundation, Inc. *Waste Characterization Study*, 2002.

or 3,000 m^3/day. The MCBD generates about 240 tons/day, which is almost half of the Makati city's total waste generation. This amount increases by at least 30% to 40% during holiday seasons, particularly in the commercial center. The MCBD therefore plays a crucial role in the total waste-reduction program of Makati City.

Key Elements of SWM

Makati City contracted private companies for the collection and disposal of domestic waste. They collect about 80% of the domestic waste generated.[19] The business and commercial establishments have also taken the responsibility of solid-waste collection and disposal by hiring a private contractor/hauler to provide the required services. Solid-waste trucks usually go from building to building during the night, with a detailed route map as their guide. The private contractors make use of the existing government disposal facilities such as the Rodriguez controlled dumpsite in Montalban, Rizal as final destination of the collected solid waste.

The MCBD Solid-Waste Management Program

The MCBD's solid-waste management program addresses the need to educate building occupants and commercial establishments to help protect the environment through waste reduction by segregation, recycling, and composting. It also provides a venue for businesses to express corporate social responsibility by managing their own waste properly while providing income opportunities from the sale of recyclable materials and realizing savings in solid-waste handling and management. The recovery of materials for recycling also helps the environment and the economy as it enables the conservation of natural resources and the optimization of dollar reserves by providing local supply instead of import. The MCBD's solid-waste management program was developed with the following objectives: reduce the generated residual waste in the MCBD to 25% in 2 years, demonstrate private sector capabilities in addressing environmental and other developmental efforts, and to serve as a showcase and model environmental program in a commercial/business area.

Institutional Linkages and Partnerships

The SWMP banks heavily on strong partnerships with major stakeholders and other partners. Each is indispensable in the waste-management process, as they have specific tasks to

[19] Asian Development Bank. *The Garbage Book*, 2004.

Box 7.4: Environmental Regulations and Compliance for SWM Program

Although the SWM program was already a strong advocate for corporate social responsibility, government regulations and legislation provided the legal framework to compel the target participant establishments in the program. These are:

- Presidential Decree No. 825, Garbage Disposal Law, 1975;
- Presidential Decree No. 856, Sanitation Code, 1975;
- Presidential Decree No. 1152, Philippine Environmental Code, 1978;
- Republic Act 8749, The Clean Air Act of 1999; and
- Republic Act 9003, Ecological Solid-Waste Management (ESWM) Act of 2000.

Before the enactment of the R.A. 9003, the SWM program also relied on some local regulations that helped to push for program enforcement. These are as follows:

- Municipal Ordinance 93-299, Municipality of Makati;
- MMDA Regulation 96-009; and
- MMDA Regulation 99-004.

The enactment of R.A. 9003, however, superseded all the other legislation on SWM. In support of R.A. 9003, the City of Makati has likewise enacted City Ordinance No. 2003-095, which adopted the Makati City Solid-Waste Management Code and provided penalties for its violation, subject to all laws and existing legal rules and regulations. Subsequently, the Barangay Councils of San Lorenzo and Bel-Air issued Barangay Ordinances adopting the same framework as mandated by the ESWM Act. The different associations, administrations, and establishments have similarly issued various Memorandum Circulars to all their members and tenants adopting the R.A. 9003. Some even incorporated the guidelines to their existing house rules and company policies. Guided by these regulations, the establishments have achieved an 80% compliance rate.

ensure the successful implementation of the program. The core partners provide oversight and overall management to the program. They consist of Ayala Land, through its property manager, the Ayala Property Management Corporation (APMC); the Ayala Center Association (ACA), the association of tenants and establishments in the Ayala Center, Makati; the Makati Commercial Estate Association (MACEA), the association of office and residential buildings in the MCBD; and the Ayala Foundation. The implementing partners consist of the building owners and CEOs, the building administrators and administrative staff, the collectors of the segregated materials, and the Makati City chapter of the Metro Manila Federation of Environment Cooperatives.

Project Coordination

In 2000, Ayala Corporation's Co-Vicechair, Fernando Zobel de Ayala, served as Governor, Co-Chair of the Environment Committee, and Chair of the Solid-Waste Management Subcommittee of the Management Association of the Philippines (MAP). The MAP is a 52-year-old association of more than 700 chief executive officers and other top management practitioners of leading organizations in business, government, and civil society in the Philippines. Immediately after Fernando Zobel de Ayala (FZA) assumed the Chairmanship of the

Box 7.5: Institutional Linkages and Partnerships
The resource partners provide the necessary training and technical assistance to the program implementers and provide inputs in the preparation of informational, educational, and communication materials. Among them are: • Solid-Waste Management Association of the Philippines, • Environmental Studies Institute of Miriam College, • Zero-Waste Recycling Movement of the Philippines, • Polystyrene Packaging Council of the Philippines, • Tetra Pak Philippines, Inc., • Mother Earth Philippines Unlimited, • United Architects of the Philippines, • Department of Environment and Natural Resources, and • Metro Manila Development Authority. • The advocacy partners such as Philippine Business for the Environment, Earth Day Network Philippines, Partnerships for Clean Air, etc. work with core partners for activities such as the Annual Earth Day, recyclables-collection events, recycling programs for specific materials, etc. These activities are all aimed at proper solid-waste management. These partnerships and linkages have brought valuable contributions to the success of the program while the partners are able to exercise what they are best at, such as training, advocacy, materials development, etc.

MAP Environment Committee's Subcommittee on Solid-Waste Management, he decided to start working in his own backyard, the MCBD. FZA formed a Task Force on Solid-Waste Management at the start of 2003 to design and implement a feasible and effective solid-waste management program that would start with waste segregation. The Task Force designed and initiated the SWMP to cover residential, commercial, and other establishments in the MCBD.

The Task Force (TF) members included designated management officers from Ayala Land, Inc., developer of the MCBD; Ayala Property Management Corporation, the property management arm of the Ayala Land, Inc.; the Ayala Center Association, a merchant association; Ayala Foundation, Inc., the social-development arm of the Ayala Corporation; and the Makati Commercial Estate Association, which represents buildings and properties in the MCBD.

Consequently, a Technical Working Group (TWG), represented by supervisors from the same organizations was organized by the TF to implement the plans and programs. The TF, through the TWG, serves as the coordinator among generators and collectors of solid-waste materials. It coordinates project implementation and ensures the continuing education and information campaign, including project monitoring, evaluation, and documentation. The TWG reports regularly to the TF.

The Process

In March 2001, through the Task Force, the program started a campaign to promote solid-waste management in the entire MCBD. Initially, 11 buildings (5 commercial and 6 residential buildings) managed by APMC became the pilot buildings. It was expanded in August to all MCBD buildings.

Box 7.6: SWM Program Project Coordination
While the Task Force is the key mover in getting things started in a building or establishment, the responsibility of keeping the project going falls on the building administration, by ensuring that the guidelines, schemes, and facilities for solid-waste segregation, collection, and disposal are strictly enforced. Two players hold vital roles in the program implementation. At one end are the building occupants and tenants who segregate the recyclable materials and donate or sell them for recycling. At the other end are the collectors or buyers who consolidate the recyclable items further and bring them to the recycling facilities. To facilitate segregation at the office and building levels, the building administration is required to put in place infrastructure supports such as separate containers or compartmentalized depositories for the different types of waste and provide a space for the temporary storage of recyclable materials or the composting of biodegradable materials. The building administration is also expected to oversee compliance by its tenants once the orientation sessions are conducted and the systems are put in place. The TWG, through the AFI, conducts orientation seminars on solid-waste management for building personnel and tenants who decide to implement the project. The orientation covers the basic principles of solid-waste management, clarifies the roles of the administration, building maintenance and cleaning staff, and tenants. It also lays down systems and procedures for proper waste segregation and disposal. Seminar participants from offices include administration officers and staff. For residential condominiums, unit owners and domestic help were enjoined to attend. As a requirement of the IEC campaign, the foundation is also in charge of the conceptualization, development, production, and distribution of materials such as brochures, posters, training manuals, and newsletters. Seminars and workshops are also conducted for building administrators to provide updates and to gather inputs to enhance the project's implementation.

In order to facilitate an effective system for the collection of segregated waste, a tie-in with the group of scrap shops under the Metro Manila Federation of Environment Cooperative was arranged. The whole MCBD was divided into 13 clusters according to geographic location. Eight members of the federation were assigned and tasked to do the collecting from the buildings in a specific cluster. The bigger clusters were assigned to bigger scrap shops. The scrap shops maintain a regular face-to-face contact with the building personnel and administrators. Their role in most cases is not just limited to buying the recyclable materials, but they also act as trainers by promoting and teaching waste segregation to the administrative staff and security guards from the buildings. The organizational structure of MCBD's SWM program is shown in Figure 7.7.

Some Difficulties

The biggest hurdle to the program's implementation is getting the buildings and establishments to participate. From a strictly business point of view, it's still simpler, cheaper, and more efficient for a building to dump all its waste together and allow its waste contractor to do the sorting, transporting, and dumping. Proper waste segregation requires manpower, space, and segregation equipments, the costs of which cannot be offset by the revenues generated

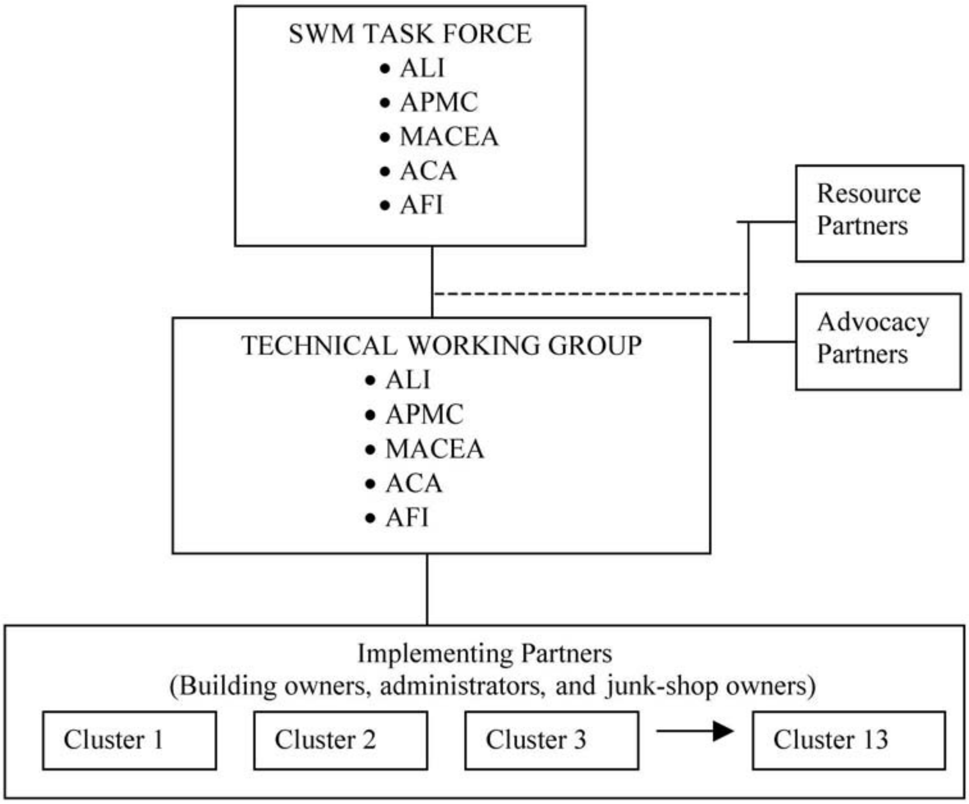

Figure 7.7: Organizational Structure of the MCBD SWM Program

from the sale of recyclables or by the reduction in waste-handling and disposal costs. On the other hand, there have been stories of buildings, establishments, and even hotels that have started generating enough revenue and savings to cover SWM related costs, which only proves that solid-waste management is viable, a good business practice, and does present good business sense. The flow chart of MCBD activities is shown in Figure 7.8.

One of the convenient excuses for not participating fully in the solid-waste management program is the physical set-up limitations of the buildings. There are buildings that do not have enough spare space to accommodate segregation receptacles, sorting areas, and storage areas. Moreover, every inch of space in prime Makati area is just too expensive for buildings to allocate to SWM. Organizations would rather turn this space into an income-generating facility such as a rent-producing storage area or office space. In buildings where composting is recommended, lack of space for the composting equipment is the usual reason that hinders a composting project. Such problems were addressed with the partnership of the United Architects of the Philippines (UAP), Manila Corinthian Chapter, a major partner in the preparation of architectural design manuals for integrating solid-waste management facilities into building designs. With inputs from the Ayala Group, the UAP has devised ways to retrofit existing buildings for "SWM readiness," and developed standards to be considered in designing new buildings to make them SWM compliant. The design manual serves as an effective tool for advocacy, to

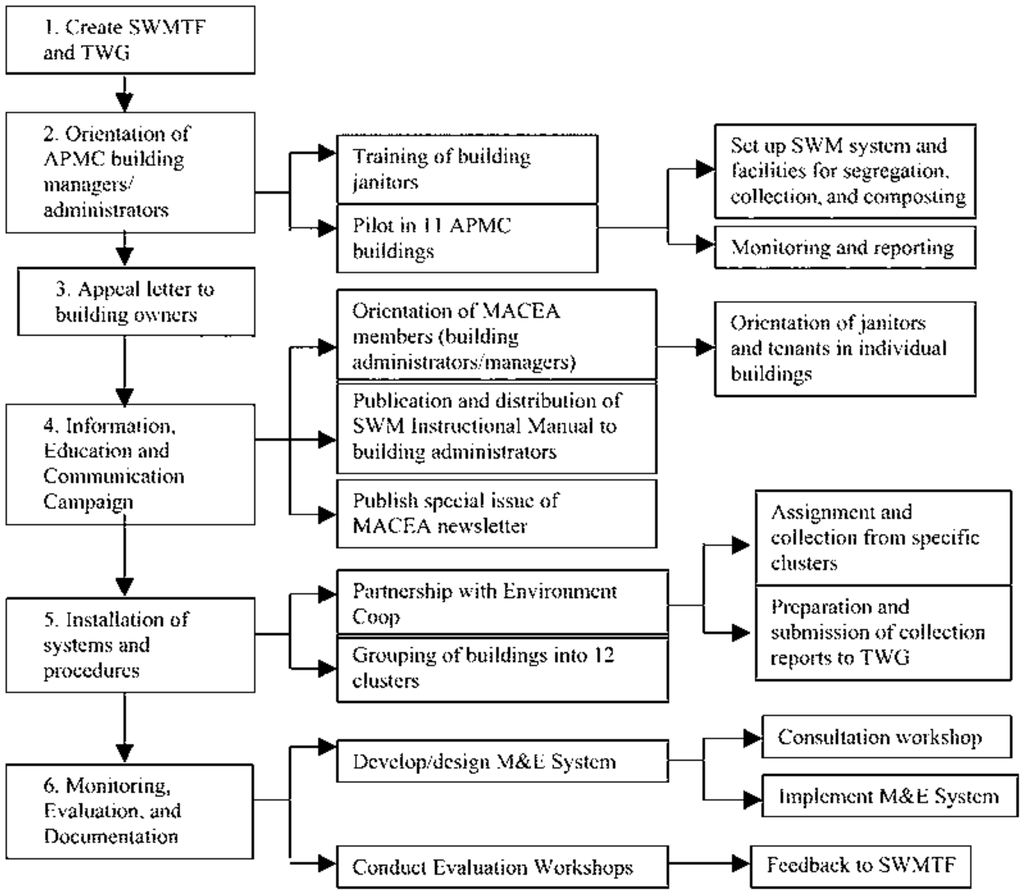

Figure 7.8: Flow Sheet of the MCBD SWM Program

convince building owners and administrators to adopt SWM practices, because it is technically sound and addresses real problems preventing proper SWM.

The Results

The project was carried out in varying degrees and the extent of implementation varied for each building. The extent of cooperation depended on several factors.

- The buildings had different facilities and procedures for disposing of their waste. In some buildings, the storage space was big enough to allow separate compartments for different types of waste. In other buildings, there was a single storage area for all waste, and constructing a new storage area would have required new financial allocations by the building owners.
- While building occupants observed waste-segregation procedures after a seminar, they tended to forget the procedures after a while. Ayala Foundation would then conduct repeat seminars, but the building administration plays a crucial role in sustaining project implementation and eventually incorporating it in the building's house rules and regulations.

- Some buildings have dropped out of the program for various reasons. Some buildings found a nonaccredited buyer that pays higher for the recyclables because the administrators had simply passed the responsibility of disposal to their cleaning and maintenance persons. Other buildings stopped implementing it due to a change of administration, or loss of interest, or simply because the building administrator lacked the commitment. In the final analysis, it came down to motivation or lack of motivation on the part of the implementers.

Nonetheless, the value of recyclable items that have been segregated and sold continues to increase, which means the efficiency of segregation and recovery has improved. The proceeds from the sale of recyclables go back to the buildings as project funds or cleaning and maintenance personnel special funds. In order to address the need to encourage a more active participation, intensify the IEC campaign, and ensure program sustainability, the TWG organized cluster teams and involved the active buildings as lead members in each cluster team. The formation of cluster teams is a strategy adopted for the assurance of continuous program implementation.

The program also achieved significant results. More than 200 buildings, or 56%, are now participating, while 80% of establishments in the Ayala Center are strictly complying in the segregation scheme. The policy of "nonsegregation, noncollection" of solid waste was very effective in attaining a good compliance rate. The volume of residual waste at the Ayala Center is now down to 36.25%, and it is down to 45.5% among the Ayala-managed buildings. Figure 7.9 shows that the volume of recyclable materials continues to increase while residual waste amount is continuously decreasing. For a commercial center, however, Figure 7.10 shows that the amount of recyclable materials is decreasing because merchants have learned to sell their own recyclable materials to generate income for their own companies, while the volume of residual waste is consistently decreasing.

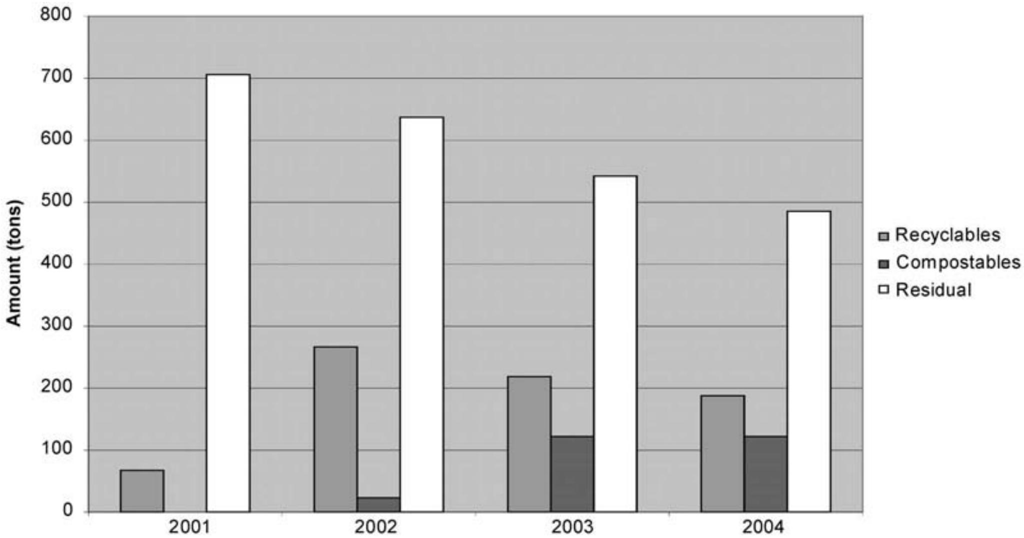

Figure 7.9: Amount of Segregated Waste in Buildings
Source: Ayala Property Management Corp. *Monitoring Reports, 2002–04.*

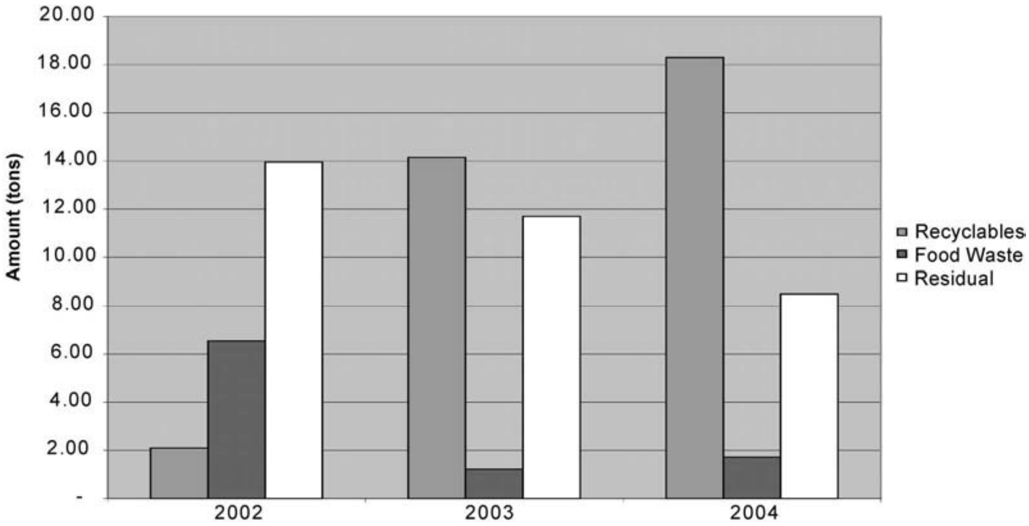

Figure 7.10: Amount of Segregated Waste in Commercial Centers
Source: Ayala Property Management Corp. *Monitoring Reports, 2002–04.*

The Impact

The SWM program helped to reduce the amount of residual waste that goes to the landfills. In the central business district, an average of 14% reduction of residual waste was noted. Until May 2004, the amount of assorted recyclable materials recovered was 2,025.6 tons, amounting to PHP6.14 million, approximately USD0.11 million from the participating buildings in a span of 4 years. Fifteen buildings have set up building-level composting facilities for biodegradable waste, further reducing the residual waste by 20%. These buildings use the compost materials for their own landscaping requirements.

The commercial center on the other hand, has noted a 56% reduction in residual waste (from 40 tons/day to 22 tons/day) from 1999 to 2001. This realized a 35% savings (PHP4.4 million or USD80,000) in the cost of waste collection and disposal fees. From 2001 to June 2004, the volume of residual waste was further reduced to 16 tons/day and 1,659 tons of recyclable materials was recovered. About 4.5 tons of compostable materials are carried to composting facilities daily.

Similarly, some have noted that waste segregation resulted in a cleaner commercial center, which is good for business. In some buildings, the waste-storage area used to overflow with trash bags and was a source of very foul smells if the waste collectors failed to collect at the scheduled time. Now the area does not overflow or smell even if the garbage trucks fail to come for two to three days.

The scrap shop operators also claim that the program has provided employment to the members of their communities. Indeed, they needed to hire additional personnel to attend to the increasing demands of collection and consolidation. Some scrap shops noted a decrease in the amount of recyclables they collect from buildings because the maintenance and cleaning personnel of tenant companies have started to sell them to their own contact buyers. It is a good indication that they have realized the value of proper solid-waste management and that they too can earn by selling their recyclables to scrap dealers instead of bringing them to the building's waste-storage bins.

The project's main objective of raising awareness of the solid-waste problem and what people can do about it is clearly and slowly being realized. The program also helps improve the image of participating buildings as responsible business establishments.

As a result of the program's success, the Ayala Foundation is looking at expanding its coverage to include all the business districts and commercial areas of Metro Manila. One way of reaching out to areas outside Makati City is through sharing the various materials produced—such as the SWM Program documentation, the instructional manual for building administrators and managers, the design manual for SWM facilities, as well as brochures, flyers, posters, and other related documents—with other business districts and commercial centers.

Budget and Expenditure

The LGUs expenditures on solid-waste management is solely for collection and transport, which varies from one LGU to another. The budget allocated by LGUs ranges from 5% to 24% of total expenditures, with an annual per capita cost ranging from PHP64 to PHP1,164 (USD1.16–21.16). Makati City bears the highest cost per capita for solid-waste management expenses. Table 7.13 shows the annual per capita SWM cost.

For commercial and business establishments, the cost of solid-waste collection and disposal depends on the prevailing collection fees set by the private contractors on a per-truck basis. It ranges from PHP3,000 to PHP6,000 (USD54.5–109.1) per trip. Specific to the MCBD, the solid-waste collection and disposal fee is based on the size of the floor area occupied by the building establishment, decided at PHP0.40/m^2 for the first 2,500 m^2 and PHP0.30/m^2 for

Table 7.13: Annual per Capita SWM Cost

LGU	SWM Expenses[a]	Total Population[b]	Per Capita Cost
Caloocan	357,077	1,190,087	300
Las Piñas	76,360	477,791	160
Makati	418,577	449,583	1,164
Malabon	22,067	342,447	64
Mandaluyong	94,123	281,426	352
Manila	574,990	1,597,841	360
Marikina	52,804	395,316	134
Muntinlupa	91,377	383,331	280
Navotas	43,974	232,845	199
Parañaque	182,893	454,579	402
Pasay	243,807	358,670	680
Pasig	160,458	510,412	314
Pateros	2,988	58,016	64
Quezon City	941,828	2,196,874	429
San Juan	46,701	118,927	436
Taguig	120,949	472,329	256
Valenzuela	42,716	490,579	109

[a] Total expenses for SWM, PHP000.
[b] *Source:* National Statistics Office, *2000 Census of Population and Housing.* A growth rate of 2.36% was used to estimate 2001.

every excess thereof. The building administration or association integrates the cost of solid-waste collection in the administration fees charged to tenants. Some of the business establishments noted that this practice is charging them double since a solid-waste management fee is also incorporated in the annual application for a business permit. The MCBD, with 6 trucks servicing 331 buildings, has a monthly expense for solid-waste collection and disposal of PHP1.02 million (USD18,574) while the commercial center allocates a budget of PHP1 million/month (USD18,1818/month).

GP and Other Waste-Minimization Approaches

Implemented Measure—Waste Minimization: Recent Major Initiatives and Plans by Sector

Waste-management activities have always attracted wide attention in the Philippines. There are a number of programs and activities undertaken by various sectors to implement the provisions of R.A. 9003. Some of them are the following.

- The League of Municipalities of the Philippines (LMP) has passed several resolutions for adoption by its members and committed a portion of the Municipal Development Fund to support the solid-waste management programs.
- The Department of Interior and Local Government (DILG) has required all municipalities and barangays to organize waste-management boards and committees through an executive order by the local chief executive and the barangay captains. As of 21 December 2003, 97% of the provinces have organized SWM Boards, 100% of the cities, and 88% of the barangays.
- The Department of Environment and Natural Resources is assisting 50 cities and municipalities that have embarked on the establishment and operation of ecological solid-waste management programs based on the provisions of the Ecological Solid-Waste Management Act. The LGUs are assisted in setting up materials-recovery facilities including composting. It should be pointed out that most of the LGUs that have expressed an interest in promoting the ESWM program have accomplished some initiatives (i.e., purchase of land for their controlled dumpsites, established an Environment and Natural Resources Office, etc.) using their own funds.
- The Industrial Technology Development Institute (ITDI) of the Department of Science and Technology (DOST) has initiated some research and development projects on recycling and composting technologies.
- Various donor agencies are also prioritizing solid waste as a project for LGUs by providing technical assistance, loans, grants, infrastructures, or equipment.
- Non-Governmental Organizations (NGOs) and citizen organizations such as the Zero-Waste Movement, Inc., the Solid-Waste Management Association of the Philippines, Centre for Advanced Philippine Studies, Ayala Foundation, Inc., and Mother Earth Unlimited, Inc. are also doing their share in promoting the provisions of R.A. 9003 by conducting training activities and producing IEC reading materials and video presentations.
- The private sector, made up of the business industries and recyclers (scrap shops and big recyclers), is also helping the government promote the provisions of R.A. 9003. Coca-Cola Bottlers Philippines, Inc. has initiated a recycling program for the collection of aluminium cans and PET bottles. The San Miguel Corporation established the first bottle-to-bottle PET recycling system in Asia in 2005. It is now promoting the program to future consolidators of PET, especially to LGUs. Other recyclers are also assisting interested LGUs in undertaking recycling programs for specific commodities like paper.

Paper mills like Trust International Paper Corp. (TIPCO), which uses 100% recyclable papers, are encouraging LGUs to collect waste paper, which TIPCO is willing to buy.
- Specific to Metro Manila, a Solid-Waste Reduction Master Plan (SWARM Plan) being funded by the President's Social Fund which was organized to implement an IEC and advocacy program on SWM in the six sectors: business industry, commercial centers, schools, barangays, subdivisions, and public markets.
- The Philippines Re-traders' Association is implementing and conducting an education campaign on tire care, maintenance, and proper re-treading techniques to reduce the volume of waste tires through proper vehicle operation and maintenance.
- The Packaging Institute of the Philippines is giving priority to research and development. It reviews packaging structural designs, available recycling technologies, biodegradability, and the presence of toxic elements in packaging materials. Similarly, the Philippines Retailers Association is encouraging its members to use biodegradable or 100% recyclable materials for their shopping bags and recyclable paper for storage, signage, and window displays.
- The Philippines Business for the Environment Industrial-Waste Exchange Program (IWEP) is preparing a database of (1) waste materials offered by participating companies and (2) waste materials that other companies are looking for. Guided by the principle that the waste of one industry can be the input of another, this program helps lower the cost of waste disposal, gives added income from the sale of waste material that has been regarded as valueless, provides a new source of cheaper raw materials, and prevents industrial waste from reaching the municipal waste-collection and disposal system.

NPO Strategies and Action Plan—Development Context

Many sectors of Philippine society have looked at and depended on the Development Academy of the Philippines (DAP) to chart new approaches and models on how to tackle current and future development issues, be they economic, political, social, or environmental. The DAP is the National Productivity Organization (NPO) partner of the Asian Productivity Organization (APO) in the country. As a premier development agency with a long history of hosting academic, technical, and practical forums tackling pressing national issues, the DAP is in a good position to act as a strategic-service provider toward addressing the SWM requirements mandated by R.A. 9003. The DAP established its Environmental Management Office (EMO) in 1990 and took part in drafting the implementation rules and regulations of R.A. 9003. The EMO advocated zero-waste management in the 1990s and shifted to Integrated and Sustainable Waste Management (ISWM) in late 1990s. The law requires all LGUs to upgrade their present SWM system, to institute ISWM system, including waste minimization, recovery, and the environmentally sound processing and disposal of residual waste.

Obviously, the LGUs have huge obligations and responsibilities in order to comply with R.A. 9003. In this regard, the DAP, which was active in broad-based discussions and learning exercises concerning ISWM issues prior to the promulgation of R.A. 9003 in 2000, can contribute significantly and effectively in bridging the gap between supply and demand of ISWM technical knowledge. It is hoped that addressing this gap will lead to proper ISWM planning and program implementation at the local level.

Future Strategies and Action Plan

Strategic Plan by the NPO

Vision: The vision of the NPO within the next decade is to build and project itself as a strategic-service provider to assist local governments and stakeholders in addressing ISWM issues. To accomplish this vision, the DAP has conceptualized a service-oriented strategy with three major action components: information resource development, human resource development, and institutional resource development.

Objectives and Action Plan

Information Resource Development

Objective: To strengthen local and national ISWM information systems for easy access and dissemination.

Actions:

- Conduct nationwide information and awareness campaigns to assist the DENR and the National Solid-Waste Management Commission in their efforts to raise the level of appreciation and understanding of R.A. 9003 and to make compliance with the law a national and local priority.
- Formulate an appropriate ISWM framework adapted to the Philippine setting and following the legal standards and mandate of R.A. 9003.
- Identify, demonstrate, and promote environmentally sound technologies and approaches and the use of economic instruments for waste minimization, recovery, reuse, processing, transport, and disposal.
- Develop an information resource center with a web-based interactive information database system for easy access by the LGUs.
- Develop ISWM training modules in two formats: one for regular seminars and workshops, and the second, a web-based format for long-distance learning by LGUs, NGOs, and other interested parties.
- Develop information resources, such as good practices in ISWM, that are useful to LGUs for dissemination to their stakeholders and constituency.

Human Resource Development

Objective: To strengthen the local government capacity toward integrated and sustainable solid-waste management and to raise the capacity and effectiveness of the LGU officers and staff in ISWM planning, implementation, and monitoring.

Actions:

- Conduct training-needs assessments among targeted LGUs to identify their HRD requirements. This will be useful for the DAP in formulating training modules.
- Assist the LGUs in formulating ISWM plans, conducting waste-characterization feasibility studies, and assessing SWM options in waste minimization, recycling, composting, transport, processing, and disposal.
- Design, conduct, and provide training workshops and distant-learning programs for capacity building.
- Assist economically underdeveloped and remote LGUs to obtain access to information tools and technologies like computers and related software and websites.

Institutional Resource Development

Objective: To raise the internal capacity and develop linkages, networks, and associations to establish a stable institutional-service infrastructure to fulfill its strategic vision.

Actions:

- Identify core partners in information-resource and human-resource development programs.
- Collaborate with other institutions to fulfill HRD and IRD objectives and planned actions, e.g., resource-center building, training, and capacity building.

- Develop an innovative graduate course program on ISWM using both traditional classroom and distant-learning methods with corresponding diploma and/or certification.
- Access, facilitate, and mobilize international and local funding support.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Solid-waste management is a major challenge in the Philippines. It is in a state of transition because of R.A. 9003, the Ecological Solid-Waste Management Act of 2000. Signed in January 2001, the law highlights the need to treat waste as a resource. The current need is to minimize waste through waste segregation, recycling, composting, and reuse.

The national government through the National Solid-Waste Management Commission (NSWMC) has the mandate to lead and guide the country by prescribing specific policies to achieve the Act's objectives, to assist the local government units and other government agencies, and to develop and implement specific plans and programs.

Among the major targets are to achieve 25% waste diversion through recycling, implement waste-segregation at its source, close open dumpsites that are harmful to health and environment, convert open dumpsites to controlled dumpsites within three years of the law's approval, and build sanitary landfills within five years.

Following the polluters-pay principle, the law provides the legal foundation for the LGUs to impose fees based on waste generation as well as fines and penalties for violations of the law. All revenues from the implementation of the law will be placed in an SWM fund and will be used for research and development; to provide awards, incentives, and technical assistance; and to conduct information sharing, awareness, education, communication, and monitoring activities.

The law recognizes the importance of public participation to achieve the objectives of the law. All the stakeholders—general citizens and the public and private sectors—have to do their part in managing waste. In this regard, the act encourages citizen to file administrative and criminal lawsuits against any person, government agency, or official who violates or fails to comply with the law.

In a way, the law provides a very good framework to guide the actions of all concerned. Many LGUs, NGOs, and other organizations have initiated SWM programs following R.A. 9003. However, the law's objectives and targets are not easily achievable on a nationwide scale. This is evident in the current state of SWM in many parts of the country, that is, low recycling rates, low collection efficiency, and the continuing operation of open dumpsites despite the prohibition deadline.

In short, there are many issues challenging the proper implementation of R.A. 9003. Many of these issues stem from the lack of political will among the national and local governments to implement the law. The issues are as follows.

Lack of sustainability of the SWM program: The term of office of the SWM board (provincial and municipal levels) is dependent on the term of office of the local chief executive (LCE). The board may be reorganized or reconstituted based on the political situation of the municipality or city. Its functionality is also dependent on the priorities of the LCE. Even the presence of an executive order creating the board is still not a guarantee that the board will function as planned. A challenge in this front is how to sustain the interest and participation of the members of the board including the barangay waste-management committees.

Vague and fragmented organizational structure: At present, many departments within a municipality implement most of the waste-management program. Hence, the coordination and communication in carrying out the SWM services between different departments is poor, resulting in uncoordinated schedules, delayed responses to complaints by residents, and the creation of either a gap or unnecessary overlapping in the provision of services.

Lack of planning activities including implementation of the Strategic Waste-Management Plan: Most local governments lack comprehensive plans as required by R.A. 9003. In these local governments, there are usually no clear goals for solid-waste management. The operation is reactive rather than proactive—equipment is purchased only when needs arise and funds are available. This lack of planning can be traced to inadequate information systems or databases that would be very useful in identifying the priority areas that require immediate improvement.

Choice of technology and equipments: Because of R.A. 9003, LGUs are offered the latest technologies and equipment from local and foreign suppliers. This creates problems for the LGUs because they often are rushed into buying these things without any assurance about parts and maintenance viability, as well as the technical skill needed for operation and maintenance.

Creation, monitoring, and enforcement of waste-management ordinances: One of the limitations of LGUs is the implementation of municipal ordinances and laws. Enforcement of an ordinance is assigned to the barangay *tanods* at the barangay level or police at the municipal level. Sustaining enforcement of waste-management ordinances is a major undertaking for a successful waste-management program. The incorporation of waste-management concerns in the administration of the municipality—such as business permits, building construction, procurement criteria, and procedures—needs a closer look. Assessment of the above-mentioned procedures may be necessary to institutionalize the waste management program in the locality.

Not-In-My-Backyard Syndrome: The NIMBY syndrome is a major barrier to locating waste-disposal facilities and the establishment and operations of materials-recovery facilities. At present some LGUs cannot establish waste-disposal facilities due to protests by communities that are concerned the facilities might lead to pollution, contamination, and other environmental hazards. LGUs without disposal facilities cannot share with other LGUs because their communities do not want to accept "other people's" waste, as in the case of metro Manila's garbage being brought to Quezon province.

Limited/inadequate budget for SWM program: The LGUs usually have a limited budget or no specific budget for their solid-waste management program. The LGU budget is generally allotted for household collection, transportation to open dumpsites, and minimal operation expenditures for disposal. Hence, LGUs are not able to fund other SWM activities such as IEC, training of personnel, etc.

Recommendations

Given these issues, there are still many activities to be undertaken and targets to be achieved. Clearly there is a huge gap between the intentions of R.A. 9003 and the present SWM situation in the country. As such, there are clear opportunities where the NPO, the Development Academy of the Philippines, can play a major role in bridging this gap. It is suitable for the DAP to position itself as a strategic-service provider to both the national and local governments. The services can be provided in capacity building, training, planning, information and knowledge sharing, and resource build-up and mobilization.

The following are action points invariably addressed to both DAP and the national government.

- Assist LGUs in developing their 10-year SWM plans.
- Provide more innovative incentives to LGUs to comply with R.A. 9003.

- Assist in accomplishing the education, enforcement, and engineering requirements of LGUs.
- Mobilize and provide a sustainable and affordable funding mechanism for MRF and disposal sites.
- Strengthen recycling in Visayas and Mindanao by providing incentives to recyclers to set up plants in these regions and to establish regional materials-recovery facilities to make the transport of recyclables economical.
- Study policy reforms in lessening or prohibiting waste imports to maximize local waste recovery.
- Find ways to export recyclables by studying export markets and trade conventions. Provide long-term incentives to the exporters of recyclable materials.

8. SINGAPORE

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INTRODUCTION

Singapore is a highly urbanized and industrialized city-state with a total land area of about 690 sq km. It comprises the main island of Singapore and some 60 smaller islands. Owing to the relatively small land area, land use has to be properly planned and controlled to ensure optimum usage and to minimize pollution.

Prior to 1979, all solid waste was disposed of by sanitary landfill in coastal swampy areas. As available landfill sites were limited and rapidly being depleted, other, more efficient disposal methods were needed in order to conserve the remaining landfill sites. Refuse incineration, which reduces volume by as much as 90%, was found to be the most cost-effective method of waste disposal in Singapore. The incineration plants were also designed as waste-to-energy plants. Electricity is generated for its own consumption and excess power is sold to the electrical grid. Ferrous scrap metal is also recovered from the incinerated residue for reuse.

Since 1979, Singapore has started to build incineration plants for the disposal of the country's refuse. There are currently four refuse incineration plants in Singapore with a total capacity of incinerating 8,200 tonnes of refuse a day. These incineration plants are owned and operated by the government. The fourth incineration plant was commissioned in 2000 and has the latest technology in refuse incineration. It has an incineration capacity of 3,000 tonnes of waste a day. Due to the constraint in land space on the mainland of Singapore, an offshore landfill was developed for the disposal of nonincinerated waste and ashes from the incineration plants.

In Singapore, all incinerated waste is diverted to one of its four incineration plants. The incineration process is capable of reducing the volume of raw waste by as much as 90%. The large reduction in waste volume is important as it preserves the limited land that would otherwise be required for landfilling raw waste. In 2003, about 2.3 million tonnes of waste was incinerated in Singapore. In addition, about 1 million m^3 of landfill space was required for incineration ash and nonincinerable refuse. If refuse had not been incinerated, even more land would have been required for landfilling.

Singapore has an efficient system of refuse collection and disposal. The long-term strategy in the management of solid waste is to seek the support of the public and private sectors to minimize waste generation and to reuse and recycle waste. Industries are actively encouraged to play an active role by reviewing their production and distribution processes with a view to "minimize, reuse, and recycle" waste.

COUNTRY PROFILE

Physiography and Climate

Singapore is an island city-state and the smallest country in southeast Asia. Situated between latitudes 1° 09′ N and 1° 29′ N and longitudes 103° 30′ E and 104° 25′ E, the main island of Singapore is about 660 sq km. It measures 43 km from east to west and 23 km from north to south. More than half of the mainland is urban area, while the remaining area is occupied by parkland, reservoirs, and nature reserves. Malaysia, Indonesia, and Brunei are Singapore's immediate neighbors. Being very close to the equator, Singapore's climate is characterized by abundant rainfall, relatively uniform temperatures, and high humidity throughout the year. The island is wettest from November to January and driest from May to July.

Demography

The total population of Singapore, comprising Singapore residents and nonresidents, was estimated at 4,185,200 in 2003. Singapore is a multiracial society. Chinese form about 76% of Singapore's population, while Malays and Indians make up approximately 14% and 8% respectively. Other races make up almost 2% of the population. The main religions in Singapore are Buddhism, Taoism, Islam, Christianity, and Hinduism. The official languages in Singapore are Malay, Chinese (Mandarin), Tamil, and English. Malay is the national language and English is the language of administration.

Governance

Singapore is a republic with a parliamentary system of government. A written constitution provides for governance through the executive, the legislative, and the judiciary of the state. The president is the head of state. The prime minister leads the cabinet in the administration of the government. The prime minister and other cabinet members are appointed from among the members of parliament. There are currently 94 members of parliament.

Economy

Since achieving independence in 1965, the Singapore economy has experienced rapid growth. The Gross Domestic Product of Singapore was approximately SGD159 billion in 2003. Real GDP grew at an average of 8.6% per annum and real per capita GDP increased about eightfold between 1965 and 1999. The brisk economic growth was accompanied by low inflation averaging 3.2% per annum. Singapore's economic performance compares well with that of the OECD countries over the same period, with GDP growth more than twice the OECD growth and inflation at about half of the OECD average inflation rate.

The manufacturing sector retains its position as the single largest sector in the economy, accounting for about a quarter of the GDP. The manufacturing sector has underpinned the strong contribution of trade to economic growth in Singapore over the years. Merchandise exports have averaged more than 130% of GDP since the mid-1980s, with total merchandise imports averaging close to 150% in the same period. Figure 8.1 shows the percentage share of each sector in the nominal GDP in 2003. Excluding entrepôt trade, the figures were 85% and 98%, respectively. The service-sector exports make up 28% of the GDP. The striking feature of Singapore's trade performance is the changed composition of exports to higher capital and skill-intensive products. The largest component of Singapore's composition of nonoil domestic exports has shifted to higher value-added products like electronics and chemicals from food, beverages, furniture, and garments. Even within electronics, exports have moved away from the lower-end consumer electronics of the early 1980s, into areas like disk drives in the late 1980s and 1990s, and semiconductors from the mid-1990s.

Openness to capital and technology from abroad, an honest and efficient government, macroeconomic policies aimed at long-term investments, and a cooperative relationship between labor and management are the key factors responsible for Singapore's strong economic performance. Equally important is a set of sound macroeconomic policies aimed at maintaining

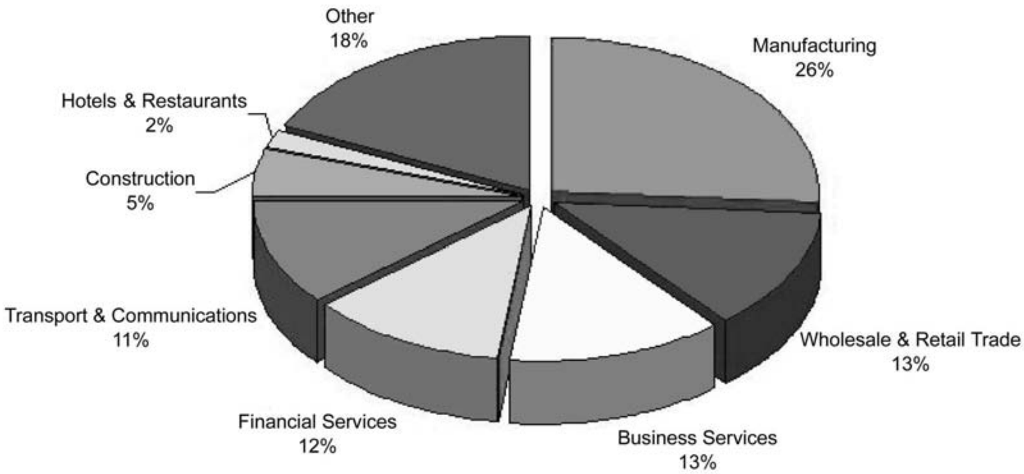

Figure 8.1: Percentage Share of Nominal GDP

a conducive environment for long-term investment in the economy. Singapore's government pursued the route of job creation and free-market competition rather than unemployment benefits and price support schemes.

The Singapore government is also committed to building and maintaining a world-class infrastructure. Over the last three decades, development expenditure accounted for around one-third of government expenditure on average. This does not include the large investments made by the statutory boards. The equivalent figure in industrial countries is 5–10%.

Environmental Profile

To ensure that rapid economic growth and industrialization were not achieved at the expense of the environment, the Ministry of the Environment (ENV) was formed in 1972 to protect and improve the environment of Singapore.

National Environmental Regulatory Framework

The main role of the ENV was to maintain a high standard of hygiene, provide infrastructure and measures to prevent and control air and water pollution, and to manage hazardous waste and municipal solid waste. In August 2004, ENV was renamed to Ministry of Environment and Water Resources (MEWR) to reflect the synergies between the land, air, and water issues that the Ministry carefully looked after. There are two statutory boards under MEWR: (1) the Public Utilities Board (PUB) and (2) the National Environment Agency (NEA) formed on 1 July 2002.

MEWR focuses on policy issues, PUB focuses on water-related issues, and NEA's focus is on ensuring a clean living environment and a high standard of public health in Singapore. The NEA works with industry as coregulatory partners with the aim of achieving responsible care in environmental management.

Singapore strives to balance environmental protection and economic development through close collaborative relationships between its environmental agencies and the key economic development and promotion agencies. Close interagency cooperation ensures that the environmental requirements are conveyed to prospective investors in the early stage of planning so that investors can consider them into their economic and technical feasibility studies. Overseas investors also have access to the environmental requirements and Code of Practices from the NEA website.

The NEA adopted comprehensive environmental protection measures based on the following key strategies.

Prevention: Pollution prevention is carried out through proper land-use planning, development of the environmental infrastructure, and the provision of pollution-control measures.

Enforcement: Controls are stringently enforced to ensure that pollution-control measures are properly maintained and implemented. NEA officers carry out regular surveillance and inspection rounds to make sure that pollution and illegal actions are kept in check. Enforcement action is taken promptly where pollution levels exceed the statutory limit.

Monitoring: Ambient air and water quality are monitored regularly to determine whether the pollution-control measures are adequate and whether new preventive measures need to be taken.

Public education: In addition, programs are conducted to educate the public on environmental protection and management.

Responsible care in environmental management: The NEA holds dialogue sessions with industries, trade associations, and industrial association representatives to exchange views and get feedback on policy changes.

Examples of dialogue partners are: the Singapore Chemical Industry Council, the American Chamber of Commerce, the Institution of Engineers Singapore, the Singapore Institute of Architects, and the Motor Traders Association of Singapore.

Some industry groups have leveraged on collective expertise to enhance corporate environmental responsibility. An example is the Singapore Chemical Industry Council's "Responsible Care Programme" under which the chemical industry is committed voluntarily to continual improvement in all aspects of health, safety, and environmental performance.

Players in the various environment-related communities also come together to work in a more cohesive manner. One such example is the Waste Management and Recycling Association of Singapore (WMRAS) which helps strengthen the partnership in industries with the user community and various government agencies.

Awards and Funding Institutions

The public sector is a close partner of the NEA. For example, the Singapore Environment Council (SEC) gives out the Singapore Environmental Achievement Award to recognize the efforts of local companies and government agencies to improve the environmental performances of their processes and practices. A myriad of groups such as SEC, Nature Society (Singapore), Youth Challenge, Habitat Forum, and the Waterways Watch Society organize a variety of programs to make caring for the environment a lifelong interest and commitment for Singapore's citizens.

In order to recognize the efforts of individuals and companies in improving environmental performance and provide some form of monetary assistance, an SGD20 million Innovation for Environmental Sustainability (IES) Fund was set up in 2001. The IES fund will help to encourage and assist Singapore-registered companies to undertake innovative environmental projects that could help meet the government's effort to speed up environmentally sustainable applications and jointly develop long-term solutions to the specific environmental problems faced in Singapore.

As a small and densely populated city-state with a lack of natural resources, Singapore tackles challenges in environmental management via an innovative use of technologies. Various sectors in Singapore work together to ensure environmental sustainability. Cooperation within and among the industries, people, and government, together with stringent laws and regulations, have kept the various environmental issues well under control in Singapore.

OVERVIEW OF SWM

Singapore's warm and humid climate makes solid waste extremely putrefiable. The waste therefore has to be removed and disposed of quickly, efficiently, and safely before it gives rise to odor nuisance, infectious disease, and other public health hazards. Singapore has a comprehensive and reliable refuse-collection system that has been fine-tuned over the years. All solid waste is collected and disposed of on a daily basis to prevent problems associated with the decomposition of organic wastes.

Landfilling was the main method of disposal in the 1970s. All solid waste was then disposed of by sanitary landfilling in coastal swampy areas. A more efficient disposal method was needed to dispose of solid waste in order to conserve the life of landfill sites on the main island of Singapore. Available landfill sites were limited and depleting rapidly. Various alternative methods such as composting, pulverization, compaction, and incineration were studied. In the early 1970s, incineration technology, which reduces volume by as much as 90%, was found to be the most cost-effective method of disposal in a land-scarce country like Singapore. In addition, energy could be recovered for power generation in the incineration process and ferrous scrap metal was also recovered from the incinerated residues for reuse.

By the late 1970s, landfilling was progressively replaced by incineration as the main method of waste disposal. The first incineration plant in Singapore was commissioned in 1979. This plant is still operating efficiently. Incineration has been found to be an effective method of disposing of waste in Singapore.

There is no more land available for landfill sites on mainland Singapore. An offshore landfill was developed off Pulau Semakau, an island about 25 km to the south of mainland Singapore and was completed in 1999. The landfill site has a land area of 350 hectares and a capacity of 63 million cubic meters. Its expected lifespan is about 30 to 40 years. The offshore landfill was formed by enclosing the sea around Pulau Semakau and another small island, Pulau Sakeng, with a 7 km perimeter bund to create the landfill space. Nonincinerable refuse and incineration ash are transferred daily from mainland Singapore via barges to Pulau Semakau.

Environmental Impact of MSW

Land use in Singapore has to be properly planned and controlled to ensure optimum usage and to minimize pollution owing to its relatively small land area. As part of the effort to provide a green environment in spite of rapid urban development, at least 5% of the total land in Singapore is set aside for nature conservation. The rest of the available land is divided among the many other land utilization needs such as land for residential, industrial, commercial, educational, and recreational purposes. It is therefore important for Singapore to have a solid-waste management system that takes into account the scarcity of land resources and keeps its environment clean. Singapore's solid-waste management strategy is therefore to incinerate all incinerable waste safely and to promote waste minimization and recycling.

National SWM Regulatory Framework

Legislation and Regulations

Licensing solid-waste collectors was introduced in 1989 as a means of regulating the waste-collection industry. Under the legislation, it is an offense for any person or company to collect or transport solid waste as a business without a solid-waste collector's license issued by the NEA. Any person who is found collecting solid waste as a business without the license is liable on conviction to a fine not exceeding SGD10,000 or to imprisonment for a term not exceeding 12 months, or to both.

There are currently three classes of license, namely Class A, B, and C. Each class allows the licensed waste collector to collect respective types of solid waste. A solid-waste collector may apply to hold more than one class of license at any one time. Approval for the license depends on the applicant's having the proper vehicle and equipment to collect and transport that particular class of waste.

Licensed waste collectors are required to comply with: the Environmental Public Health Act, the Environment Public Health (General Waste Collector) Regulations, and the Code of Practice for licensed general waste collectors. The types of waste corresponding to the three classes and the requisite vehicle type to be used for transporting the waste are elaborated in Table 8.1.

SWM Situation Analysis

Quantification and Characterization

Over the last 30 years, Singapore has gone through a period of rapid industrialization, urbanization, and high economic growth. In 1970, about 1,300 tons per day of waste were

Table 8.1: Types of General Waste-Collector Licenses Based on Type of Waste and Vehicles

Class of License	Type of Waste	Type of Vehicle/Equipment
Class A	*Inorganic waste* E.g., construction debris, excavated earth, tree trunks, discarded furniture, appliances, wooden crates, pallets, and other bulky items destined for disposal	Skip container and prime movers, lorries with crane and pick-ups, and lorries with tipper Waste must be properly covered
Class B	*Organic waste* E.g., food and other putrefiable waste from domestic, trade and industrial premises, markets, and food centers	Roll-off compactors and prime movers and refuse-compaction vehicles
Class C	*Sludge & Grease* E.g., sludge from water treatment plants, grease interceptors, water-seal latrines, sewage treatment plants, septic tanks, or other types of sewerage systems; waste from sanitary conveniences in ships and aircrafts	Trucks with septic tanks

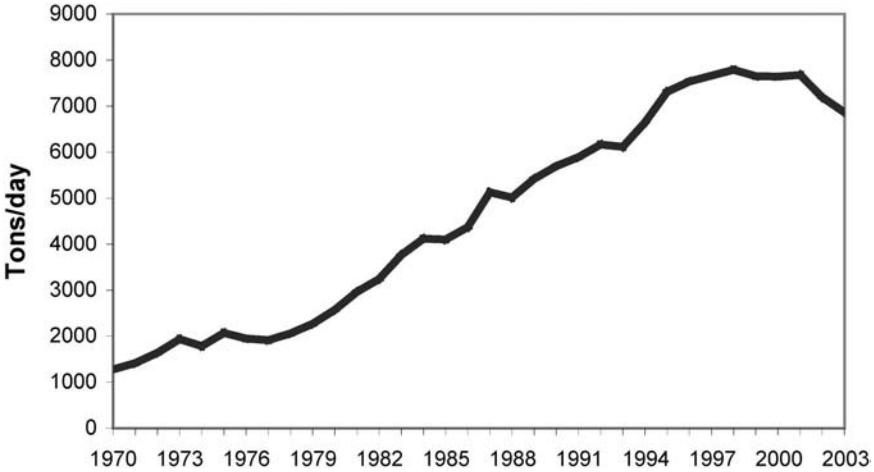

Figure 8.2: Total Waste Disposed Daily, 1970–2003

disposed of in Singapore. By 1980, the amount of waste disposed had increased twofold to about 2,600 tons per day. In 1990, about 5,200 tons per day of waste were disposed of. By year 2000, waste disposed had increased sixfold since 1970 to about 7,800 tons per day. Figure 8.2 shows the total waste disposed of from 1970 to 2003. The increase is attributable mainly to the increase in population, a rising standard of living, and rapid industrial and economic growth.

The daily average amount of waste collected in 2003 was 6,863 tons per day. During the past few years, the increasing trend of waste output was observed to be slowing down. The decreasing trend can be attributed to higher recycling activities, slower economic growth, higher incineration fees, technology, and the higher value of recycled products.

The waste stream in Singapore is broadly categorized into industrial waste and domestic and trade waste. The main sources of industrial waste are industrial premises, construction sites, and shipyards. The domestic and trade waste stream comes mainly from residential premises, markets, food centers, restaurants, and shops. In 2003, the percentage of industrial waste and domestic and trade waste in the total waste stream was about 43% and 57% respectively.

In Singapore today, about 92% of the refuse generated is combustible. Its composition and heat (calorific) value varies from load to load. It is affected by seasonal variation and weather conditions. It contains an assortment of things people throw away including furniture, scrap items, plastic bags, food wastes, vegetation, packaging materials, tires, glassware, and textiles. Some of these items such as rubber, paper, textiles, wood, and plastics are highly combustible, while others such as metal, sand, and glass are not combustible. The typical property and composition of the refuse in Singapore are shown in Tables 8.2 and 8.3 respectively.

Table 8.2: Properties of Solid Waste

Properties	Average	Typical Range
Net calorific value (kj/kg)	9,000	6,000–12,000
Water content (% by weight)	45	30–60
Incombustibles (% by weight)	10	8–15

Table 8.3: Composition of Waste

Typical Compositions	Percentage by Weight
Fruits, vegetables, garden, and food waste	29.4
Paper, cardboard, and wood	29.2
Plastics	27.3
Textile, leather, and rubber	4.6
Metals	3.7
Glass	3.0
Ceramics and stones	2.8

Key Elements of SWM

Collection

Prior to 1 April 1996, the government was responsible for the collection of waste from households, trade, and institutional premises. The refuse-collection services for the domestic and trade sectors was privatized and taken over by SEMAC Pte. Ltd. (now known as Semb-Waste Pte. Ltd.), the first appointed public waste collector (PWC), on 1 April 1996. The collection services for the domestic and trade sector was further privatized from 1999. The island was divided into nine geographical sectors and prequalified companies were invited to participate and compete for the licenses to provide the waste-collection services. The public waste-collector licenses in the nine sectors were tendered out progressively. Successful bidders were appointed as PWC at their respective sectors for a five-year license period.

It is mandatory for industries, commercial premises, and construction sites to engage licensed general waste collectors to collect the waste they generate. There are currently about 350 licensed private waste collectors.

The NEA regulates both the public and private waste collectors through licensing. The Code of Practice for licensed general waste collectors serves as a guideline on the requirements for the proper handling and transportation of solid waste. The objective of the Code of Practice is to regulate the waste-collection industry and to create an environment such that licensed general waste collectors will be able to make the first step toward enhancing professionalism and raise the service standards in the waste collection industry.

Refuse Collection Fees

The refuse-collection fees are determined via a tendering system. With the privatization of refuse collection for domestic and trade premises, fees levied by the appointed public-waste collectors are based on the tendered rates. The rates are determined by market conditions and they vary from one sector to another.

The premises are classified into domestic and trade premises in the tender. The contractors are expected to tender the waste charges for each of these categories.

Domestic Premises: Domestic premises are housing units, i.e., flats (indirect collection) and landed property (direct collection). There is one fixed, monthly rate per residential premise. The collection fee is SGD6–9 for indirect collection and SGD18–25 for direct collection.

Trade Premises: The fee structure for trade premises is dependent on the volume of waste. The PWC regularly assesses the average waste generated by individual trade premises and accordingly bills. Several waste-output categories are specified in the tender. For special removal services of items such as bulky waste and excessive garden waste, the occupier must make special arrangement with a licensed waste collector. A separate fee is chargeable for the service.

Waste Collection Methods

Singapore has a comprehensive refuse-collection system that has been fine-tuned over the years. Since the 1970s, all solid waste is collected and disposed of daily. A daily collection of waste is necessary to prevent the problems associated with the decomposition of organic waste. Waste collectors provide collection services to households, trade premises, commercial buildings, and industrial premises daily. Refuse is collected by the following methods.

Direct Collection: This method involves the removal of refuse directly from individual domestic premises in landed private housing estates and individual trade premises such as shops and houses. A refuse truck with one or two collection crew members moves from door to door to collect the refuse placed outside the premises. The operation is labor intensive and time consuming. It is therefore a more costly collection operation.

Indirect Collection: This method involves the collection of refuse from designated centralized collection points such as bin centers and centralized refuse chutes where large amounts of refuse are transferred and stored in bulk containers or compactors. Each bin center usually serves a sector comprising domestic high-rise apartment blocks either in public housing estates or private condominiums and may include shopping and commercial complexes, market, and food centers.

Separate groups of conservancy workers are required to remove refuse from the refuse chutes at ground level in older public housing estates to the bin center, resulting in double handling of refuse. In new public housing estates, one common, centralized refuse chute is provided on each floor with the discharge point located near the lift lobby. The chute terminates in a storage chamber on the first story where an automated refuse-handling facility is installed. This system eliminates the double handling of refuse and also minimizes the odor nuisance. It is less efficient as compared to indirect collection from bin centers as the refuse collector has to collect from every block.

Pneumatic Refuse Transport System: In this system, refuse is transported through underground pipe networks by vacuum suction to a central collection station where it is compacted and stored in containers, similar to bin centers. However, this is much more productive and hygienic as there is no manual handling and transfer of the refuse. There are currently pneumatic systems installed in some hospitals, food industry locations, and private condominiums. Owing to its high cost of installation, operation, and maintenance, the system has yet to be adopted on a larger scale despite its clean and quiet operation and higher productivity.

Disposal

There are two methods of disposing of waste in Singapore, incineration and landfilling. Refuse incineration, which offers a high volume reduction of as much as 90%, was found to be the most effective method of disposal as Singapore is a land-scarce country. Moreover, the waste heat produced can be recovered for power generation. Ferrous scrap metal is also recovered from the incineration residues for recycling. Today, all incinerable wastes are burned in the incineration plants while only nonincinerable refuse and ashes from the incineration process are disposed of at the offshore landfill.

Refuse Incineration Plants

There are four refuse incineration plants in Singapore with a total incineration capacity of 8,200 tons per day of waste. The salient details of the incineration plants are shown in Table 8.4 as well as the location of the refuse disposal facilities.

Table 8.4: Incineration Plants in Singapore

Incineration Plants in Singapore	Incineration Capacity (tons/day)	Capital Cost (SGD million)	Year Commissioned
Ulu Pandan Incineration Plant	1,100	130	1979
Tuas Incineration Plant	1,700	200	1986
Senoko Incineration Plant	2,400	560	1992
Tuas South Incineration Plant	3,000	890	2000

Refuse incineration with power generation and scrap-metal recovery has proven to be a technically sound method of waste disposal in Singapore. Although the primary objective of refuse incineration is to treat and reduce the volume of the waste, it is possible that with proper design, substantial amounts of energy in the form of electricity can be recovered. As electricity generation in Singapore is currently almost entirely derived from the burning of fuel oil, by utilizing the heat from waste incineration, precious imported fuel oil is saved.

At every stage since the first incineration plant in 1979, Singapore has implemented the latest technology in the design and construction of its waste-to-energy plants. All four plants have performed well over the years and the capacity availabilities have been consistently in the high ranges of 85% to 95%. In 2003, the four incineration plants incinerated a total of about 2.3 million tons of refuse. This represented about 92% of the total refuse disposed of in Singapore. From this, about 980 million kWh of electricity were produced from the waste heat. The power generated represents about 2–3% of the total electricity generated in Singapore. The quantity of scrap metal recovered amounted to 22,500 tons. The scrap metal was sold to a local steel mill for reprocessing into steel products for the construction industry.

Offshore Landfill

An offshore landfill was developed at Pulau Semakau to receive primarily nonincinerable waste and inert ashes from the incineration plants. The offshore landfill became operational on 1 April 1999 after the last landfill on the mainland was closed on 31 March 1999. Pulau Semakau is an island to the south of mainland Singapore. The new Semakau Landfill covers an area of 350 hectares and has a fill-capacity of 63 million m^3. Its life span is expected to be more than 30 years.

A 7 km perimeter bund was built to enclose part of the eastern sea area off Pulau Semakau as well as another small island, Pulau Sakeng, to create the landfill space. The landfill site was made impervious with the installation of an impermeable membrane along the entire perimeter bund. The leachate generated within the site is treated before it is discharged into the surrounding seas. The project also involved the construction of a marine transfer station on the mainland. At the transfer station, nonincinerable waste and incineration ash are dumped directly into barges berthed within an enclosed transfer building. The barges make the 25-kilometer sea journey to Pulau Semakau. Nonincinerable waste and incineration ash are transferred daily from mainland Singapore via barges to Pulau Semakau. It was necessary to develop an offshore landfill as no more suitable sites on the mainland could be used as landfills. The Semakau Landfill was constructed at a cost SGD610 million.

One of the key challenges faced in ensuring that recycling is sustainable is to create a demand for the final recycled product. To create such a demand, resources have to be channeled to develop high-quality recycled products at affordable prices and end users must be educated to use them, perhaps even showing preference for these products as being environmentally friendly. The government provides incentives to develop and market such products. Through the Singapore Green Label scheme, recycled products can be identified as being green products.

The refuse disposal fee is reviewed annually. The disposal fee has increased from SGD47 per ton in 1997 to SGD77 per ton in 2002. The increasing disposal fee has to some extent brought about a decline in the total waste disposed of, as it is now more economically viable for companies to implement and support recycling programs since the disposal costs can be significant.

Future Strategies: National Strategic Plan for Solid-Waste Management

The main challenge in managing solid waste in Singapore is to minimize another possible "waste explosion" similar to the one the country experienced from the 1970s to 1990s. Waste disposed had increased sixfold from about 1,300 tons per day in 1970 to 7,800 tons per day in 2000. In order to manage this potential problem, Singapore has placed a new emphasis on waste minimization and recycling as a long-term solution to address waste disposal. In 2003, about 47% of the waste was recycled, mainly by the industry and commercial sectors, as their waste is more homogeneous in nature and generated in larger quantity. Singapore has set the following targets to work toward better solid-waste management: (1) raise the overall recycling rate to 60% by 2012, (2) extend the lifespan of Semakau Landfill to 50 years and strive toward "zero landfill," and (3) reduce the need for building new incineration plants.

Based on the above targets, three strategies were developed to address solid-waste disposal: (1) reduce waste disposed of at incineration plants, (2) reuse incineration ash to reduce landfilling, and (3) reduce waste disposed of directly at landfills.

Reduce Waste Disposed of at Incineration Plants

The key success factor to this strategy is recycling. The recycling programs that have been launched to reduce the waste going to incineration plants are as follows.

Domestic Sector-National Recycling Programme (NRP): The National Recycling Programme (NRP) was introduced in 1989. Under this program, public waste collectors were required to provide door-to-door collection of recyclable materials from households. This responsibility was specified as a condition in the tender specification to be granted with a license to collect waste. Under the program, residents are given recycling bags or bins in which to deposit their recyclables such as paper, plastic, bottles, and tin cans. The bags are collected once every fortnight on predetermined dates. On these predetermined collection dates, residents place their recycling bags at their doorsteps to be collected by the waste collectors or recycling companies. The participation rate of the NRP was about 15% in 1989. It was found to be a successful approach to educate and promote recycling activities. The participation rate was about 33% in 2002 and was expected to increase to 50% (one out of two households) by 2003.

Recycling Bins at Public Places: Recyclable waste such as flyers, newspapers, soft-drink cans, and plastic bottles are also generated at public places. To promote and facilitate recycling in public places, recycling bins have been provided at strategic public places having high human traffic. Examples of such places include MRT stations, bus interchanges, airports, shopping areas, parks, and beaches.

Waste Recycling in the Industrial and Commercial Sector: Several waste streams have been identified in the industrial and commercial sectors to increase the recycling rates. The result of this effort is a reduction in the amount of waste going to the disposal facilities. The targets set to increase recycling rates for these waste streams (to be achieved by 2012) are as follows:

- *Food waste:* industry sector—food factories, food courts, markets, and major catering facilities; target—6% to 30%;
- *Paper/cardboard:* industry sector—factories, shopping centers, and offices; target—36% to 55%;
- *Wood waste:* industry sector—factories and construction sites; target—8% to 40%;
- *Plastic waste:* industry sector—factories; target—10% to 35%; and
- *Horticulture waste:* industry sector—tree pruning and parks maintenance; target—32% to 70%.

The plans to meet these targets include providing support and incentives for technology development work to recycle these wastes, such as providing suitable industrial lands to set up recycling facilities, manpower skills development and training, and facilitating market development of recycled products.

Good progress has been made in recycling waste in the industrial and commercial sectors. For example, the electronics industry is an important industry in Singapore and its growth has resulted in an increase in electronic waste. This waste is collected and processed by a recycling company that recovers the materials. Wood is another waste stream that has met with good success in recycling. A large amount of the waste wood is either reused to produce wooden crates and pallets or processed into recycled wood. Horticulture waste from the maintenance of trees and plants in parks and along roads is recycled into compost. A new recycling facility is being set up to recycle horticulture waste into charcoal.

Reuse of Incineration Ash to Reduce Landfilling

About 1,400 tons of incineration ash is produced as the residue of incinerating 6,300 tons per day of waste. The ash is landfilled and constitutes about 73% by weight of the total waste disposed of at the Semakau Landfill. Reuse of incineration ash would significantly reduce the amount of waste disposed of at the landfill. A pilot project on the use of incineration bottom ash for road construction has been successfully completed. The NEA is facilitating several private companies to explore setting up a plant to process incineration bottom ash into road construction material. If successfully implemented, this will help to divert about 30% of the incineration bottom ash from the landfill, thus conserving landfill space. The NEA is also currently exploring with the university on the use of incineration bottom ash as a material for land reclamation.

Reduce Waste Disposed of Directly at the Landfill

Nonincinerable waste that is directly disposed of at the landfill constitutes about 30% of the total amount of waste disposed of there. The main constituents of nonincinerable waste are construction and demolition (C&D) waste from construction sites and used copper slag from the marine industries. The 2012 recycling targets set for these two waste streams are as follows: C&D waste (from 85% to 90%) and used copper slag (from 90% to 95%). Currently, four C&D waste recycling companies have set up facilities to recycle the C&D waste into secondary aggregates and nonstructural concrete products. The NEA is working closely with the Building & Construction Authority (BCA) and the construction industry to promote more recycling. Used copper slag generated by the marine industries is recycled at three recycling plants. The processed copper slag is classified into coarse slag for reuse as grit blasting material and fine slag, which is used to make paving blocks and concrete. One recycling company is exploring other uses for fine slag such as road-base material for road construction.

By reducing waste disposed of at the incineration plants and landfill, land that would otherwise be needed for building more such facilities can be saved for other uses. In addition, the capital expenditures for building these facilities would also be avoided. Equally important, recycling helps conserve resources.

CASE STUDY: PULAU UBIN— MANAGING SOLID WASTE ON SMALL ISLANDS

Singapore has several other smaller islands besides the main island. The collection and disposal of waste on these islands is largely left to the islanders. The solution of transporting waste to the incineration plants located on the main island is expensive. For the case study on Green Productivity (GP) practices for solid-waste management, we will look at how solid waste is managed on one island, Pulau Ubin.

City Profile

In the native Malay language, Pulau Ubin means granite island. It is the second largest island among the group of islands belonging to Singapore. It is shaped like a boomerang and is situated at the northeastern corner of mainland Singapore. The 1,020-hectare island was once a cluster of five smaller islands separated by tidal rivers, but the building of bunds for prawn farming has since united these into a single island. Two other islets, Palau Ketam (Crab Island) and Palau Sekudu (Frog Island) lie to its south.

The topography of Ubin is largely a series of undulating granite hills. In the early days, granite mining supported the livelihood of a few thousand settlers. Much of the original vegetation was cleared for the cultivation of rubber and crops like coffee, pineapple, coconut, and jasmine. Today, most of the original Ubin settlers have moved to the main island of Singapore, leaving the abandoned granite quarries and the wild flora and fauna as unique sceneries for the visitors to the island.

Pulau Ubin is home to about 100 villagers. It has the ambience of a laid-back lifestyle and seems not to have been affected by the rapid economic development of mainland Singapore. The island residents still rely on ground wells for water and individual diesel generators for their electricity. Some villagers depend on traditional farming and fishing for survival, while others depend on their small provision stores and hotels. At the main village near the jetty, some houses have been converted to bicycle rental shops to support the quiet tourist trade that peaks during weekends and school holidays.

Solid-Waste Generation

Besides the villagers who mainly reside in the town area of Pulau Ubin, there are three other major stakeholders of the island, namely the National Parks Board (NParks), Outward Bound Singapore (OBS), and the National Police Cadet Corps (NPCC). This report will examine how these four stakeholders manage solid waste in their own sectors.

Municipal Solid Waste (MSW)

Pulau Ubin Town Area

The town area of Pulau Ubin covers a sector within an approximately 500 m radius of the main jetty. There are a total of 47 premises: 15 residential houses, 8 bicycle shops, 6 provision shops, 4 hotels, 5 government offices, 2 holiday homes, a community center, and 7 other smaller, stand-alone structures like temples, resting points/sheds, and public toilets.

The cleanliness of the town area is under the charge of the National Environment Agency (NEA). Two workers are deployed to sweep the roads (approximately 650 m) and clean the drains (approximately 220 m) in the town area and to collect waste from bins. The swept refuse together with the waste from the eight standing bins around the town area are collected daily on a hand-pushed cart and disposed of at a refuse transfer area. The beach area around the town center is cleaned twice a week under a beach-cleaning contract. The rubbish from the beach is bagged and transported to the refuse-transfer area.

The waste generated from the town area is stored at the refuse-transfer area and transported by bumboat to mainland Singapore twice a week. On the mainland, a licensed public waste collector disposes of the bagged waste at the incineration plants. The weekly amount of waste collected and disposed of is estimated to be about 1,200 kg. The waste generated in the town area consists mainly of domestic waste from the residential and trade premises in the area. The main recycling activity is in the recovery of aluminium drink cans. There is a large portion of plastic waste (e.g., mineral bottles and drift materials), organic waste (e.g., food remains), and coconut husks in the waste stream. Odor nuisance is a major concern for waste from the Pulau Ubin town area.

National Parks Board (NParks)

The National Parks Board (NParks) is a statutory board under the Ministry of National Development. It is responsible for developing and enhancing Singapore's image as a Garden City. NParks has the responsibility of providing and managing the quality of parks, greenery, and related services to meet the needs of both residents and overseas visitors.

About 50% of Pulau Ubin is under the care of NParks. These are mainly beaches and recreational areas that are frequently visited by nature lovers and visitors to the island. NParks engages contractors to maintain the cleanliness of the parks areas, sweep the main roads and tracks, and clear the refuse bins in areas under their charge. The refuse collected is bagged and transferred off the island weekly for disposal at facilities on the main island of Singapore. The total amount of refuse cleared weekly is approximately 200 kg.

Outward Bound Singapore (OBS)

Outward Bound Singapore (OBS) was established in 1967. It is part of the international network of Outward Bound centers. OBS is situated in the western sector of Pulau Ubin. In the peaceful and natural settings of Ubin, OBS educators are constantly welcoming and helping students, staff, and leaders discover new heights of achievements and self-motivation through its various courses and expeditions.

About 257 hectare or 25% of the total land area in Pulau Ubin is under the care of OBS. Of this, some 8.7 hectares are used for buildings like dormitories, offices, and facilities, while the remaining land is mainly undeveloped forests that serve as training areas for the activities planned by the trainers. OBS is self-sufficient in terms of water supply and electricity. There is a reservoir and they operate a water treatment facility within the compound. Diesel generators power the electricity needed for the compound. OBS has a jetty built within the compound.

OBS receives approximately 12,000 trainees each year. On average there are 200–300 trainees in the compound per week. There are also approximately 100 staff members working on the island every day who travel to and from the island by ferry services provided by OBS.

OBS engages its own contractors to clear the refuse generated within its compounds. There are two main sources of waste generated: waste from general cleaning, including office waste and waste from cleaning the compound, and food waste from the kitchen. OBS employs its own food caterer to prepare meals. The general cleaning contractor cleans the compound daily. Waste from general cleaning is collected and stored at a holding area. The contractor transfers the collected refuse weekly to the main island via bumboat. The amount of refuse from general cleaning disposed of every week is approximately 170 kg.

The food caterer has a different waste arrangement. Food waste is collected daily from the cookhouse and kitchen. It is properly bagged and transported off the island in containers at the end of each day when the food caterers travel back to the main island. The containers are placed near the jetty on Singapore where a licensed waste collector removes them for disposal at the incineration plants. The amount of food waste disposed weekly is approximately 140 kg.

National Police Cadet Corps (NPCC) Campsite

The NPCC campsite is located near the northern end of Pulau Ubin. It covers an area of 25 hectares and has full-accommodation facilities for 150 instructors and 750 campers within its base and satellite camps. All uniformed groups can make use of this campsite, which has adventure training facilities. The campsite also has its own jetty, thus making it more accessible from the mainland. The peak periods occur during the months of May, June, November, and December every year. During these months, the campsite receives as many as 300 students a week.

Unlike OSB, the campsite does not have a reservoir for its water supply. Water is transported from Singapore and stored in large tanks at the campsite. Like the other stakeholders on the island, the NPCC Campsite also uses a diesel generator for its electricity supply.

Similar to the approach taken by OBS, the NPCC Campsite engages its own cleaning contractors for the general daily cleaning of the compound. Refuse is properly bagged and stored in a bin center within the premises. The refuse is transported for proper disposal in Singapore fortnightly. The contractors make their own arrangements for boat transfer using the jetty in the NPCC campsite.

The amount of refuse generated at the NPCC campsite is largely dependent on the number of students visiting there. During its peak season, the amount of waste generated averages approximately 800–1,000 kg per week.

Solid Waste Characteristics and Quantification

The sources, composition, and quantification of solid waste from four areas is described in Table 8.5.

Key Elements of SWM

Applicable Environmental Regulations and the Status of Environmental Compliance

Although Pulau Ubin is an offshore island away from the main island of Singapore, it is still subject to Singapore's environmental regulations. The National Environment Agency (NEA) works together with the residents and other stakeholders on the island to ensure that waste is properly disposed of to prevent environmental problems. Only the town area is under the direct care of the NEA. The NEA engages the stakeholders of the other areas in a close partnership to ensure their complete compliance with the environmental regulations. This has been successful and Pulau Ubin has been free from major solid-waste problems.

Solid-Waste Management on Pulau Ubin

The single and biggest challenge for managing solid waste on Pulau Ubin is the lack of direct disposal facilities on the island. Currently, solid waste that is generated on the island

Table 8.5: Sources, Composition, and Quantification of Waste Generation from Pulau Ubin

Name of Area	Sources of Waste	Composition of Waste	Quantity (kg/week)
Pulau Ubin Town Area	Residential area, shops, resorts, hotels, government offices, general cleaning	Solid waste such as household waste, beach sweepings, drink cans, and road sweepings	1,200
National Parks Board (NParks)	Gardens, beaches, recreational areas, general cleaning	Solid waste such as garden waste and beach sweepings	200
Outward Bound Singapore (OBS)	Kitchens and cook-houses	Food waste	140
	Dormitories, offices, training schools, general cleaning	Solid waste	170
National Police Cadet Corps (NPCC) Campsite	Base camp, satellite camp, general cleaning	Solid waste	800–1,000
Total			2,500–3,000

must be transported by sea for proper disposal at facilities on the main island of Singapore. Solid-waste collection and disposal are individually managed by the stakeholders.

Collection, Storage, and Transport

Each of the stakeholders on the island has its own arrangement for transporting waste off the island. OBS and the NPCC campsite have built jetties in their compounds to transport people, stores, rations, and refuse. Little or no effort has been put into collaborating with the other stakeholders for a concerted solution.

One logical approach for solid-waste collection on Pulau Ubin is to have a central refuse collection site where all the solid waste generated on the island can be deposited and then transported for disposal on the main island. The centralized refuse bin can be situated at a location convenient to the major sources of solid waste. By doing this, it is likely to achieve an economy of scale for refuse collection and thus reduce the cost incurred by each of the stakeholders. Centralized refuse collection could also lead the way to the development of other disposal methods since the volume of waste would then be larger.

Disposal

From the four major sources of solid waste generation on Pulau Ubin, we can estimate that the total waste generated per week is approximately 2,500 to 3,000 kg. Despite its size and small amount of waste, Pulau Ubin faces the same solid-waste disposal challenges (i.e., limited land, technology, cost, and health factors) as encountered in any village, city, or island. Looking from a macro level, there are three possible traditional methods that can be used to dispose of the waste collected.

Landfill

This is one of the most direct and easiest methods for waste disposal. Sanitary landfill is probably still the most common method of disposing waste today. Although this method is no longer widely adopted by Singapore due to land constraints, it is possible to implement it on Pulau Ubin because of the low volume of waste generated there. This approach is cheap and easy to implement.

Incineration

Refuse incineration was adopted in Singapore in 1979. The technology is much-matured in Singapore because of the extensive knowledge and experience acquired from the four incineration plants there. The existing plants make use of large incinerators and boilers to burn the refuse. The heat generated during the incineration process is recovered and converted to electricity.

It would be impractical to build large-scale incineration plants on a small island like Pulau Ubin. Recent technologies like gasification and pyrolysis make it possible to build small incinerators, and without the risk of emitting harmful substances like dioxins. Cost effectiveness will, however, be the deciding factor before proceeding with the installation of small incinerators on Pulau Ubin. The capital cost for one small system incinerator that is capable of incinerating 600 kg per day of waste is approximately SGD230,000.

Composting

Composting is also a feasible method for waste disposal on Pulau Ubin since at least 50% of the total waste is organic. The composted organic-output material can be used as a soil conditioner for the natural vegetation on the island. Composters come in various sizes and capacities. It costs approximately SGD50 to treat one ton of organic waste. With proper maintenance, a composter can last eight to ten years.

Cost of Waste Collection and Disposal for Pulau Ubin

Under the current arrangement, the total cost of solid-waste disposal on Pulau Ubin has two main components and two subcomponents: the cost of transportation—sea-transport cost from Ubin to port and land-transport cost from port on mainland Singapore—and gate fees.

The sea-transport cost via bumboats is about SGD60 per ton while the land-transport cost from the port to the main island and then to the incineration plant is about SGD30 per ton. The current gate fee charged at the incineration plant is SGD77 per ton. Therefore, the total estimated cost for collecting and disposing one ton of waste is approximately SGD170.

GP and Other Waste-Minimization Approaches

Recycling

There is clear evidence of recycling activities taking place on Pulau Ubin. Around the town area where most of the eating houses are situated, a special area was assigned for the collection and storage of aluminum cans. These collected aluminum cans are periodically cleared and sold to recycling companies on the main island.

One of the main reasons why the residents and hotel operators sort out aluminum cans for recycling is the price of aluminum cans. Although the price may not be high, it may be still significant to the residents of the island who lead simple lives.

Future Strategies and Action Plan

The case study on Pulau Ubin reveals that it is difficult for a small island with a small population to implement a proper solid-waste management program. The lack of a critical mass in the population makes it economically not viable to implement capital-intensive solutions where the infrastructure (e.g., roads) has to be upgraded, facilities have to be developed, or equipment has to be installed. This is even more unusual with Pulau Ubin as its long-term development plans, including linking the bridge to mainland Singapore, may make capital intensive solution redundant.

Pulau Ubin is one of the 60 odd islands that belong to Singapore. There are other more developed islands like Sentosa Island, a resort island. There are also other less developed islands like Kusu Island, which is frequently visited by religious devotees and St. John's Island, a favorite campsite of young people. For each of these islands, there are existing arrangements made by the island management for solid-waste collection and disposal. The relevant authorities, such as the NEA, should continue to play an active role as a facilitator and partner and better help each of the island managements in the areas of public cleaning and public health.

Notwithstanding the above, some plans can still be carried out for the Green Productivity study of solid-waste management on small islands, as the accumulation of waste and its proper disposal will always be of considerable importance. Good waste management is essentially a three-stage process and these should all be considered.

The first process is *minimization of waste generation*. In the context of Pulau Ubin, this can be achieved through public education, especially for visitors to the islands who normally bring along with them plastic bags, mineral-water bottles, food with excessive paper and plastic packaging, and items made of nonbiodegradable materials. Many of these items are subsequently left behind on the island as waste.

The second process is *recycling* the maximum number of products and determining the specific use for each product. In the context of a small island, this means refillable containers, rechargeable torches, organic matter composted and reused to fertilize the grounds, and aluminum cans and glass bottles that are returned to the manufacturer. In addition, waste sorting can be conducted twice, once at the source and then again in the waste-disposal collection area.

The third process is the *appropriate disposal* of any remaining wastes in an environmentally friendly manner. Waste on an island can be disposed of by using a glass crusher for bottles that cannot be returned, a shredder to accelerate the speed of decomposition for organic waste, an incinerator for flammable waste such as coconut husks and wood, an oil burner/flare for waste oil, using kitchen wet garbage as animal feed, and sanitary landfilling for the other forms of waste.

As a follow-up action plan to this preliminary study on managing waste on a small island, a small-scale pilot project with the larger stakeholders like OBS could be implemented. OBS has a group of about 100 staff and 200–300 trainees per week. The three-stage process of good waste management outlined above could be fine-tuned and used as the broad framework to develop a master plan for good waste management in the OBS compound. Besides exploring the area of waste minimization and identifying the use of recycled products, the master plan should include a pilot project to install or develop an appropriate waste-disposal facility on the island that might include installing a small incinerator, composting organic waste, or sanitary landfilling to meet its solid-waste disposal needs. The pilot project should be able to identify issues that may arise due to the implementation of technologies that are not yet widely adopted on the main island. The lessons learned could serve as guiding points for future solid-waste management projects on small islands.

On an economic basis, there is a high probability that the pilot project would be successful, as the cost of disposing of the waste in-situ would be less than the cost of sea transportation and disposing the waste at the incineration plant on the mainland is about SGD170/ton. (This cost is estimated from a sea-transport cost via bumboats to the mainland at about SGD60/ton, land transport at the main island to the incineration plant at about SGD30/ton and the refuse disposal charges of SGD77/ton for disposal at the incineration plant.)

OBSERVATIONS AND RECOMMENDATIONS

With a population density of more than 6,000 people per sq km, Singapore needs to have a proper and efficient system for solid-waste management. Since 1972, Singapore has established a robust legislative system and comprehensive infrastructure network to collect and dispose of solid waste. Since 1989, all general waste collectors in Singapore need to be licensed. Under the legislation, it is an offense for any person or company to collect or transport general waste as a business without a license issued by the NEA. Offenders face a maximum fine of up to SGD10,000 or imprisonment for a term not exceeding 12 months, or both. Solid-waste collection in Singapore was privatized in 1999. The privatization effort has resulted in lower monthly refuse-collection fees as there is a better use of manpower, methodology, and technology in waste collection and greater efforts at recycling.

Due to the land constraints in Singapore, incineration, which is capable of reducing the volume of waste by as much as 90%, has been adopted as the main mode of waste disposal since 1979. Expertise in incineration has been built up over the years among the government officials involved in the design and construction of all four incineration plants in Singapore. Sanitary landfill is still needed for the disposal of waste that cannot be incinerated and ashes from the incineration process. Singapore closed its last landfill, the Lorong Halus Dumping Ground (LHDG), on the main island of Singapore in March 1999. With the closure of the LHDG, there is no available land for landfilling on the mainland. An offshore landfill had to be developed and the Semakau Offshore Landfill was commissioned in April 1999. The landfill site is expected to be able to meet the nation's disposal needs for more than 30 years.

Singapore is also aware that it is not possible for the "throw and burn" approach of solid waste to remain sustainable for a country with limited land. There was, therefore, a shift in its solid-waste management program to focus on recycling in 2000. A new department, the Resource Conservation Department, was formed to spearhead the waste-minimization strategies and programs in Singapore. Several major initiatives such as the National Recycling Programme in the public sector and the 3R (Reduce, Reuse, Recycle) strategy in the industrial sector were implemented. These initiatives have resulted in the recycling effort's taking a big step forward and achieving a recycling rate about 47% in 2003. The target under the Singapore Green Plan 2012 (SGP 2012) is to achieve an overall recycling rate of 60% by the year 2012.

Singapore has managed its solid waste well. There are, however, pockets of opportunity for improvements evident from observing how waste is currently managed at Pulau Ubin. Instead of transporting waste back to the mainland, the solid-waste management of Pulau Ubin and the other 60 islands could be explored further to develop a master plan by considering their unique constraints and evaluating what improvements can be implemented. Technologies such as small-scale composting, modular thermal-disposal equipment, and progressive landfilling techniques have the potential for implementation on the islands.

There are many lessons that Singapore can learn from its fellow solid-waste management expert members in the Asian Productivity Organization who have extensive knowledge and expertise in their respective areas of specialization in solid-waste collection and disposal. As each country has its own unique solid-waste management constraints and problems to overcome, the organization of seminars would provide an excellent platform and a unique opportunity for the experts to share their knowledge and exchange ideas with each other. It is certain that country experts at these seminars would take home workable practices in solid-waste management that can be implemented in the respective countries and make the world a better place to live in.

RECOMMENDATIONS FOR SOLID-WASTE MANAGEMENT ON PULAU UBIN

It appears that there are feasible solutions to better manage the refuse generated on Pulau Ubin. However, there are issues that make the solutions difficult to implement. We discussed earlier creating a collection refuse bin center for solid-waste collection on Ubin. The main constraint for implementing this solution is the absence of a proper road network around the island. Many of the roads on Pulau Ubin are actually narrow dirt tracks. It is difficult and time-consuming to travel from one end of the island to the other, even though the island is fairly small. This is one main reason why OBS and the NPCC campsite built their own jetties. It is simply faster to travel directly to their premises by sea from the main island. Redevelopment plans for the entire island are not clear at the moment and thus there is no proper network of roads and other infrastructures. Until the development plans from the relevant authorities are finalized, it is unlikely that major upgrading will be carried out on Pulau Ubin.

For solid-waste disposal, we discussed three possible solutions: landfilling, incineration, and composting. Landfilling, although cheap, may not be a sustainable solution as land will always be a rare commodity for a small country like Singapore. In case the development plans for Pulau Ubin take off and more land is needed, landfills would have to be closed to make way for estate development. Incineration and composting present similar concerns. First, there must be a large enough population living on Ubin to justify the need to have the facilities installed. With the population on Ubin declining at the moment, the incinerators or composting plants built may only serve a small community, and there would not be economies of scale. Second, the residues and by-products of incineration and composting still need to be properly disposed of. Transportation for these residues and by-products will escalate the cost of disposal.

Due to the decreasing population and high capital cost for each of the options, it is simply not cost effective to implement long-term solutions for waste disposal on Pulau Ubin. The current situation, where the stakeholders make their own arrangements for solid-waste disposal seems to be the best solution. These stakeholders can include provisions in their cleaning contracts for the contractors to transport the solid waste generated within their compounds to the main island of Singapore for proper disposal by licensed waste collectors. These arrangements, together with regular monitoring by the authorities and dialogues with the residents and stakeholders on the island, seem to be the best solutions for solid-waste management on Pulau Ubin at this moment.

9. SRI LANKA

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INTRODUCTION

Sri Lanka is a tropical island nation situated just north of the equator. From a predominantly agricultural economy, Sri Lanka is rapidly shifting toward achieving Newly Industrialized Country (NIC) status. This has resulted in increasing urbanization and a rural-urban population shift. The rapid growth of the urban population has placed increasing pressures on urban infrastructure services. The quantity of solid waste has also increased with changes in the consumption pattern. The need to manage this ever increasing problem has never been so acute as at present.

COUNTRY PROFILE

Physiography and Climate

Sri Lanka is an island in the Indian Ocean located in the southern part of the Indian subcontinent. It is situated just north of the equator. The total land area is 62,705 km^2. The climate of Sri Lanka is typically tropical with an average temperature of 27° C and an average annual rainfall of 2,030 mm. The rainfall is experienced during four distinct periods: two monsoonal periods and two intermonsoonal periods. Sri Lanka is divided into two principal climatic zones based on rainfall. The southwest quarter of the island is known as the wet zone and the remaining three quarters are referred to as the dry zone.

Demography

Sri Lanka has a population of 19.25 million. The population density is 307 persons per km^2. The average household size is 4.2, and the majority of the people are Sinhalese. Other ethnic groups include Sri Lankans, Tamils, Moors, Malays, Burghers, and others. The majority religion is Buddhism; there are also Hindus, Muslims, and Christians. Sinhala and Tamil are the official languages, but English is widely spoken and understood. Sri Lanka's literacy rate of 90.1% is one of the highest in Asia.

Governance

For administrative purpose Sri Lanka is divided into 25 districts and 9 provinces. There are 18 municipal councils, 37 urban councils, and 256 Pradeshiya Sabhas. The shift from an agricultural to an industrial economy has resulted in increasing urbanization and a rural-urban population shift. The rapid growth of the urban population has placed increasing pressures on urban infrastructure services such as electricity, water supply, and water- and solid-waste management. Both the government and local authorities have, in the past, given higher priority to direct-benefit services such as electricity and water supply at the expense of sanitation.

Economy

Sri Lanka is a developing country in southern Asia with a real output (% change) Gross National Product of 6.4 and a Gross Domestic Product of 5.9. The sectoral classification of GDP is as follows: agriculture (1.5), industry (5.5), and services (7.7).

Sri Lanka is mainly an agricultural country. The chief crop is rice with which the country is almost self-sufficient. Agriculture includes the forestry and fishing subsectors. Tea, rubber, and coconut are also important agricultural crops, with tea being a major foreign exchange earner. Cocoa and spices are other important crops.

In the past two decades, Sri Lanka has made rapid shifts away from a predominantly agricultural economy toward the target of achieving Newly Industrialized Country status by 2010. Industry comprises the mining and quarrying, manufacturing, electricity, gas and water supply, and construction subsectors. Industry contributes to the employment of 21.7% of the population. All other subsectors are classified under services and employ 43.3% of the population. Sri Lanka is also a major exporter of precious and semi-precious stones. In the last three decades, tourism, the garment industry, and emigrant workers have emerged as important industries.

Environmental Profile

Article 27 (14) of the constitution of Sri Lanka states that "The state shall protect, preserve, and improve the environment for the benefit of the community." This policy is implemented through the institutional structure created by legislation approved by parliament.

The mandate of the Ministry of Environment and Natural Resources is to implement the National Environment Policy that renews the commitment of the government for sustainable development. The environment is a cross-cutting subject and all policy decisions related to the environment are prepared through a consultation and stakeholder participatory process. The ministry has already established six high-level Committees on Environment Policy and Management (CEPOM) for the major sectors: forestry and wildlife conservation, land development and mining, agriculture, fisheries, plantations, coastal and marine areas, industry and tourism, energy and transportation, health and sanitation, and urban development

Three committees are chaired by the secretaries of the related line ministries, cochaired by the ministry, and represented by all the relevant stakeholder agencies.

National Environmental Regulatory Framework

The major policy decisions are arrived at through the committees mentioned above. Implementation is by the related sectoral agencies under the supervision of the CEPOM. The development of an environmental framework has been gradual; some of the important events are presented in Figure 9.1.

Some of the policies, strategies, and action plans that have emerged as outputs of these comities are as follows.

- National Environment Policy
- National Strategy for Solid-Waste Management (1999)
- National Cleaner Production Policy and Action Plan (2003)
- National Coordinating Committee on the Implementation of the Basel Convention on the Transboundary Movement of Hazardous Waste and Its Disposal (bi-monthly)
- Interagency Coordinating Committee for the Implementation of the Environmental Impact Assessment Process
- National Action Plan for the Protection of the Marine Environment from Land-based Activities in Sri Lanka (2003)

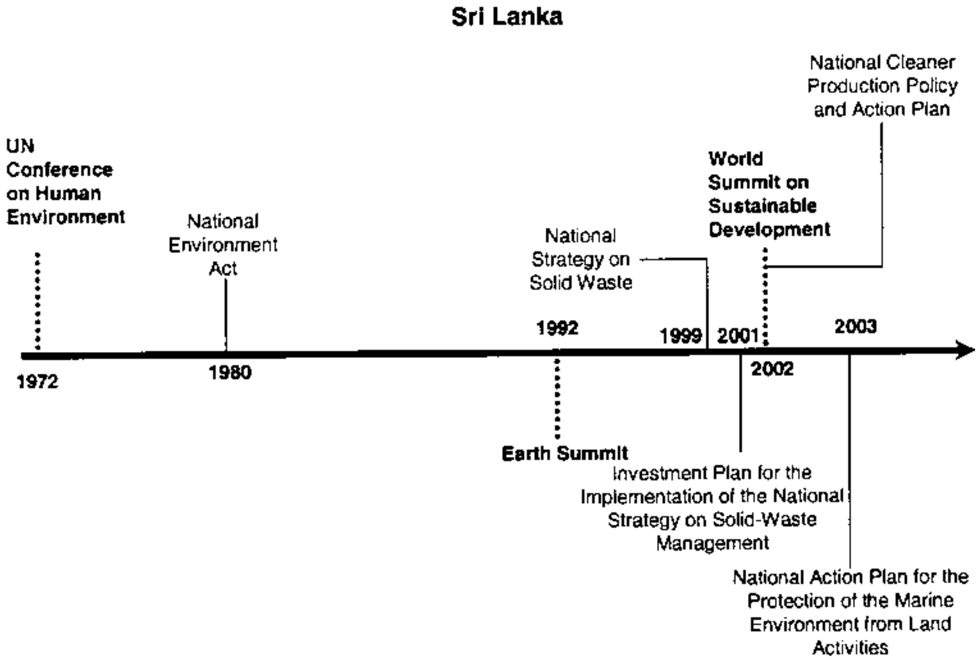

Figure 9.1: Timeline of the Development of Environmental Framework and Important Events

- Investment Plan for the Implementation of the National Strategy on Solid-Waste Management (2001)
- National Implementation Plan for the Implementation of the Stockholm Convention on Persistent Organic Pollutants (POPs, on going)

By the provisions of the National Environment Act No. 47 of 1980, the Central Environmental Authority (CEA) is empowered to issue directives to the local authorities to take the necessary actions for the protection and management of the environment. There is a coordinating committee to handle environmental matters. This committee comprises officers from the Ministry of Environment, the Ministry of Local Government and Provincial Councils, the Ministry of Urban Development, the Ministry of Education, all chief secretaries of all provinces, and all commissioners of local government.

The Ministry of Local Government and Provincial Councils does not have the authority to give directives to the local authorities. Its duty is to facilitate the local authorities through the provincial councils and to organize funding arrangements for local-level initiatives.

National Environment Act (NEA) No. 47 of 1980

Section 12 states that the Central Environmental Authority may, with the concurrence of the Minister, from time to time give any local authority written special or general directions to do or cause to be done any act or thing that the authority deems necessary for safeguarding and protecting the environment within the limits of such local authority.

Section 23A states that effective from the date appointed by the minister and published in the gazette, no person shall discharge, deposit, or emit waste into the environment that will cause pollution except: (1) under the authority of a license issued by the authority and (2) in accordance with such standards and other criteria as may be prescribed under the act.

Some of the other environmental regulatory provisions applicable to solid-waste management are contained in the following discussion.

OVERVIEW OF SWM

Solid-waste management incorporates the management activities associated with the generation, storage, collection, transfer and transport, processing, and disposal of solid waste in an environmentally sound manner. It encompasses planning, organizational, administrative, financial, legal, and engineering aspects involving interdisciplinary relationships.

MSW management is a growing problem in Sri Lanka. It has a direct relationship with urbanization and industrialization. Therefore, MSW-related matters are more serious in cities and in urbanized areas than in rural areas. However MSW management is statutorily treated as a local-government subject in Sri Lanka.

Environmental Impact of MSW

The improper management of solid waste gives rise to problems of health, sanitation, and environmental degradation. WHO studies have indicated that 22 diseases are directly linked to improper SWM practices. Rodents and vector insects transmit various diseases like dysentery, cholera, plague, typhoid, infective hepatitis, etc.

Special epidemiological studies have shown that workers engaged in SWM services are exposed to high health risks and frequently suffer from respiratory tract infections and gastrointestinal parasites and worms. The rag pickers who move from street to street, and bin to bin, and go to dumpyards to retrieve recyclable waste are most vulnerable to diseases on account of their direct contact with the contaminated waste. They are found to suffer from intestinal and respiratory infections, skin disorders, and eye infections. They all suffer from injuries at open dumps that can cause tetanus and serum hepatitis.

Due to the time constraints and urbanization issues, the study's scope was based on the impact of MSW on the city of Colombo. The following areas have been selected for the study: illnesses such as water-related diseases, skin diseases, respiratory problems, malaria, filariasis, and dengue, the pollution of bodies of water, and the cost for cleaning the canals. The study's results on health impacts of solid waste are depicted in Table 9.1.

It can be observed that 55% of the rag pickers, 20% of the staff, and 27% of the community have respiratory problems. The rag pickers are particularly vulnerable because they are constantly exposed to dust when they handle mixed garbage. The situation is aggravated by weather conditions in Sri Lanka. Skin diseases are also very common in all categories. Rag

Box 9.1: MSW
Municipal solid waste (MSW) is described as nonliquid waste material arising from domestic, trade, commercial, industrial, and agricultural activities as well as waste arising from the public and private sectors. MSW comprises different materials such as food waste, discarded clothing, garden waste, construction waste, factory and process waste, and packaging in the form of paper, metal, plastic, glass, etc.

Table 9.1: Health Impacts (percentages)

Selected Group	Respiratory Problems	Skin Diseases	Water-Related Diseases	Malaria	Filariasis	Dengue Fever
Community	27	35	15	12	—	—
Staff (laborers)	20	34	11	2	—	—
Rag pickers	55	45	23	9	5	5
Total number	30	35	15	7	1	1

(sample size = 92)

pickers handle the solid waste without taking any hygienic measures to avoid contamination. Although the laborers are provided with gloves, gumboots, etc., they do not routinely use these while they work. Since Colombo is not prone to malaria, the number of people with this disease is low. The percentage of filariasis is low because there are immunization campaigns going on. Water-related diseases are mainly due to bad habits and behaviors.

Pollution of Bodies of Water

A survey was done of water bodies in nine locations to measure the pH value, conductivity, turbidity, NH_3, NO_3, phosphates, COD, BOD, temperature, and DO. Water bodies are polluted for a number of reasons such as: the discharge of untreated domestic and industrial wastewater, the uncontrolled dumping of solid waste, sewer overflows, the direct discharge of sewage, and insufficient maintenance.

Although there is a serious impact from landfills and temporary dumping points on the water bodies, no such study has been reported. However it may be inferred that the locations near dumpsites have a higher BOD component.

National SWM Regulatory Framework

The Ministry of Environment and Natural Resources is the policy-planning agency for solid-waste management activities. The mandate of the Central Environmental Authority, which comes under the purview of the ministry, is the protection and management of the environment for the present and future generations. The Central Environmental Authority has a regional network and officers attached to the Divisional Secretary's office.

The CEA gives directives to the local authorities (LAs) while monitoring the process. If any local authority does not follow the directives, the CEA has the power to take legal action against it. An environmental officer is appointed to each LA by the CEA to monitor the work there. All LAs operate in independent legal enactment and financial frameworks. Only the Western Provincial Council has the SWM authority. It handles transboundary issues for the local authorities and gives technical advice as needed.

There are by-laws cited concerning SWM under Ordinance 6 of 1910. These by-laws are enacted for the regulation, supervision, inspection, and control of the segregation, storage, discharge, collection, transportation, operation, and maintenance of transfer stations, processing, treatment and disposal of the solid waste generated in public places, private premises, on municipal streets and thoroughfares, and all other incidental activities. These by-laws are being updated. The technical drafting is completed and legal drafting is in progress.

In addition, the CEA has prepared technical guidelines for MSW management. Various components of solid-waste management such as collection, transfer, recovery of useful components, incineration, composting, biogas generation, and landfilling are covered so that these operations can be performed with minimal environment impact.

The guidelines begin with the general legal and operational requirements that are common to all components of solid-waste management. Facility-specific requirements applicable to each component have been addressed separately under subheadings such as introduction, general requirements, design requirements, and operational requirements for the convenience of the user. This guideline has been targeted to municipal solid waste, construction waste, and industrial waste that can be accepted in municipality landfills. It comprises the following topics: general guidelines, waste collection, transfer stations, material-recovery facilities, incineration facilities, composting facilities, anaerobic digestion/biogas production, and landfill facilities.

Recently, legal action was taken against the LAs regarding the improper management of solid waste. After that, the LAs undertook several initiatives for strategic management. Each local authority was compelled to find strategic solutions using the available resources and a variety of plans for sorting waste at the source.

Legal Responsibility of Local Authorities Concerning Solid-Waste Management

SWM is regarded as a local government concern in many countries. The legal responsibility of the local authorities in Sri Lanka can be considered under four categories: broad legal coverage under the constitution, the legal framework defined in the governing legislation of the local authorities, legal provisions under other legislation, and legal provisions under subsidiary laws.

• *Broad legal coverage under the constitution:* According to Article 27 (14), "The state shall protect, preserve, and improve the environment for the benefit of the community." This policy is implemented through the institutional structure created by legislation approved by the parliament. Article 154-G-(1) states, "Every Provincial Council may, subject to the provisions of the constitution, make statutes applicable to the province for which it is established with respect to any matter set out in the Provincial Council list."

The Western Provincial Council (WPC) has independently studied the problem and in 1999 passed a statute under the above-mentioned article to establish an SWM authority under its wings and allowing the WPC to contribute toward SWM. This authority addresses all transboundary and common problems of the local authorities and gives technical solutions. The authority has prepared action plans to combat the SWM issues. Some actions proposed are as follows: improve operations at all existing open dumps to reduce pollution, where possible convert the existing dumps to controlled landfills until a long-term solution is found, where possible share the land facilities among neighboring local authorities, and develop semi-engineered landfills.

• *The legal framework defined in the governing legislation of the local authorities:* The legal framework required for SWM is adequately provided for under local government acts. The local authorities are responsible for the collection and disposal of solid waste in the country. Sections 129, 130, and 131 of the municipal council ordinance, sections 118, 119, and 120 of the urban council ordinance, and sections 93 and 94 of the Pradeshiya Sabha Act have clearly and adequately provided for the management and disposal of solid waste in the respective areas.

The SWM provisions of the Pradeshiya Sabha Act, and the urban and municipal council ordinances are as follows.

- All street refuse, house refuse, night soil, or other similar matter collected by the local authorities shall be the property of the council, and the council shall have the full power to sell or dispose of such matter.
- Every Pradeshiya Sabha, urban council, and municipal council shall, from time to time, provide places convenient for the proper disposal of all street refuse, house refuse, night soil, and similar matter removed in accordance with the provisions of the law, and for keeping all vehicles, animals, implements, and other things required for that purpose and shall take all such measures and precautions as may be necessary to ensure that no such refuse, night soil, or similar matter is removed, in accordance with the provisions of the law, and is disposed of in such a way as not to cause a nuisance.

• *Legal provisions under other legislation:* The National Environment Act No. 47 of 1980 establishes its power to give directions to local authorities, as has already been discussed. The Nuisance Ordinance, Section 12 also states its power to give directions to local authorities.

• *Legal provisions under subsidiary laws:* The local authorities are empowered to make by-laws for the supervision, regulation, inspection, and control of health and sanitation activities including solid-, liquid-, and industrial-waste management. Following are some examples.

- Section 272 (5) sanitation, including the prevention and abatement of nuisances, the removal and disposal of night soil, the charging, levying, and recovering of fees for such removal and disposal, and the conservancy of private premises
- Section 30 (B) the regulation and control of industrial waste: standard by-laws, extraordinary Gazette No. 541/17 of 20/01/1989, X preventing of nuisances, and by-laws relating to scavenging and conservancy

Environment Impact Assessment (EIA)

The National Environment Act requires landfill sites to undergo an environmental impact assessment under EIA regulations (No. 772/22, June 1993) when the capacity of a site is over 100 tons per day. Potential areas that could be developed as solid-waste disposal sites should be identified on a countrywide basis. Necessary clearances should be obtained after going through an Initial Environmental Examination (IEE) or Environmental Impact Assessment (EIA) study as required by law. However current regulations should be changed to require all MSW sites to undergo an EIA or IEE. Landfill sites should require an environmental protection license to operate since the pollution potential from leachate is much higher than most of the industrial discharges.

National Strategy on Solid-Waste Management

After considering all these facts, a national strategy on SWM was developed and implementation started in the recent past. It was developed by the Ministry of Environment. It reveals that the policies should be formulated to encourage solid-waste management practices through waste avoidance, reduction, reuse, and recycling, and then, final disposal in an environmentally sound manner. These policies should also be mutually supportive with economic, industrial, and urban planning policies. It has addressed the following activities: waste avoidance/reduction, composting, reuse of waste, energy recovery, recycling of waste, biogas utilization, and final disposal (sanitary landfilling and incineration).

An Integrated Solid-Waste Management Strategy

An efficient SWM strategy will include the integration of the above activities in an economically feasible manner. Integrated SWM strategies consisting of reducing, reusing, and recycling waste and its final disposal in a sound manner can be developed by combining several local authorities together, depending on the amount and type of waste generated. The main objectives of this strategy should be as follows.

- Prioritize waste avoidance over recycling, and recycling over the other forms of environmentally sound disposal.
- Reuse unavoidable waste as far as possible.
- Maintain the content of hazardous substances in waste at the lowest possible level.
- Guarantee environmentally sound residual-waste treatment and disposal as basic perquisites for human existence.

In addition, it must address the following functions as well.

• Legislation, incentives	the role of the government
• Law enforcement	need for multisectoral partnerships and interactions in solid waste management
• Research and development	institutional mechanism for implementing the national strategy for solid waste management
• Private sector participation	education and awareness creation
• Community participation	

Figure 9.2 shows the framework that has been developed for the implementation of the proposed strategy for SWM. The local authorities will formulate their own SWM activities in conformance to the national strategy.

SWM Situation Analysis

Quantification and Characterization

The quantity of solid waste in Sri Lanka has increased over the years with changes in consumption patterns. An analysis of the data reveals that in 1998 the average per capita per day waste generation was 0.85 kg in the Colombo Municipal Council area, 0.75 kg in other municipal council areas, 0.6 kg in urban council areas, and 0.4 kg in Pradeshiya Sabha areas.[1] The quantification of solid waste in Sri Lanka is depicted in Figure 9.3.

Table 9.2 represents the solid-waste collection in all local authorities in the Western Province. The per-capita generation of solid waste in the Western Province is 0.69 kg in the municipal council area, 0.34 kg in an urban council area, and 0.13 kg in a Pradeshiya Sabha area as per 2004 data.

The moisture content and organic fraction of the MSW stream are significantly high and has a low calorific value. In the Greater Colombo area (Colombo, Dehiwala, Sri Jayawardanapura, Maharagama, and Moratuwa) the heterogeneity of the MSW characteristics impedes employing a unique solution for proper treatment.

The ratio of nonbiodegradable to biodegradable solid waste in the municipal council is much greater than that of the urban council and the Pradeshiya Sabhas. In the recent past, JICA did a thorough study in Negambo Municipal Council (NMC). The difference in ratios is due to some unquantifiable matter collected by rag pickers, since there are organized rag pickers in the cities who take most of the nonbiodegradable waste. Also as there is enough

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[1] Urban Development Sector Unit, East Asia and Pacific Region. *What a Waste: Solid-Waste Management in Asia.*

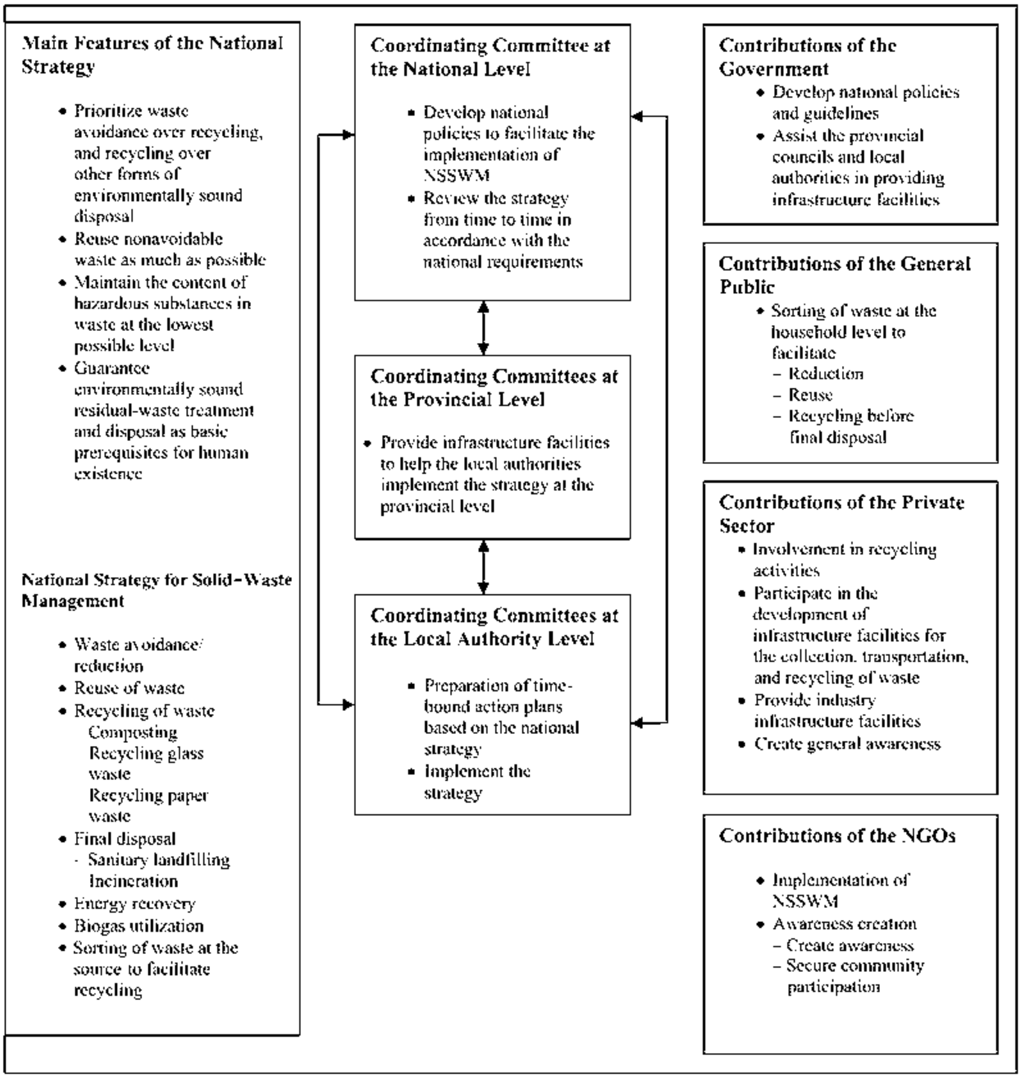

Figure 9.2: Framework for the Implementation of the Proposed Strategy for Solid-Waste Management (NSSWM)

space on each household premise, biodegradable solid waste had been reduced in the urban council and Pradeshiya Sabha areas. The researchers have found the following data.

- 42% of Negombo municipal council workers are involved in recycling.
- Approximately 20 scavengers collect about 250 kg/day of glass, bottles, paper, and metal.
- An interview with 12 middlemen found that all had established their businesses more than 3 years ago (3 more than 10 years ago) and had created jobs for at least 30 people (2.77 T/d, 71% with NMC). Their income generally comprised purchases of LKR890,300 per month and sales of LKR1,157,390 per month.

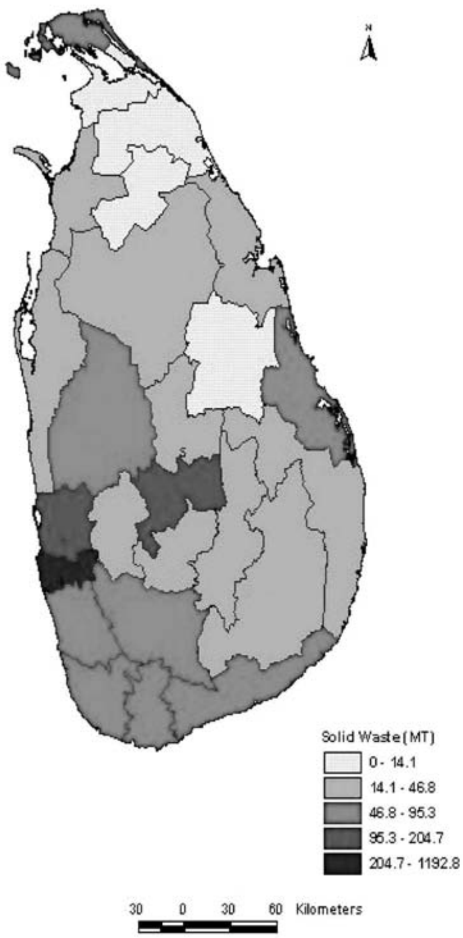

Figure 9.3: Quantity of Solid Waste in Sri Lanka in 1998
Source: Department of Census Statistics, 1998.

Key Elements of SWM

The collection and disposal of MSW has become a widely discussed issue among the public, local politicians, and planners, particularly in the urban areas. The accumulation of a large volume of garbage/waste and its haphazard dispersal along the roads and other public places have led to a number of problems such as crude dumping, environmental pollution, water contamination, an increase in epidemic diseases, frequent complaints reported to respective local authorities, disputes among dwellers, blocked drainage systems, and a lack of financial and human resources within the government to deal with this issue. The various sources of this waste are depicted in Table 9.4.

MSW disposal could be handled in a number of ways. Unlike in developed countries, the management techniques, machinery, and equipment being used in Sri Lanka are not very sophisticated. Burning and dumping garbage into collection yards are the most common modes of disposal in Sri Lanka. This problem is aggravated day by day, particularly in urban areas, due to the fragmentation of land and the compact style of dwellings. Therefore, this problem

Table 9.2: Composition of Solid Waste, 2004

Type of Local Authority	Population	Land Area (km^2)	Average Daily Quantity of Solid Waste Collected (MT)	Paper (MT)	Plastic (MT)	Glass (MT)	Metal (MT)	Nonbiodegradable (MT)	Biodegradable (MT)
Municipal Council	1,747,931	167.05	1,212.0	81.5	65.6	12.8	20.2	180.1	961.3
Urban Council	551,844	140.37	198.5	32.8	11.0	7.4	7.5	58.7	107.3
Pradeshiya Sabha	3,462,108	3108.7	433.0	18.6	18.3	4.1	6.6	47.6	268.2

Table 9.3: Composition of Solid Waste in the Western Province

Type of LC	Paper (%)	Plastics (%)	Glass (%)	Metal (%)	Nonbio-degradable (MT)	Biodegradable to Nonbiodegradable Ratio (%)
Municipal Council	6.7	5.4	1.1	1.7	14.9	79.3
Urban Council	16.5	5.5	3.7	3.8	29.5	54.1
Pradeshiya Sabha	4.3	4.2	1.0	1.5	11.0	61.9

needs to be addressed by the LAs in a systematic and participatory manner while having a paradigm shift from technical solutions to understanding and integrating the social elements. Due to financial constraints, however, most LAs—except for two or three municipal councils—are finding it difficult to purchase new vehicles and equipment or to maintain what they have.

Commercial places from street food outlets to established hotels also find this a serious problem since they need to maintain better hygienic practices in and around their business places. However, the problem is not severe in rural areas since the residents have sufficiently large blocks of land where they can dispose of their daily waste collections.

A study revealed that 48% (1,843.5 MT) of the solid waste collected in Sri Lanka is from

Table 9.4: Sources of Solid Waste in Sri Lanka

Source	Description
Household	Waste generated from domestic activities, including food preparation, cleaning, fuel burning, yard sweeping, gardening, and other miscellaneous household waste (e.g., old clothing, appliances, etc.)
Commercial	Waste generated by trade, service, processing, and production enterprises, excluding hotels, markets, and industries (covered separately)
Hotels	Waste produced by hotels within the city
Markets	Waste from markets selling a high proportion of vegetables, fruit, meat and/or fish (e.g., Manning market, fish market, and other markets)
Institutions	Waste from schools, other education centers, hospitals, Colombo Municipal Council, central and provincial government offices, police, prisons, and religious institutions. Hospital waste includes some hazardous items as discussed further under hazardous/special waste and later in this report
Industries	Waste from various industries
Other	Waste from parks, road/drain cleaning waste
Construction and Demolition	Waste originating from construction, rehabilitation, and demolition activities, etc. Typically, they are used as clean fill at other sites or in low-lying areas.
Hazardous (Special)	Hazardous waste originating from various sources, including household items (e.g., batteries, spray cans, etc.). These are described separately for each category as appropriate. The management of sharps, clinical waste, body parts, and highly infectious waste from hospitals is a major concern in the country.

the Western Province. Therefore, the major intervention should be tried out in this province immediately. This study has given a special consideration to the Western Province.

Collection

The total solid waste collected in Sri Lanka is 3,790 MT. The study reveals that house-to-house solid-waste collection is being utilized only in 9 municipal councils out of 16. Community collection and curbside collection are also utilized in six municipal councils. A new intervention, *the bell system*, was introduced by JICA and is being tried out by the Kandy, Negombo, and Matale Municipal Councils. It has been successful so far. The various methods of collection employed by the municipal councils are presented in Table 9.5.

Treatment

The various methods of treatment employed are depicted in Table 9.6. Most of these projects started as pilot projects. Up-scaling and replicating these projects will be undertaken in the future.

Only 5 municipal councils out of 16 have sanitary landfills; 7 are promoting composting as a treatment method. Biogas generation has been tried out only in 2 municipal councils. In August 2004 a biogas project was installed by the National Engineering Research and Development Center. It has a capacity of 160 MT/month and serves a few local authorities in the Western Province. The Western Provincial Council has formulated an integrated solid-waste management project covering eight local authorities that are converting solid waste to biogas, compost, and electricity. EIAs have been obtained, but due to unavoidable reasons the project has not yet been implemented.

Table 9.5: Method of Collection Used by Municipal Councils

Municipal Council	Population	Method of Collection			
		House-to-House	Communal	Curbside	Other
Colombo	1,042,000	Yes	Yes		
Dehiwala-Mt. Lavinia	209,787				
Moratuwa	177,190				
Kandy	145,000	Yes	Yes	Yes	Yes
Negambo	144,551				Yes
Sri Jayawardanepura Kotte	115,826				
Anuradhapura	84,171	Yes	Yes	Yes	
Galle	84,099	Yes	Yes	Yes	
Batticaloa	83,101				
Matara	75,875	Yes	Yes	Yes	
Badulla	60,204	Yes			
Gampaha	58,577				
Rathnapura	51,380	Yes		Yes	
Nuwara Eliya	49,000	Yes			
Matale	36,532	Yes	Yes	Yes	Yes
Kurunegala	30,000				

Table 9.6: Methods of Treatment Used by Municipal Councils

Local Authority: Municipal Council	Population	Method of Treatment		
		Sanitary Landfill	Composting	Biogas Generation
Colombo	1,042,000		Yes	
Dehiwala-Mt. Lavinia	209,787		Yes	Yes
Moratuwa	177,190		Yes	
Kandy	145,000	Yes		
Negambo	144,551	Yes		
Sri Jayawardanepura Kotte	115,826		Yes	Yes
Anuradhapura	84,171			
Galle	84,099		Yes	
Batticaloa	83,101	Yes		
Matara	75,875		Yes	
Badulla	60,204			
Gampaha	58,577			
Rathnapura	51,380		Yes	
Nuwara Eliya	49,000	Yes		
Matale	36,532	Yes		
Kurunegala	30,000			

Disposal

The study reveals that almost all the local authorities have come up with strategies to dispose of waste in a systematic way, but only a few councils have actually implemented these strategies.

The Western Province has been using sanitary landfills since 1991 through different funding agencies. These, however, have failed either due to the selection of an unsatisfactory location for the landfill or due to the conflicts arising in the communities in the vicinity. Therefore, this method has had little success in the Western Province. See Table 9.7 for the methods of disposal employed.

Strategic handling is being done only in some local authorities such as Colombo and Nuwara Eliya. The information is tabulated where the methods for disposal are described for the various municipal councils.

Only seven municipal councils were able to provide the 2004 budgetary allocations, because SWM is not a function of only one department of the council. The study attempted to establish the cost incurred for the different categories of SWM, but only the total budget for SWM was available in most of the councils. Therefore, it was not possible to focus on costs by function. The budgetary provisions of the municipal councils are presented in Table 9.8.

Green Productivity (GP) Practices and Other Proactive Measures

The study reveals that eight Municipal Councils out of 16 have promoted recycling. However, it is difficult to measure the volume of garbage being recycled as a percentage of the total volume of garbage. The reduction concept has been promoted in only six municipal councils and the reuse concept has been tried in three municipal councils.

Table 9.7: Method of Disposal Used by Municipal Councils

Municipal Council	Method of Disposal				
	Open Dumping	Open Dumping with Soil Covering	Sanitary Landfill	Composting	Biogas Generation
Colombo		Yes		Yes	
Dehiwala-Mt. Lavinia		Yes		Yes	Yes
Moratuwa		Yes		Yes	
Kandy		Yes	Yes		
Negambo	Yes		Yes		
Sri Jayawardanepura Kotte	Yes	Yes		Yes	Yes
Anuradhapura		Yes			
Galle	Yes			Yes	
Batticaloa			Yes		
Matara	Yes			Yes	
Badulla	Yes				
Gampaha		Yes			
Rathnapura		Yes		Yes	
Nuwara Eliya			Yes		
Matale			Yes		
Kurunegala					

Table 9.8: Budgetary Provisions of the Municipal Councils

Municipal Council	Population	Budgetary Provisions (in LKR)	
		2003	2004
Colombo	1,042,000	555,866,000	523,590,227
Dehiwala-Mt. Lavinia	209,787		
Moratuwa	177,190		
Kandy	145,000	13,751,000	13,696,300
Negambo	144,551		
Sri Jayawardanepura Kotte	115,826		
Anuradhapura	84,171	4,014,100	
Galle	84,099	2,133,240	2,698,200
Batticaloa	83,101		
Matara	75,875	43,090,800	20,409,600
Badulla	60,204		
Gampaha	58,577		
Rathnapura	51,380		11,089,602
Nuwara Eliya	49,000	20,601,400	20,333,100
Matale	36,532	12,579,900	14,009,400

CASE STUDY: COLOMBO CITY

City Profile

Colombo is the commercial capital of Sri Lanka and the Colombo Municipal Council (CMC) is the biggest local authority. The total population in Colombo City is about 645,000 people and the daily floating population is about 400,000. The city is divided into six districts for its administrative purposes. The basic fact sheet of Colombo is presented in Table 9.9.

SWM is one of the main responsibilities of the CMC and is handled by the Municipal Engineer's Department. This department is headed by the Deputy Municipal Commissioner (Engineering Services) and the SWM division is headed by the Director (Engineering) SWM. There are two superintending engineers who assist the director in solid-waste collection and disposal and also in research and development.

The main responsibilities of the division are the collection, safe transportation to the disposal facility, and proper disposal of solid waste. There is a district engineer in each district because collection has been decentralized. Each district has been divided into several wards and each ward has a subdepot with two supervisors who handle the collection and transportation works in their respective wards.

In addition to the above responsibilities, other responsibilities are sweeping and brushing

Table 9.9: Basic Fact Sheet of Colombo

General Data	
Province	Western Province
District	Colombo District
Local authority status	Municipal Council
Location	Colombo City
Description	Very flat, low lying coastal city
Colombo Municipal Area (CMA)	3,721.28 hectares
Number of council wards	47
Socioeconomic Data	
Total population (2003)	642,000
Daily floating population	400,000
Average population density	17,217 person per km^2
Average annual population growth rate	0.4
Number of households (2003)	160,964
Family size	4.2
Overall Colombo Municipal Council Data	
Total approved cadre (2003)	13,215
Available manpower at present	9,109
Total budget expenditure (2003)	LKR3,915,583,000
Solid-Waste Management	
Budgeted SWM expenditure (2003)	LKR657,816,000
Cadre for SWM works (2003)	1320
Percent of SWM to total expenditure	16.1%
SWM expenditure per capita	LKR657/person/year
SWM expenditure per tonne waste	LKR1,500/tonne

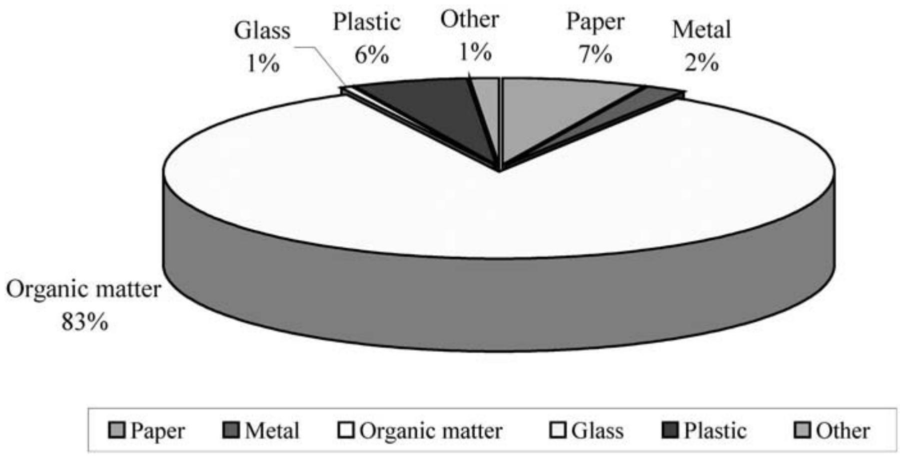

Figure 9.4: Waste Generation in Colombo

the roads and pavements, removal of weeds, cleaning of the roadside drains, and removing unauthorized banners and posters.

Solid Waste Composition and Quantification

The composition of Colombo City's solid waste and the percentages of the components by weight are given in Figure 9.4.

The other features of the waste generated are as follows. The specific density of the solid waste in Colombo City is 300–350 kg/m^3. The moisture content of the household refuse is between 55% and 65%. The calorific value is between 600 kcal/kg and 1,200 kcal/kg.

The quantity of solid waste has increased over the years in Sri Lanka with changes in consumption patterns. An analysis of the data has revealed that in 1998 the per-capita/day waste generation was, on average, 0.85 kg in the Colombo Municipal Council area.

Key Elements of Solid-Waste Management

Collection

The collection of solid waste in districts 1, 2A, and 5 is handled by private contractors and in the other three districts by direct CMC labor. The daily average of waste collected in Colombo City is about 650 tonnes per day.

Before 1997, the division had only 31 compactor trucks and a few tractors for collection. At that time solid waste was collected from the roadsides. Laborers of the SWM division collected garbage from the households and institutions and piled it up at temporary collection points at the road's edge.

Later, trucks collected the waste from the collection points. At that time, there were about 1,250 temporary collection points, and the division wanted to implement a new strategy to improve the collection and transportation efficiency.

In 1997, the council received a fleet of garbage-collection vehicles and a workshop in a grant from the Japanese government. As a result, the division was able to start house-to-house collection by following a planned route. Many improvements were observed in the city.

In 1998, the policy of the council was to reduce the nonproductive, unskilled labor force, diminishing worker strength gradually. As a better management practice, council decided to outsource garbage collection and transportation in some parts of the city. That has been implemented in districts 1, 2A, and 5.

Outsourcing Garbage Collection and Transportation

The CMC decided to hand over one municipal ward to the private sector on a pilot scale for the collection and transportation of solid waste. As a result, the municipal ward of Fort (where the business center is located) was contracted to a private company after competitive tendering with effect from 1998.

Since there was a remarkable improvement in the general cleanliness, the council decided to expand privatization to other areas. As a result, districts 2A and 5 (15 March 1999) and district 1 (15 May 1999) were contracted to private companies. According to the conditions of the contract, contractors are paid monthly after deducting charges for hiring CMC vehicles and fines for work not done. Contractors have to hire a minimum number of vehicles from the CMC as stipulated in the contract documents.

These contracts were given for four years. After four years, the tenders were again called by following the two-envelope system, i.e., separate proposals for technical and financial bids. The technical proposals were evaluated first and then the financial proposals were negotiated.

The contracts include garbage collection, sweeping and brushing the roads and pavements, removing weeds, maintaining verges, removal of tree cuttings, removal of building debris, and the removal of all decorations including banners, cut-outs, strings, and posters.

At that time, 50% of solid-waste collection and transportation work was given on contract. The other three districts were managed by direct municipal-council labor. During this period, this was done without enough laborers because of the nonrecruitment policy of the government since 1994. Then the council decided to outsource all services other than domestic garbage collection in the other three districts from 1 August 2004. At present 50% of garbage collection of the city and all of the road cleaning work is done on contract. The contract work is supervised and monitored by the council staff. The present manpower distribution in these six districts is given in Tables 9.10 and 9.11.

Details concerning the current SWM vehicle fleet and supporting equipment are summarized in Table 9.12.

The CMC has its own mechanical workshop, which was supported by a grant from the Japanese government. The workshop is managed by a senior mechanical engineer and supervised by two foremen. It employs 9 mechanics, 2 welders, 24 laborers, 1 auto electrician, 3 tire fitters, and 1 lathe operator.

Table 9.10: Colombo Municipal Council Staff

	Engineers	Managers/ Technical Officers	Supervisors	Administrative Staff	Drivers	Laborers
Head Office	4	3	—	4	4	—
District 1	1	1	2	—	—	—
District 2A	1	1	1	—	—	—
District 2B	1	—	18	10	37	180
District 3	1	1	17	07	41	175
District 4	1	—	13	08	30	105
District 5	1	1	2	—	—	—

Table 9.11: Contractor's Staff

	Engineers	Managers/ Technical Officers	Supervisors	Administrative Staff	Drivers	Laborers
Head Office						
District 1		1	12	9	17	220
District 2A		1	27	3	20	447
District 2B		1	7	—	8	140
District 3		1	8	—	6	125
District 4		1	5	—	4	110
District 5		1	10	1	32	220

Garbage is collected from normal residences three times a week and from all other places daily. There are three methods of collection: house-to-house collection, curbside collection, and community collection.

Hospital waste and industrial waste are not managed properly. In some hospitals, separated collection is done, but there is no treatment or any special facility at the disposal site.

There is a final disposal facility, a compost plant. All the waste collected within the city limits is brought to an intermediate station and then transferred to the compost plant. This project is managed by a private contractor. The capacity of the compost plant is 600 MT/day. The council has to pay a gate fee of USD5.5 per metric ton. Manual sorting is done at the intermediate station as well as at the compost plant.

Treatment

The features for the treatment of solid waste are as follows.

The waste dumpsite is leveled and brick paved or cemented for ease of movement by the vehicles and the prevention of groundwater contamination.

The waste is stacked in windrows 50–100 meters long, 3–5 meters wide, and 2–3 meters high. The temperature of the heap reaches 65–70° C within 36 hours. This kills pathogens and ensures proper fermentation. The required moisture is maintained during the fermentation cycle. Frequent aeration is done for accelerated fermentation, i.e., the rapid multiplication of microorganisms. It is done by turning the windrows through front-end loaders or compost-turning machines.

Table 9.12: Fleet of Vehicles for Solid-Waste Management in the CMC

Vehicles and Equipment	Head Office	District 1	District 2A	District 2B	District 3	District 4	District 5
Compactor trucks	—	13	25	22	19	16	11
Tipper trucks	—	—	2	3	4	3	2
Tractors	—	—	—	7	11	6	—
Multiloaders	—	1	1	3	3	3	1
Wheel loaders	—		—	1	2	1	1
Propaganda vehicles	1	—	2	—	—	—	1
Poster-removal machines	1	—	2	—	—	—	1

As the fermentation progresses, the organic biomass changes color to a dark brown humus-like substance. Decomposed biomass is processed through mechanical separating, grinding, sieving, and air classification machines.

Fully matured and stabilized organic compost is recovered through appropriate machines. In the preparing stage, well decomposed biomass is recovered through separating, grading, sieving, and air classification by a series of trommels at the processing site to recover the enriched organic soil.

Quality-control tests are done randomly for physical, chemical, and biological parameters as per standards recommended by the Sri Lanka Standards Institution. At the final stage, the finished product is packed in 50 kg and 20 kg HDPE bags, and 5 kg polybags for use in agricultural and horticultural crops.

Inorganic and nonbiodegradable products like plastic, metal, and rubber are recovered for different uses by recycling methods. The remainder, such as stones, bricks, etc. is disposed of in landfills. The process of composting is completed in six weeks.

Disposal

In the 1970s CMC did not have any problem finding bare land for garbage disposal sites. Due to many available open spaces such as marshy lands and abandoned quarries in and around the city, there was ample space to dump garbage. This contributed to the changing locations of disposal sites. There was not much environmental awareness or organizational capacity to protest at that time, and hence the communities tolerated the dumpsites. The legal innovations on the environment have changed the scenario affecting the indiscriminate dumping of garbage and this opened the eyes of the authorities to finding new disposal mechanisms.

However, after 1977 new developments emerged in the country and the population of Colombo City expanded at a rapid rate. Colombo, being the main port city of Sri Lanka, was the hub for imports and trade in general and demanded large business and storage facilities. Most bare lands were filled in order to construct container yards and warehouses, and sites that were used for dumping of garbage were converted to building sites for various business purposes. In the early 1980s land became a scarce resource due to other socioeconomic reasons.

The people who migrated into the city occupied much of the bare land. They held great political clout as their number was increasing and they were indispensable to the functioning of the city economy. The city planners were compelled to look for land outside the city limits for garbage dumping purposes. In the latter part of the 1980s, due to increased awareness, disposal sites became a critical issue. And then the public protests began. The CMC requested that the government solve the problem. After reviewing all possible and probable options, sanitary landfills were considered the best option, and this concept was promoted.

In 1991 the World Bank agreed to fund a feasibility study for a sanitary landfill at a low lying area in Hanwella. Since it had great promise and potential, the project was to proceed ahead. However, the project was abandoned due to political implications, which fuelled public protests. Thus the proposed site was shifted to Welisara. An Environmental Impact Assessment (EIA) and a feasibility study were conducted by the Colombo Environment Improvement Program (CEIP), funded by the World Bank and implemented by the Ministry of Urban Development, Housing, and Construction.

Welisara is a marshy land and the environmentalists lobbied and protested against the construction of the sanitary landfill here. In addition, the construction costs were considered very high. Thus after calling for tenders in 1995–96, the site and project were abandoned.

In 1997 the authorities reverted to another site at Hanwella, but this time they chose a relatively elevated land area. All necessary investigations such as EIAs, feasibility studies, and the regulatory procedures of calling tenders were carried out. Once again in 1999 the project was abandoned due to social, political, and electoral reasons. They also stressed the "not in my backyard" factor.

From 1996–99 the Colombo Municipal Council received many proposals from private-sector investors with new methods and technologies such as composting, incineration, and anaerobic digestion. However nothing was considered at the time due to the involvement of the World Bank with the sanitary landfill proposal. After that, the CMC decided to outsource the disposal functions. In November 2002 the CMC opted for a large-scale MSW composting project in Colombo on a risk-sharing basis. The CMC has guaranteed the investor an average daily tonnage of solid waste and the rate will vary according to inflation. After that, the Council was able to dispose of all the waste collected at the intermediate station. It increased the SWM efficiency in Colombo City.

Green Practices (GP) and Other Waste-Minimization Approaches

Separation at the Source

Separation at the source was started in 1999 in 35 houses in one municipal ward as a pilot project. About 35 houses were selected in the Colombo 05 m district. Before launching the pilot project a community meeting was called in the project area. At this meeting, residents were informed about the project and how they could participate in it. After the meeting two gunny bags were distributed to each resident to collect colorless bottles and glass in one bag and colored bottles and glass in the other. Collection of recyclable items was done on the first Saturday of each month.

After the first collection day, a questionnaire was given to the residents to get their views on the project. Most of the residents were pleased with the project and gave positive comments and suggestions for further improvements. Two of the suggestions were to provide a better storage container for the recyclable items and to begin the separate collection of other recyclable items such as plastic, polyethylene, paper, and cardboard. After reviewing the progress of the pilot project, it was decided by the standing committee on Environmental Management and Protection to expand the pilot project into other areas.

The committee decided to issue three polysack bags to each household to collect glass, plastic and polyethylene, and paper separately. It was also decided to select about 600 houses from three municipal wards for the project and in 2001 it started distributing designated bags for each selected household. Before distributing the bags, an awareness program was done for each household. When the bags were distributed, technical officers from the division visited each household and demonstrated how to separate the waste. Collection was done fortnightly by the council staff in a separated vehicle. All collected items were taken to a central location and sorted further. Because there was no proper procedure to sell these items, the laborers who handled the project sold the items to earn additional money. In this stage, low-income settlements were not considered because of the limited space in their houses to store the bags.

After these 600 houses, the SWM division decided to expand the project to another 5,000 houses. This was started in Thimbirigasyaya ward and then expanded to two more wards. It is now being expanded to another two wards. In addition, another project was started on 1 March 2004 in Kirillapone municipal ward for home composting and the collection of recyclable items such as paper, plastic and polyethylene, and glass. This is being introduced in 4,500 houses. Further to this, separation is being done in the contracted areas, and has been introduced in 2,000 houses. The staff of the Colombo Municipal Council was able to construct a building to store recyclable items in early 2004 by selling the recyclable items already collected.

Plastic Bin Distribution

There were 1,250 roadside collection points within Colombo City in 1997. After starting house-to-house collection, the solid-waste management division reduced the number of collection points to 600. Those points were necessary because the council could not do house-to-house collection in low-income settlements where there were no access roads.

As a solution to this problem, in 2000 lidded plastic dustbins were distributed to each household free of charge. After that, the division was able to eliminate about 400 more dumping points. And this project is still in progress. The cost for one plastic dustbin is about USD4. In 2000, 30,000 plastic bins were distributed among the households in low-income settlements and in 2004 again 12,000 bins were distributed. The aim of this project is to eliminate all the dumping points within Colombo City.

Home Composting

A pilot project was done in 2000 to promote composting at the household level. Compost barrels were distributed to selected households in the middle- and low-income ranges. This project was successful.

Another special project was started in March 2003. In one selected ward in the District 4 area, a compost barrel and three bags are distributed to each household free of charge. This project covered 4,500 houses in Colombo's eastern area and was scheduled for completion at the end of August 2004. This project was given on contract to an NGO for distribution, collection, and follow-up activities for four years.

Public Awareness and Education

Public awareness and education are brought about in many different ways: through the electronic and printed media and street dramas, through community organizations such as schools, institutions, and households, using a public-address system, distributing leaflets, and using the division's public-awareness team. For example, there is a team of environmental facilitators in each school and those students are responsible for serving as the environmental coordinators.

Legal Responsibility of the Municipal Council

There are Municipal Council ordinances and by-laws relating to SWM. These by-laws were enacted for the regulation, supervision, inspection, and control of the segregation, storage, discharge, collection, transportation, processing, treatment, and disposal of solid waste generated in private and public places, on municipal streets and thoroughfares, and all other incidental activities. They also pertain to the operation and maintenance of transfer stations. There is a public health inspector in the division to take legal action against illegal dumping and other violations.

Centralized Composting

Windrow composting is the most widely used method for processing MSW in Sri Lanka. About 5% of the collected MSW is processed in households and central composting systems. Household-level composting has proved to be more successful than centralized composting projects. The Council decided that public awareness is essential to maintain this quantity. Due to a natural disaster in May 2003, the covered building collapsed and it is still undergoing repairs. In addition, there are problems with the quality of the compost and a market for it must be identified.

Future Strategies

Although the National Strategy was approved by the government in 2001, SWM is still not being addressed at a satisfactory level. Some of the reasons are as follows.

- Most LAs do not have the capacity to design or formulate their own strategies.
- Although the LAs are empowered to formulate their own by-laws, they depend on the higher authority for instructions, either because of unawareness or inability at both levels.
- Each council has to formulate and pass resolutions concerning storage at the source, collection, transportation, recovery, disposal, etc., depending on its resources and other capacities.

Storage at the Source

- No waste is to be thrown in the streets, footpaths, open spaces, drains, or bodies of water.
- Waste shall be stored at the source of waste generation in two or three bins or bags.
- All households may be directed not to throw any solid waste in their neighborhood, the streets, open spaces, vacant lots, or drains.
- All hotels, schools, restaurants, shops, offices, and institutions must refrain from throwing their solid waste, sweepings, etc. on the footpaths, streets, or open spaces.
- They must keep their waste on-site in a suitable container until it is collected.

Segregation of Recyclable and Nonbiodegradable Waste

The Municipal Council may direct households, shops, and establishments not to mix recyclable waste with domestic food and other biodegradable waste, and instead to keep it in a separate bin or bag at the source of waste generation.

Box 9.2: Identified Strategies for the Improvement of Solid-Waste Management
To make Colombo a clean, healthy place for people to live and to protect its environment through the establishment and operation of a stable, appropriate, and reliable SWM system is one of the corporate goals in the CMC. The following strategies have been identified to improve SWM over the next 10 years. (Pilot projects can be up-scaled.) • Encourage participatory-approach management. • Strengthen the institutional system. • Promote the 3Rs (reduce, reuse, recycle). • Improve public education and awareness. • Improve the SWM technical system. • Promote the garbage-processing system (privatizing). • Improve the central composting plant and final disposal.

Primary Collection of Waste

- Domestic, trade, and institutional food and other biodegradable waste, as well as recyclable waste, should be collected from the doorsteps or from the community bin on a daily basis.
- Adequate provisions should be made for sweeping the streets and public spaces.
- Norms of work for street sweepers and human resource development should be established.
- NGOs and waste-collector cooperatives should be encouraged.
- A good collection system for flats and condominiums should be established.
- The system for transporting solid waste should be improved.

Institutional Strengthening

Since population, lifestyles, and other factors affecting SWM are dynamic, it is essential to have a Management Information System to face future challenges. This can be accomplished by providing infrastructure facilities to the staff and by providing training for the managerial staff, the supervisory staff, and the workers.

Mining the Landfills

It is necessary to mine the old landfills due to the scarcity of land in the urban areas. Therefore, the state must take the necessary actions to promote this intervention. In addition, mining the landfills helps to extract biogas.

Education and Awareness

For a proper solid-waste management system, the most important thing is the awareness of the general public. LAs have to change their attitude that the garbage is the property of the municipal council. They should also participate in community programs.

Education is easy among schoolchildren since they get used to new systems more willingly than adults. There are environmental committees in every school as well as some training programs.

Environmental commissioners have been appointed in some areas and they are conducting environmental programs. The LAs should coordinate with other authorities to make a master program for all the schools.

Promotion of Recycling

Recycling is a very important method to reduce garbage generation. Only by promoting intermediate centers and empowering rag pickers can the state achieve its goals.

OBSERVATIONS AND RECOMMENDATIONS

Integrated Solid Waste Management (ISWM) is defined as the selection and application of appropriate techniques, technologies, and management programs to achieve specific waste-management objectives and goals. ISWM takes into account the technical, legislative, economic, sociocultural, institutional, and environmental aspects involved in the process, along with community participation. Figure 9.5 illustrates the link between the stakeholders and MSWM aspects to derive an integrated approach.

This scenario shows that one of the main inputs is from the stakeholders. Unless the local

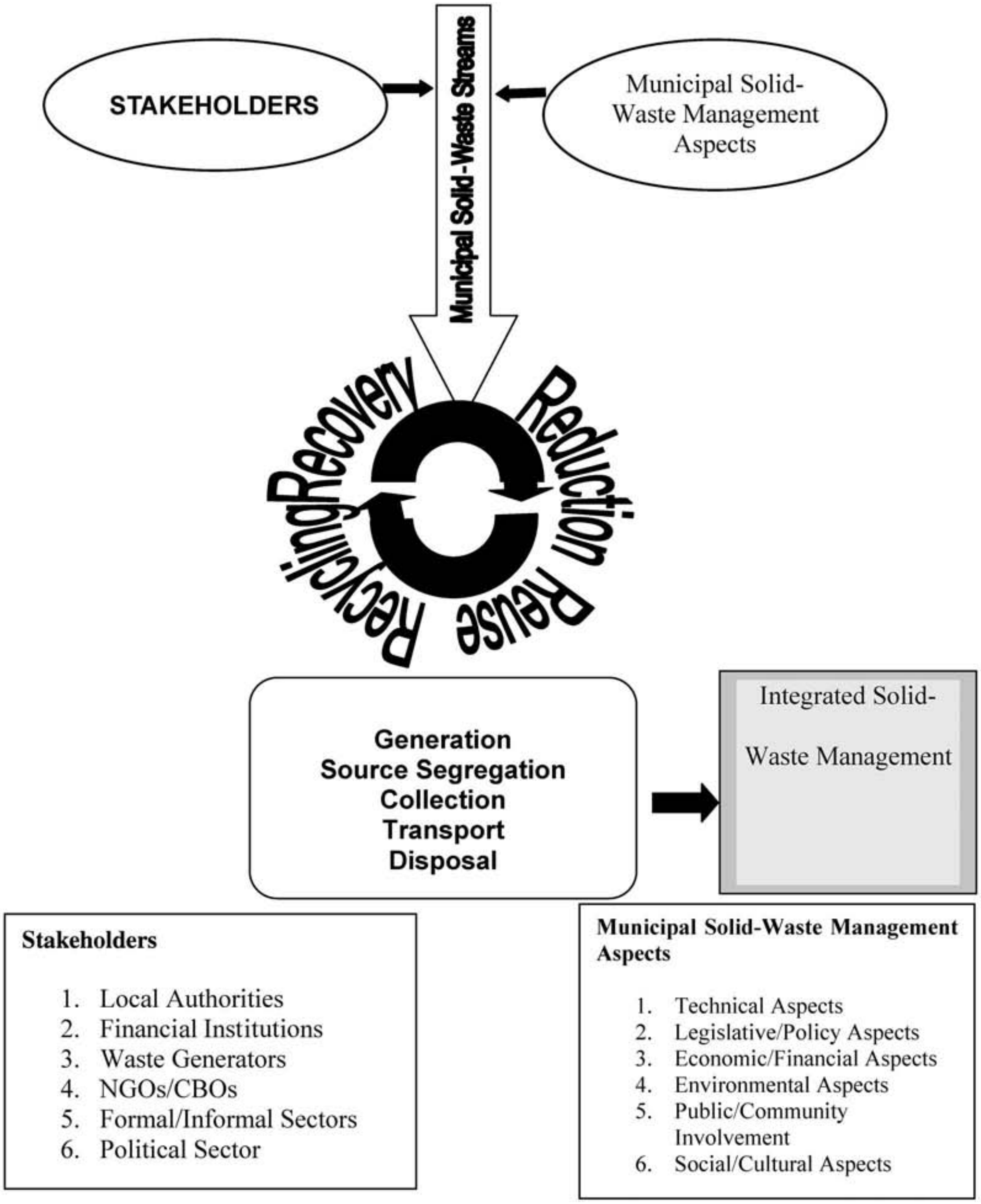

Figure 9.5: Integrated Solid-Waste Management (ISWM)

authorities are geared up to formulate mechanisms for public and community involvement, it is unlikely they will achieve their SWM goals. Therefore it is recommended that all LAs follow a participatory approach to managing solid waste.

The approach would consider the following elements of MSWM where problem identification is required: waste generation, source segregation, collection and transport of waste, recycling, resource recovery from mixed waste, existing disposal systems and their need for upgrades, and public participation.

The study shows that except for waste generation, the other factors have not been carefully researched or studied in the past. Therefore it is necessary that detailed studies be conducted on each factor, taking into account the demonstration projects and foreign-funded projects.

It is therefore recommended that for actual sustainable integration to take place, the following interventions must be achieved.

Using a range of different collection and treatment options that include prevention, recycling, energy recovery, and environmentally sound landfilling.

Involvement and participation of all stakeholders (waste processors and formal and informal recyclers), waste generators (households, industries, and agriculture), financing agencies, nongovernmental bodies (NGOs and CBOs), and government institutions (waste managers and urban planners).

Interaction between the waste system and other relevant systems relating to product design in industry, which can have a significant impact on the recyclability of products after their consumption.

Technical Aspects

- It is essential to keep the streets and public places clean at all times. This is possible only if the waste producers cooperate and participate in the waste-management efforts of the LAs. (Colombo, Negombo, Matale, and Nuwar Eliya municipal councils have by-laws to be passed.)
- Recyclables and nonbiodegradable waste must be segregated. It is essential to save recyclable waste material from going to the waste processing and disposal sites and using up landfill space. Salvaging them at the source could make profitable use of such material. This will save national resources and also save the cost and efforts to dispose of such waste. Waste generators should be encouraged to get into the habit of keeping recyclable waste material separate from food waste, in a separate bag or bin. Biodegradable waste for composting or biogas generation and recyclable waste can be handed over to the waste collectors or rag pickers.
- Collection methods like the Colombo bin project and bell system should be replicated in other cities.
- A schedule for cleaning the streets and public spaces should be prepared, prioritizing the roads requiring daily cleaning and the ones that can be cleaned periodically.
- Norms of work should be given to the street sweepers.
- The system of transportation should be such that it can easily be maintained in the cities by means of route maps.
- Follow the guidelines for final disposal.
- There is a national strategy for SWM, but there is no policy to implement the strategy, and since there is no operating policy, SWM is not taken seriously by the local authorities. There should be a committee to formulate the policy on implementing the national policy.

- All major projects that will be operational as per the national strategy should be coordinated with the neighborhood authorities to avoid duplications and to keep performance up to the expected level. Therefore, integrated plans or solutions must always be formulated. For this reason a waste-management authority in the provincial council is best suited and can start by forming a core working group to strategize, plan, and implement the project.
- In each local authority, policies should be formulated and approved on storage, the 3R system, and participatory management as they are applicable to the relevant authorities.
- Each local authority should strengthen its institutions. Each should have a separate organizational structure (a managerial-level unit is required), budget line, and an information system on SWM, labor, and equipment fleet.
- An official status should be given to the rag pickers.
- It is necessary to share resources such as technical assistance and infrastructure facilities under the guidance of the waste-management authority for each process.
- Although, the waste-management authority of the Western Provincial Council has some shortcomings, it was successful at integrated planning. Not all local authorities are fully competent with the new technologies, however, and only a waste-management authority can give this kind of assistance. It is therefore advisable to form waste-management authorities in all the provinces.

The Focus of Solid-Waste Management Activities among Local Authorities

Each local authority should have an updated database so that measures can be implemented depending on the situation of each council. For that to happen, it is necessary to have research and laboratory facilities to test the solid waste. It can be a shared one among several local authorities, perhaps under the proposed waste-management authority.

Job descriptions should be given to all staff members and their performance should be monitored. Standards for each and every activity should be defined and reported to the staff. Records should be maintained in each section. Gaps should be identified and training programs should be arranged to cover the gaps.

The 3R system should be improved. All available technologies should be identified and a feasibility study should be done to select the best method for each local authority. The government should assist the local authorities in promoting the 3R systems.

Medium-scale businesses should be supported and promoted.

The rag pickers should be empowered through the formation of community-based organizations. These should be strengthened and arrangements should be made to provide better access to government agencies.

It is necessary to alert the general public to store its solid waste in each household, business location, government organization, and hotel because the local authorities cannot collect solid waste daily. Better cooperation from the citizens is most important to reducing illegal dumping.

The transport system should adhere to the planned route and all the residents should be informed of the collection times, etc. Operation and maintenance should be managed effectively, and there should be alternative arrangements, in case of breakdowns.

The state has already taken steps to include environmental education in the primary syllabus. The LAs can replicate the handbook used in the JICA project and distribute it among all the local authorities. The handbook can serve as a tool for school teachers to use when formulating environmental projects in their schools.

There should be a mechanism to store all hazardous waste, since not doing this may have a major impact on the environment.

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10. THAILAND

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INTRODUCTION

Thailand is approaching Newly Industrialized Country status. Economically the country has changed rapidly from its agricultural base to an increased output in manufacturing. With this has increased the urban population. Also, the major cities of Thailand have a large portion of nonresidents such as tourists and workers. This has aggravated the problems of solid-waste management.

The country already has a legal framework but the overall management of solid waste still needs a lot of impetus. The need therefore is to implement the available legal framework along with efforts to increase the awareness of the impacts of solid waste and to implement Green Productivity measures to reduce the load of disposal.

COUNTRY PROFILE

Physiography and Climate

Thailand is situated in the heart of the southeast Asian mainland, covering an area of 513,115 km^2. Thailand borders the Lao People's Democratic Republic and the Union of Myanmar to the north, the Kingdom of Cambodia and the Gulf of Thailand on the east, the Union of Myanmar and the Indian Ocean to the west, and Malaysia to the south. Out of the total area, 511,770 km^2 is occupied by land and the rest is covered with water. The coastline adds up to 3,219 km. Thailand is divided into four distinct areas: the mountainous north, the fertile central plains, the semi-arid plateau of the northeast, and the southern peninsula, distinguished by its many beautiful tropical beaches and offshore islands. Out of the total land 7% is permanently occupied by crops and 32.88% is arable land.

Thailand exhibits a typical tropical climate: rainy, warm, cloudy southwest monsoons (mid-May to September) and dry, cool northeast monsoons (November to mid-March). The southern isthmus is always hot and humid. Land subsidence in the Bangkok area resulting from the depletion of the water table and droughts are the noted natural hazards of Thailand.

Demography

The population in Thailand is approximately 64 million, of which around 6 million live in the capital city, Bangkok. The age distribution of the population is: 24.2% is 14 years and younger, 68.8% is 15–64 years, and 7% of the population is above 65 years.

Thailand is ethnically diverse because historically the area has been a migratory crossroad and thus strains of Mon, Khmer, Burmese, Lao, Malay, Indian, and Chinese exist in the area. Ethnic Thais form the majority of the population (75%) followed by Chinese (14%). Buddhism is the main religion in Thailand, however there are also people from other religions viz., Hindu, Muslim, and Christian. However the people of Thailand exhibit enormous cultural and social unity. Thai and English are the main languages with several other ethnic and regional dialects; 96% of the population above 15 years old is literate.

Governance

Thailand is a constitutional monarchy wherein the king is the chief of the state. The country is divided into 76 provinces for administrative purposes. The prime minister and the council of ministers manage state affairs. The prime minister is typically the leader of the largest party in the ruling coalition from the members of the House of Representatives. Members of the House of Representatives are selected by national elections and form the executive branch.

Thailand has a bicameral National Assembly or Rathasapha which consists of the Senate or Wuthisapha (200 seats; members elected by popular vote to serve four-year terms) and the House of Representatives or Sapha Phuthaen Ratsadon (500 seats; members elected by popular vote to serve four-year terms).

The Supreme Court (Sandika) is the highest authority in judicial matters. It is based on the civil law system, with influences of common law. The judges are appointed by the monarch. Thailand has not accepted compulsory ICJ jurisdiction. Thailand is the only southeast Asian country never to have been taken over by a European power.

Economy

Thailand's economy has traditionally been dominated by agriculture. However, over the last decade, the country has undergone considerable development and urbanization such that it is approaching Newly Industrialized Country status. Its economic growth has been one of the highest and steadiest of the developing nations. The GDP of Thailand in 2003 was THB5,456 billion (i.e., USD136.4 billion) with the growth rate of 6.3%. Thailand is the world's foremost exporter of tapioca and rice. It is a leader in the production of frozen shrimp, canned pineapple, natural rubber, and sugar. Thailand's industry sector offers a wide variety of goods ranging from famous Thai silk garments to integrated circuits, plastics, jewelry, footwear, knocked-down furniture, and fiberglass yachts. The country is rich in natural resources which include tin, rubber, natural gas, tungsten, tantalum, timber, lead, fish, gypsum, lignite, and fluorite.

Thailand has a free enterprise economy and welcomes foreign investment. Exports feature computers and electrical appliances. After enjoying the world's highest growth rate from 1985 to 1995—averaging almost 9% annually—increased speculative pressure on Thailand's currency in 1997 led to a crisis that uncovered financial sector weaknesses and forced the government to float the baht. Long pegged at 25 to the dollar, the baht reached its lowest point of 56 to the dollar in January 1998, and the economy contracted by 10.2% that same year. Thailand then entered a recovery stage, expanding by 4.2% in 1999 and 4.4% in 2000, largely due to strong exports. An ailing financial sector and the slow pace of corporate debt restructuring, combined with a softening of global demand, slowed growth to 1.4% in 2001. Increased consumption and investment spending pushed GDP growth up to 5.2% in 2002 despite a sluggish global economy. The present economic statistics are as follows.

- GDP purchasing power parity: USD445.8 billion (2002 estimates)
- GDP real growth rate: 5.3% (2002 estimates)
- GDP per capita purchasing power parity: USD7,000 (2002 estimates)
- GDP composition by sector: agriculture, 11%; industry, 40%; and services, 49% (2001 estimates)

In recent years manufacturing has surpassed agricultural products in Thailand's Gross National Product (GNP) and tourism, the largest source of foreign exchange, has replaced agriculture. Although the agriculture sector accounts for 11% of the GDP, it employs more than 50% of the population. The industry and service sectors account for 40% and 49% of the GDP respectively. The unemployment rate in Thailand is 2.9%. In recent years local factories have been established to manufacture industrial goods from the rich reserves of minerals the country possesses.

Thailand exports rice and textiles as well as computers, etc. The exports amount to about USD67.7 billion (f.o.b., 2002 estimates). Its export partners are the Unites States 19.6%, Japan 14.5%, Singapore 8.1%, Hong Kong 5.4%, China 5.2%, and Malaysia 4.1% (2002), while Thailand imports capital goods, intermediate goods and raw materials, consumer goods, and fuel, which amount to $58.1 billion (f.o.b., 2002 est.). Its partner countries for imports are Japan 23%, the United States 9.6%, China 7.6%, Malaysia 5.6%, Singapore 4.5%, and the Republic of China 4.4% (2002).

But 12.5% of the population is below the poverty line (1998) since the benefits of the nation's recent economic growth are not evenly distributed among the population. The country has an external debt of USD62.5 billion (2002 estimates).

Environmental Profile

The current environment-related issues of Thailand are air pollution from vehicle emissions, water pollution from organic and factory waste, deforestation, soil erosion, and wildlife populations threatened by illegal hunting.

Thailand is a party to the following international agreements on the environment: climate change, endangered species, hazardous wastes, marine life conservation, ozone layer protection, Tropical Timber 83, Tropical Timber 94, and wetlands. It has signed but not ratified the following international agreements: biodiversity, Kyoto Protocol (climate change), and the law of the sea.

OVERVIEW OF SWM

Usually, the term municipal solid waste covers domestic and commercial waste. In practice, industrial waste is combined with municipal solid waste in the collection and disposal system. Industrial waste generally includes both hazardous and nonhazardous waste. Hazardous waste is applied to any waste containing explosive substances, flammable substances, oxidizing agents and peroxide, toxic substances, substances causing diseases, radioactive substances, mutation causing substances, corrosive substances, irritating substances, and other substances that may cause injury to persons, animals, plants, and the properties of environments.

Solid waste is becoming a major problem in Thailand, particularly Bangkok Metropolis and other major cities in regional areas. Each year more than 7 million tons of solid waste are generated in urban areas (Bangkok Metropolis, municipalities) where more than 22 million people reside. Since this figure tends to increase every year, it will inevitably create a great solid-waste management burden for local administrations. Presently, only 60–80% of the residences in the municipal area are serviced for solid-waste collection and disposal.

Unfortunately, the traditional disposal method employed by most local administrations is open dumping and burning on vacant lands. Lack of disposal technology, inadequacy of budget and qualified personnel, as well as less than enthusiastic administrators, account for the inappropriate disposal practices. Consequently, public opposition and protest against the unsanitary solid-waste disposal methods exist and tend to be increasing to an extent that appropriate remedial actions must be readily made or the adverse environmental and public health impacts will be too severe to manage in the future.

National Solid-Waste Management Regulatory Framework

All municipal waste is managed under the Public Health Act A.E.1992 which gives full responsibility to the local administrations to develop ordinances and regulate solid-waste management systems including collecting fees. Citizens are prohibited from littering or dumping waste at clandestine sites, punishable by penalty of fine.

The Cleanliness and Orderliness of the Country Act A.E.1992 further obliges householders to maintain the cleanliness of their dwellings and prohibits the illegal disposal of solid waste. Also local community ordinances generally specify how householders should store and place their solid waste for collection, prohibit illegal disposal and littering, and establish potential penalties for offenders.

The Factory Act A.E.1992 provides a legal basis for the establishment and control of industrial operations including setting and enforcing industrial standards. The import, export, manufacturing, storage, transport, use, and disposal of hazardous substances are controlled according to the Hazardous Substance Act A.E.1992.

Furthermore, the Enhancement and Conservation of the National Environmental Quality Act A.E.1992 empowered local administrations to construct central disposal facilities for public use either by themselves or by licensed private contractors. The Environment Fund was established to disburse grants or loans to government agencies and the private sector for investment in and operation of those central facilities. This act also empowered the Ministry of Science, Technology, and Environment to publish emission/effluent standards and guidelines/regulations for the control of waste disposal facilities. In addition, the polluter-pays principle (PPP) was also introduced.

The other laws involving the control, prevention and solution of solid wastes are as follow.

- Canal Maintenance Act B.E.121
- Internal Water Navigation Act B.E.2456 (as amended by the Internal Water Navigation Act, No.14, B.E.2535)
- Civil and Commercial Code
- Royal Irrigation Act B.E.2485
- Fisheries Act B.E.2450
- Criminal Code
- Minerals Act B.E.2510
- Petroleum Act B.E.2514
- National Executive Council Announcement No. 68 (B.E.2515) on the Control of Canal Anchorages
- National Executive Council Announcement No. 286 (B.E.2515) on the Control of Land Allocation (including Land Allocation Regulation B.E.2535 dated 17 August 1992 which repealed the Land Allocation Regulation B.E.2530)
- Building Control Act B.E.2522 (including Ministerial Regulation No. 33 (B.E.2535) dated 14 February 1992)
- Bangkok Metropolitan Regulation on Building Construction Control B.E.2522
- Water Supply Canal Maintenance Act B.E.2526
- Highway Act B.E.2535 (which repealed the National Executive Council Announcement No. 295 B.E.2515 on Highways)

Laws involving organizations that have powers and duties to operate garbage collection and disposal activities are vested with the Bangkok Metropolitan Administration, established under the Bangkok Metropolitan Administration Act B.E.2528; the District Municipality, City

Table 10.1: Solid-Waste Generation in Thailand, 1999–2003

Area	Solid Waste Generation (tons/day)				
	1999	2000	2001	2002	2003
Bangkok Metropolitan Administration	8,990	9,131	9,317	9,617	9,340
Municipalities and Pattaya City	12,328	11,893	11,903	11,976	12,100
Outside of municipality	16,561	17,256	17,420	17,632	17,800
Total	37,879	38,280	38,640	39,225	39,240

Municipality, and Town Municipality established under the Municipality Act B.E.2496; the Sanitary District established under the Sanitary District Act B.E.2495; the Provincial Administrative Organization established under the Provincial Administrative B.E.2498; Pattaya City established under the Pattaya City Administrative Act B.E.2521; the Industrial Estate Authority of Thailand established under the Industrial Estate Authority of Thailand, which was created under the Industrial Estate Authority of Thailand Act B.E.2522; and all other government or state enterprise agencies involved, such as the Industrial Factory Control Department of the Industry Ministry, Public Works Department of the Interior Ministry, etc.

SWM Situation Analysis

Quantification and Characterization

In 2003, approximately 39,240 tons per day of solid waste was generated across the country, of which 24% was from Bangkok Metropolitan Administration (BMA), 31% from municipalities, and the remaining 45% was from rural areas (outside municipalities) as illustrated in Table 10.1. It is estimated that about 84% of the total is classified as municipal waste and 12% is industrial waste (of which 8% is hazardous waste).

The solid-waste characteristics summarized in Table 10. 2 show that food waste (garbage), paper, and plastic are the largest portion. The moisture content is about 50–60% with little difference between the dry and wet seasons throughout the country.

Key Elements of SWM

Most cities in Thailand use noncompaction trucks for daily solid-waste collection. Very few cities (including BMA) have compaction trucks and container hauling trucks. It was found that only 70–80% of generated waste is collected regularly. The main reason is budget constraints to provide sufficient equipment and manpower.

Table 10.2: Solid-Waste Composition of the Bangkok Metropolitan Administration

Composition	Percentage
Organic and food waste	50–60
Mixed plastic	15–20
Paper	10–15
Textiles	5–7
Wood	5–7
Glass	3–5
Metal	2–3
Other	2–3

In 2002, approximately 98–99% of solid-waste generated was collected in BMA. All collected waste was transported to the transfer stations at On-Nooch, Nong Khaem, and Tha Raeng which were operated by the private sector. Three private firms were hired to take the solid waste from the transfer stations to be disposed of in a sanitary landfill.

In Table 10.3 the collection and disposal mechanisms of various cities across the country are presented along with the other features of the city. In other cities open dumping is practiced as the disposal technique. There are about 90 municipalities employing sanitary landfills. Typically, the waste is burned on-site during the dry season to control vectors and reduce volumes. During rainy season, insecticides are sprayed on-site to control vectors. In some cities with strong objections from nearby villagers about this unhygienic disposal method, the city is forced to bury its waste.

Local objection to open dumping is increasing as awareness is spreading about the effects of the open-dump disposal method. More sanitary landfill sites are expected to operate in many other municipalities in the next few years. In addition to the landfills, incinerators for Phuket province and Samui Island municipality were constructed in 1998 to handle 250 tons/day and 70 tons/day respectively.

Green Productivity (GP) Practices and Other Proactive Measures

In Thailand, recycling is employed as a GP Practice. Some residents separately store and sell the valuable items in their waste stream (e.g., paper and plastic). It is estimated that in 2003 the residents of BMA separated and sold 1,500 tons/day of recyclable waste to junk shops.

In addition to the collection service, there are two main recycling systems that are carried out by the collection crews and by scavengers at the disposal sites. It is estimated that in 2003 16–34% of the collected waste had recyclable materials, but only 7% or 2,360 tons per day was actually recycled.

The concept of recycling did get much interest throughout the country. It came about through the national policy on solid-waste management. Many campaigns have been conducted to promote recycling and reduction of waste by the public and private sectors and by NGOs during the past few years.

Future Strategies

The problems of MSW management in large communities like Bangkok and major regional cities have become evident and enhanced in recent years. The steadily growing amount of MSW each year, inadequate provisions of waste collection and disposal equipment and tools, and the inability of the recyclable agencies to find appropriate disposal sites are among the major causes of the problems. Unless they are tackled, more unsanitary disposal sites can be anticipated and consequently, potential risks to humans and the environment are unavoidably aggravated.

It is reported that in 2003, 39,240 tons of waste were generated throughout the country each day, with an annual growth rate of about 6%. While the overall waste-collection service did not fully cover the service area (about 70–80% of the total MSW generated), the uncollected waste coupled with the improper disposal methods have inevitably created health hazards and environmental contamination. The causes for these problems are as follows.

- The allocated budget for MSW management is always meager and the service-fee collection is also ineffective.
- There is no active planning on establishing common disposal facilities among adjacent communities.

Table 10.3: Participating Cities

City	Registered Population (2001)	Land Acreage (km^2)	Subdistricts	Solid-Waste Management	
				Collection	Disposal[a]
Northern Region					
Chiang Mai	173,856	40	14	75% privatized[b]	Privately engineered landfill
Phitsanulok	87,976	18	1	Municipally operated	Municipally engineered landfill
Lampang	69,334	22	8	Fully privatized	Privately engineered landfill
Northeastern Region					
Khon Kaen	179,153	46	1	Municipally operated	Municipally engineered landfill
Nakorn Rachasima	174,322	38	24	Municipally operated	Open dump (army site)
Ubon Rachathani	105,150	29	4	Municipally operated	Open dump (army site)
Central Region					
Rayong	55,942	17	4	Municipally operated	Municipal sanitary landfill
Kanchanaburi	39,065	9	5	Municipally operated	Municipal open dump
Nonthaburi	270,609	39	5	Municipally operated	Provincial open dump
Pattaya	85,533[c,d]	53	4	70% privatized[b]	Municipally engineered landfill
Southern Region					
Hatyai	157,806[c]	21	—	Municipally operated	Municipal controlled dump
Surat Thani	114,840[d]	69	6	Municipally operated	Municipal open dump
Phuket	72,753	12	17	50% privatized[b]	Private incinerator; provincially engineered landfill

[a] The definitions of open dump, controlled dump, engineered landfill, and sanitary landfill are provided by the World Bank.
[b] Measured by the percent of the municipal area served by private collection.
[c] Pattaya and Hatyai have high unregistered populations, estimated to be 500,000 and 150,000 respectively. Most of these people work in the tourist industry.
[d] 2002 population.

- There are no definite regulations and guidelines for MSW management.
- There is a lack of skilled personnel to operate an efficient waste collection and disposal practice.
- Waste-recycling programs in communities are still rare.
- The existing legislation does not adequately and effectively facilitate MSW management.
- Public cooperation and participation are very low. For instance, there is an unwillingness to pay service fees, littering habits continue, and waste-source separation programs and positive support for new disposal facility projects are needed.

Management Aspects

Apply the polluter-pay principle to all waste generators including citizens and government agencies who implement improper MSW management and create adverse impacts to human health and the environment.

The master plan and implementation plan of MSW management at the provincial level should be prepared in accordance with the national environmental-quality management plan.

Set up appropriate MSW management regulations as an implementing guideline for waste collection, transportation, and disposal.

Specify types of packaging and mandatory recovery for product manufacturers in order to reduce generated wastes.

Continually monitor and assess various waste-generation sources and the associated solid-waste management problems.

For MSW management, each province should provide appropriate land areas for disposal. A dedicated area for waste disposal should also be allocated in local town and county planning schemes.

Develop a systematic MSW information system that can be utilized, compared, and up-dated.

Appoint responsible government agencies to regulate and supervise the MSW management of both local government and private operators so as to lessen the environmental impacts.

Investment Aspects

As a waste-collection planning criterion guideline for each community, procure 150-liter collection bins for every 350 residents and a 10 m^3 collection truck for every 5,000 residents.

Encourage the investment in a sanitary disposal facility and select waste-handling equipment as appropriate for each site. Government participation includes joint investment with the private sector and full or partial subsidies to the local government in self-operated facilities.

Rehabilitate the existing unsanitary disposal sites.

Establish waste-disposal centers for adjacent communities to share common disposal facilities and adopt an integrated MSW management approach.

Encourage waste separation and recycling programs at sources such as at homes, businesses, institutions, and factories by employing a segregation strategy that matches the appropriate and effective waste collection and disposal practices.

Promote private investment in MSW management and recycling businesses and establish a waste-recycling information center.

Provide funding, incentives, technical assistance, and various facilities to private investors in the MSW management business and NGOs involved in solving the solid-waste management problem. Examples of such provisions are: economic incentives, adjusting the selling prices of commodities in accordance with the real, environment-based costs, and restructuring the taxes placed on products containing toxic materials.

Legislative Aspects

Review related laws on tariffs for MSW management in accordance with the current situation.

Set up appropriate pollution-discharge standards for the solid-waste disposal facilities, such as effluent and stack-emissions standards.

Declare solid-waste disposal facilities another pollution source whose discharges shall be regulated pursuant to the established standards.

Develop regulations, standards, and related laws for setting up mechanisms for recovered materials, waste recycling, and source reduction.

Review related laws and regulations on tariffs for waste recycling and source reduction. Higher tariffs should be imposed on manufacturers that produce commodities with excessive packaging or a high volume of discarded materials to be handled.

Regulate an appropriate solid-waste management for the public transportation terminals of railways, buses and ferries.

Set up regulations on the management of construction and demolition waste.

Initiate an environmental audit system for pollution sources by promoting private participation in this activity.

Supportive Aspects

Encourage private involvement in running businesses for waste collection, hauling, and disposal in a variety of undertakings such as contracting-out, joint venture, concession, and facility operation contracts.

Promote public education programs and correct the attitude and social values concerning public cleanliness and proper MSW management for all children and citizens in the society.

Initiate education and training programs to foster technical and administrative capabilities among concerned local-government and private personnel in the area of MSW management.

Encourage research and appropriate technology-development projects for coping with the rising MSW management problems and enhancing management efficiency.

CASE STUDY: KHON KAEN CITY

City Profile

Khon Kaen Municipality (KKM) is located in Muang District, Khon Kaen Province. The province is centrally located in the northeast region of Thailand. The KKM is located on a plain at an altitude of between 150 and 200 meters. The areas surrounding the plain to the north, west, and south reach 215 meters. The total area of the KKM is 46 km^2.

The climate of the region is tropical/semi-tropical, with long hours of sunshine and high humidity. The average annual temperature is around 27° C and the average annual rainfall is 1,244 mm. Both the geography and climate of the region make it suitable for a wide range of crops, although it is occasionally susceptible to periods of both drought and flooding.

The topography of the municipality area is undulating terrain with an elevation of 150–200 meters. The high elevation area is located in the north at the Khon Kaen University area. The moderate elevation area is located in the central and southeastern area of the municipality. The low elevation area is located around the natural ponds, streams, and canals, such as Bung (lagoon) Kaen Nakhon, Nong (lagoon), Kote and Klong (canal) Rong Muang.

Khon Kaen Municipality is responsible for the solid-waste management of the area. Solid waste is collected and transported for disposal to landfills at Ban Kam Bon, Tambon Non Ton,

Table 10.4: Statistical Features of Khon Kaen

Size of Population			Number of Births	Number of Deaths	Number of Immi-grants	Number of Emi-grants	Rate of Popu-lation Change	Popu-lation Density per km^2
Total	Male	Female						
130,582	63,348	67,234	9,038	539	11,755	19,258	0.8	2,839

Source: Department of Local Administration, Ministry of the Interior.

and Amphoe Muang. Since the disposal of solid waste is not done in sanitary landfills, it has caused problems. Moreover solid-waste generation has rapidly increased in both the Municipal and adjacent areas. Improvement of the existing landfill areas and a search for a new disposal area are essential to cope with the solid-waste problems of the future.

The Khon Kaen Municipality implemented a feasibility study for solid-waste disposal management and the design of the existing landfill under the 1996 fiscal budget of the Ministry of Science, Technology, and the Environment. Table 10.4 gives the statistical features of Khon Kaen.

The population consists of registered and nonregistered residents in the 1996 census. The population increase during 1989–96 was 3,906 people, with an average rate of population growth of 0.14% per year. It is estimated that 964 people are unregistered based on a survey of 648 households that received a questionnaire in December 1996. Nonresident is defined as the people who work daily in various places in the Municipality area. This includes the following groups.

Tourists: There are numerous hotels in the Municipality area ranging from ordinary to luxury hotels. There are quite a number of tourists staying in the hotels, particularly the ordinary hotels, which are fully occupied.

Workers: According to the 1995 record, there are 456 industries and 4,176 trade shops and service places located in the Municipality. A total of 20,830 workers were recorded.

Institutions: Khon Kaen Province is an education center for the northeast region. In the Municipality, there are 44 schools, 65,359 students, and 4,389 teachers. There is also a floating population in this category. Khon Kaen University is a major government institution.

Bus passengers: From interviews with the ordinary and air-conditioned bus station's staff, there are 1,487 ordinary buses per day and 100 air-conditioned buses per day, with an average of 25,000 passengers per day and 3,500 passengers per day, respectively.

The Bank of Thailand's economic forecast for Khon Kaen Province (KKP) anticipates low growth rates for the immediate future (see Table 10.5), but the beginning of slow economic recovery and positive growth rates in the early years of the next decade.

Although economic growth in the KKM will continue throughout the plan period, the population generating this economic growth will increase at a faster rate. Consequently the

Table 10.5: Economic Growth, 1994 to 2011

	Percentage Growth								
	1994	1995	1996	1997	1998	1999	2000	2006	2011
KKP	11.1	8.7	2.7	1.9	1.9	2.4	2.7	4.3	4.4
KKM	8.1	6.4	2.6	4.0	4.0	4.3	4.6	6.4	5.5

Source: Khon Kaen Province, 1994–96. Bank of Thailand. IUEMP forecasts.

Table 10.6: Land Uses in the Urban Area Master Plan of Khon Kaen Town, 1993

Land Use Type	Percentage
Residential area	8.70
Commercial area	1.27
Governmental buildings area	5.19
Industrial area	0.53
Warehouses	0.97
Infrastructures	0.37
Recreation, sports fields	0.45
Livestock fields	2.91
Roads and lanes	5.43
Schools	2.61
River, canal, water sources, agriculture area, forest, and abandoned area	70.73
Total area	100

GPP per capita will decrease, especially in the first five to seven years when economic growth is at its slowest.

As the economic recovery begins to manifest itself in the early part of the next decade, the GPP per capita will start to rise again, reaching 1995–96 levels by the end of the planning period. An indication of this is that the 1995 per capita of around THB60,000 will be regained only in about 2010–11. The GPP per capita in KKM for the year of 2000 was THB49,424.

City Administration

Khon Kaen as a City Municipality has 24 Council members. The mayor determines policies, presents ordinances and recommendations to the Council, and supervises the operations of the municipality and its employees. Most municipal-government revenue comes from the central government, either as a share of tax collections or as general- or specific-purpose grants.

The municipal government also collects a property tax, signboard tax, slaughterhouse tax, and various other fees. A limited amount of additional revenue is generated from municipal enterprises such as markets and pawnshops. The expenditure pattern is as follows: socio (95%), general administration (4%), and economic (1%).[1]

In Khon Kaen Province, particularly in Khon Kaen Town, there is the largest number of hospitals (government and private) and private clinics in the northeast region. Khon Kaen Town is the location of various governmental agencies and NGOs, totaling more than 200 agencies, for example, financing, environmental, industrial, export, energy, banking, etc.

Presently, the Khon Kaen Municipality's land use is well organized. Of the 46 km^2 area, the land use surveyed by the Department of City and Town Planning in 1993 is presented in Table 10.6.

There is industrial development in the region, due to which the economic status of Khon Kaen Province in terms of capital investment and labor force is increasing. Two important industrial types are general and household industries. The statistical data of registered industries recorded for 1996 to the present are 4,772 industries, with a capital cost of THB20,327.31

[1] Technical Services Planning Division, KK.

million and workforce of 34,433. Most household industries are of the handicraft type, including silk production, basketry, wooden products, and ceramics.

Solid-Waste Generation

The solid-waste sources identified in Khon Kaen Municipality are municipal solid waste and industrial/hazardous waste.

A study was conducted of hazardous-waste movement in the area of Khon Kaen municipality. This database is used to determine the management plans for hazardous waste in the future. The database covers the movement of seven hazardous wastes: batteries, alkaline cells, insecticide cans, spray paint cans, chemical cleaning products, machine oil containers, and fluorescent bulbs from houses and services. The waste is put in general-waste landfills or sent to a recycling factory. This database led to the management planning for hazardous waste in the areas of Khon Kaen municipality being repeated

Of the seven hazardous wastes 1,365 kg/day of batteries can be recycled. Other hazardous waste that can be partly recycled are spray paint cans and chemical cleaning products (417,319 kg/day) and machine-oil containers (615 kg/day). The hazardous waste that cannot be recycled at all are alkaline cells, insecticide cans, and fluorescent bulbs, amounting to 412,603 kg/day. These are disposed of with other general solid waste at Khon Kaen's municipal landfill.

The hazardous waste found at this landfill consisted of alkaline cells, insecticide cans, spray paint cans, chemical cleaning products, and fluorescent bulbs. There were not any batteries and only 393 kg/day (from 1,114 kg/day) of machine-oil containers at the time of our study. The waste came from service sources, which they collected and sold.

The study concludes that the incidence of hazardous waste in Khon Kaen municipality has been increasing. The reason is attributed to the lack of planning and visible management from the municipality. Therefore the separate collection of recyclable hazardous waste will play a significant role in decreasing the hazard potential of waste disposal. Efforts also need to be put into segregating nonrecyclable hazardous waste in view of health and environment protection in the future.

Infectious Waste/Hospital Waste

Khon Kaen is one of the most polluted cities in Thailand. The water bodies often are loaded with human excreta, decomposable household waste, nondecomposable waste, and industrial effluents. The various sources of infectious waste are: hospitals, nursing homes, physicians' offices, clinics, laboratories, dentists' offices, blood banks, and funeral homes.

The study aimed to examine the management and care of infectious waste in healthcare facilities in Khon Kaen City including the identification of infectious waste. The data was collected from in-depth interviews and samplings for an analysis of the infectious waste. Three groups of healthcare facilities were studied. Five of the participating hospitals had fewer than 150 beds, three had 151–500 beds, and two had 501–1,000 beds. The healthcare facilities in Khon Kaen City generated an average of 673 kg/day (264 tons/year) of infectious waste.

The composition by weight of infectious waste from the hospitals of various sizes is as follows.

	501–1,000 beds	151–500 beds	10–150 beds
Rubber	31.47%	54.44%	45.62%
Plastic	25.56%	15.35%	16.92%
Cotton	25.29%	12.48%	17.05%

With respect to all healthcare facilities and clinics with fewer than 30 beds, the generation rate of infectious waste was about 27.15 kg per day (10 tons/year). The related organizations should immediately begin the appropriate management of infectious waste from these sources to prevent environmental degradation and adverse public health problems.

Solid-Waste Characteristics and Quantification

Physical Characteristics

The density of solid waste collected in the Municipality area is approximately 217 kg/m^3. This is in the range of solid-waste density estimated by other agencies, i.e., 217–233 kg/m^3. A major component is food residue, as high as 47.27%. Other components are plastic (15.94%), paper (15.21%), glass (6.28%), wood and leaves (5.40%), recycled solid waste that can be sold (about 22.2%), and hazardous domestic waste (about 1.17%).

Chemical Characteristics

Analysis results of the solid-waste chemical characteristics are presented in Table 10.8.

Key Elements of SWM

Collection

Currently, the Cleansing Unit of the Khon Kaen Municipality consists of 270 workers (data surveyed in November 1996), divided into: (1) permanent workers: 24 drivers and 25 workers in other jobs and (2) temporary workers: 82 workers for collection vehicles, 72 workers for road and market cleaning, and 67 workers for other jobs.

The solid-waste collection area is divided into 17 zones. Each collection vehicle is responsible for the solid-waste collection in its designated zone.

At present, the major pattern of collection for the Khon Kaen Municipality is curbside collection. This type of collection is economical and convenient to operate and there is a low accident risk to the workers. Other collection patterns can be considered when the Municipality has an adequacy of personnel and budget.

Collection System for Infectious Waste

The types of infectious waste identified are human blood and blood products, cultures and stocks of infectious agents, pathological waste, contaminated sharps, contaminated laboratory waste, contaminated waste from patient care, discarded biological waste, contaminated animal carcasses, body parts, bedding, and contaminated equipment.

Each clinic and small hospital is provided with thick, red plastic sacks and small plastic bins. The plastic bins are used for needles and sharp items and when full, they are put into the red sack. The clinics are given one sack per day or one every second day depending on the quantity of infectious waste produced. The sacks are delivered in two sizes. Bins are provided as required. It is the responsibility of each clinic or small hospital to ask the collection crew for these as per their requirements.

The red sacks are collected by a special crew appointed by the Khon Kaen Municipality. They wear red suits when collecting, which makes it easy to recognize them when they come to the clinics. The collection crew goes inside the clinics or hospital and asks for the red sacks; the sacks must not be placed outside but stored inside the clinics or hospital until the collection crew asks for them and provides new ones.

Table 10.7: Average Physical Composition of Municipal Solid Waste in Khon Kaen Municipality, 1996

Composition	Percent in Wet Weight TA & E Consultants Study[a]	Piyaprasit Study[b]	This Study	Remarks
Garbage	56.09	45.28	47.27	
Food residue			47.25	
Bone			0.02	
Plastic	16.33	15.11	15.94	
Foam	0.66		0.52	
Paper	9.11	13.12	15.21	
Cardboard	2.91		3.82	
Colored cardboard			3.30	THB0.5/kg
Brown cardboard			1.52	THB1.0/kg
Rubber	1.00	0.34	0.24	
Leather	0.25	0.03		
Textile	1.87	1.92	0.39	
Wood and leaves	5.10	10.02	5.40	
Wood	2.46			
Leaves and grass	2.64			
Glass	5.12	5.33	6.28	
Metal	3.11	6.55	2.16	
Iron	0.55		0.18	THB1.25/kg
Tin cans	1.68		1.56	THB0.25/kg
Other metal	0.88		0.42	
Copper				THB30/kg
Aluminum			0.06	THB16/kg
Stainless steel			0.36	THB6/kg
Stone, brick, and ceramic		1.40	0.60	
Hazardous waste		1.40	0.60	
Fluorescents	2.03		1.17	
Dry cell batteries			0.12	
Chemicals and lubricants			0.14	
Containers			0.73	
Chemicals and drugs			0.18	
Batteries		0.09	5.34	
Miscellaneous				
Total	100.00	100.00	100.00	
Valuable material			22.20	
Bulk density, kg/m^3	225.40	233.04	217.40	

Sources:

[a] TA & E Consultants Co., Ltd. “Analysis of Solid-Waste Composition, Khon Kaen,” *Innovation in Urban Environmental Management (Phase I)*, 1996.

[b] Chatchaval Piyaprasit. “Estimation of Municipal Solid-Waste Generation Rate and Composition in Khon Kaen Municipality.” Master’s thesis, Chulalongkorn University, 1996.

Table 10.8: Chemical Characteristics of Solid Waste Generated in the Khon Kaen Municipality

Parameters	Unit	Quantity
Moisture content	%	52.87
Total solids	%	47.13
Volatile solids	%	23.92
Ash content	%	23.21
Calorific value		
Dry solid calorific value (DSCV)	kcal/kg	2,874.16
Higher solid calorific value (HSCV)	kcal/kg	1,354.59
Lower Solid calorific value (LSCV)	kcal/kg	1,171.54
N	% N	1.35
C	% C	28.20
H	% H	3.38
C : N%		21:1

Source: Study Analysis Results.

Storage

The Metropolitan Municipality provides 200-liter garbage containers for household waste storage. Commercial businesses have to provide their own containers for storage and transportation. There are many types of trucks, including 4-wheel pickup trucks, for collections along the narrow roads of the Municipality.

Transport

Waste collection starts at 5:00 a.m. and finishes at 2:00 p.m. In order to study the collection routes and time period for collection and transportation, the data collection included: time and distance of the collection trip, time and distance for transportation to the disposal site, time consumed for dumping solid waste at the disposal site, and time consumed for other activities.

Table 10.9: Khon Kaen Metropolitan Municipality Collection and Disposal Fees

Collection and Disposal of Infectious Waste	THB
Monthly collection and disposal fees	
Less than 2 kg or 13 liters	300
More than 2 kg or 13 liters, the fee will be charged for every 2 kg or 13 liters	300
Collection and disposal fees per trip	
Travel distance less than 50 km	3,000
Additional charge for waste less than 75 kg or 500 liters	400
Additional charge for waste more than 75 kg or 500 liters, will be charged by every 0–75 kg or 0–500 liters	400
Disposal fees with permission to collect and transfer (charged by the kg)	16
Permission license fees (the certificate follows Title 19)	
Collection and transport of waste license (per license)	5,000
Disposal license (per license)	5,000
Collection and transport of infectious waste (per license)	10,000
Disposal of infectious waste (per license)	10,000

Most collection vehicles make two round trips a day except for the agricultural truck, which makes three trips per day. The large trucks collect the solid waste and transport it directly to the disposal site.

The collection and transport of solid waste for the densely populated area totals 40–50 km per trip and consumes an average of five hours per trip. For the moderately dense populated areas, the distance averages 30 km per trip, and 70 km per trip for some zones. However, the average time consumed is five hours per trip. Agricultural trucks have a collection distance of 12–16 km per trip since they transport to the transfer station at Ban Non Tan. The average time consumed is 3 hours per trip. Waste collection is handled by a private group which obtained a concession from the Municipality.

It was found in an October 1996 survey that there are nine waste vehicles—modified pickups with an average collection capacity of 3 m^3 for each vehicle. The capacity of waste collection is 20–30 m^3 per day.

The types and numbers of collection vehicles for the Khon Kaen Municipality are dependent on the solid-waste disposal site, which has two options.

- A complete transfer station: All collection vehicles transport solid waste for transfer to the trailer at the transfer station. The trailer then transports the solid waste to the disposal site.
- An incomplete transfer station: This option is the one used at the Khon Kaen Municipality. All large collection vehicles (i.e., collection trucks that are designated for each collection zone) directly transport the solid waste to the disposal site. The small collection vehicles (i.e., the agricultural trucks and pickups) transport the solid waste to the transfer station for transport to the disposal site.

At present, the Khon Kaen Municipality owns a total of 27 collection vehicles consisting of various types of vehicles, i.e., open-sided rear-loading trucks, open-rear trucks, 4-wheel open-sided rear-loading or pickup trucks, agricultural trucks, and 10-wheel-trailers. Of the 27 collection vehicles, 17 vehicles are routinely used for designated zones and 10 vehicles are used for solid waste collection in the narrow lanes and as spares. Some vehicles are in functional condition and some are damaged due to a more than 10-year working period. The details of these collection vehicles are summarized in Table 10.10.

Table 10.10: Details of Collection Vehicles

Types of Vehicles	Call Number	Capacity (m^3)	Number of Vehicles	Years in Service
Open-sided, rear-loading truck (6-wheel)	S34, S41	8.0	2	3
Open-sided, rear-loading truck (6-wheel)	S23, S25–S32	10.0	9	10
Open-sided, rear-loading truck (6-wheel)	S42–S45	12.0	5	3
Open-rear truck (6-wheel)	S2	6.0	1	13
Open-rear truck (6-wheel)	S3	10.0	1	13
Open-sided, rear-loading Modified 4-wheel pickup	S47, S49–S52	4.0	5	—
Agriculture truck	S20, S21	2.5	2	11
Agriculture truck	S37	2.5	1	3
Trailer (10-wheel)	S40	20.0	1	3
Total			27	

Table 10.11: Time and Temperature of Steam Sterilization

Temperature		Spore Kill Time
°C	°F	Minutes
240	116	30.0
245	118	18.0
250	121	12.0
257	125	8.0
270	132	2.0
280	138	0.8

Source: Khon Kaen Province, 1994–96. Bank of Thailand. IUEMP forecasts.

Treatment

Incineration System for Infectious Waste in Khon Kaen Municipality

Previously infectious waste from clinics and small hospitals was collected along with ordinary municipal waste and placed on the pavement or roadside for daily collection. However, this created a danger toward human health, as street scavengers and municipal collection crews could be injured by needles and sharp items. Also, from a hygienic point of view, infectious waste should not be placed outside and exposed to dogs and other animals. The treatment and disposal methods used include: stream sterilization or autoclaving, incineration, thermal inactivation, gas or vapor sterilization, sterilization by irradiation, and chemical disinfecting.

It was found that 77.5% of the healthcare facilities segregated infectious waste, while there was no segregation of waste in 22.5% of them. As for pretreatment prior to disposal, 95% of the healthcare facilities had none. All of the fewer-than-30-bed hospitals sent their infectious waste to the municipality for treatment. The hospitals with more than 30 beds had incinerators for disposing of their infectious waste. The amount of infectious waste in clinics was found to average 0.21 kg/clinic/day or 0.01 kg/patient. Hospitals with 501–1,000 beds produced 283.13 kg/day, those with 151–500 beds produced 19.79 kg/day, with 10–150 beds produced 0.57 kg/day.

The system for separating infectious waste is based on source separation by the clinics and small hospitals. Infectious waste is defined as needles, syringes, blood, tissues, sharp items, remainders of medicines, bandages, etc.

Composting

As the collection system for solid waste is based on source separation, it was necessary to establish a treatment facility for organic waste as well. It was decided to construct a pilot

Table 10.12: Standard Reference Combustion Temperature for Infectious-Waste Incineration

Combustion Chamber	Previous	Newer
Primary	1,400–1,600° F	1,600–1,800° F
Secondary	1,400–1,600° F	1,800+° F
Secondary Chamber	1 to 2	1 to 2
Retention Time	Seconds	Seconds

Table 10.13: Dry Heat Sterilization

Temperature		Spore Kill Time
°C	°F	Hours
121	250	6.0
140	285	3.0
150	300	2.5
160	320	2.0
170	340	1.0
180	356	0.5

composting plant operating by means of low technology. The plant is designed to receive approximately 5 tons of organic waste per day. From this quantity the production of compost annually is estimated to be 600 tons. The process is basically of a biological nature. The mechanical equipment is employed in order to facilitate a controlled biological degradation and to minimize the negative impact on the final compost quality originating from the presence of unwanted, nonbiodegradable matter such as plastic. At the same time, the potential health hazards and nuisances associated with waste handling should be reduced compared to current waste handling.

Reception of waste: The raw waste is unloaded at the plant's reception area and fed into a shredder by means of a conveyer belt. This step is carried on continuously during normal working hours. Generally, the raw waste is fed into the system the same day it arrives at the plant in order to reduce potential smell problems and the growth of pathogenic bacteria in the waste.

Shredding: A mechanical shredder ensures that the incoming waste is cut into small parts to facilitate both handling and the biological process. Shredding will also facilitate the later removal of the plastic items, mainly from plastic bags, that are unavoidable in the waste flow. The shredder is adjusted throughout its operation in order to reach optimal performance.

Internal transport and handling: The shredded waste falls on a conveyor, which transfers the organic matter to the precomposting drum. The shredder, the conveyor, and the drum are integrated into a semi-closed unit in order to minimize the dissemination of bacteria. When leaving the drum, the matter is piled up for intermediate storage by means of a second conveyor. This conveyor does not require a cover. All other handling and internal transport at the composting plant is done by means of a front-end loader.

Air-flow control: In order to minimize the nuisances and exposure to pathogens, the above mentioned unit is equipped with an air evacuation system. By sucking out air, it is possible to limit its diffuse spreading to the surroundings. The air is evacuated from a position beneath the shredder, which creates the air flow across the shredded waste. Larger pieces of plastic or other items that are occasionally carried with the air flow are separated from the air in a cyclone before the air eventually is exhausted through a stack. If the exhausted air unexpectedly proves to cause a nuisance in the future, the air system can be equipped with a scrubber (a water spray in the air flow) or other adequate measures. Such measures are not included in the system at the present moment.

Precomposting: In order to ensure a proper start to the composing process, it is crucial to obtain an intense mixing and aeration of the organic material. Otherwise, an anaerobic zone will easily develop in the raw waste, leading to the formation of organic acids. Such unwanted intermediate products have two negative effects on the composting process: The pH value tends to be lower, which is unfavorable for the composting process, and the organic acids are volatile and have the smell that is generally associated with rotting waste. By carrying out the initial step in a rotating drum, such mixing and aeration are effectively obtained. Moreover, any occasional smell from this part of the process can be limited, as the air flow is controlled by the blower. The drum is designed so that a retention time of approximately one day is obtained. The drum is filled at normal room temperature. During the precomposting step, the temperature rises in the organic matter due to the aerobic degradation of the most volatile substances.

Bulking agent: The rest of the composting process takes place in windrows, where one of the main requirements for the process is an adequate porousness of the matter. To adjust the texture, a bulking agent of rice straw is added. Other bulking agents (leaves, husks, limps) with suitable physical characteristics might be used in the future, together with or instead of the rice straw, if it is found to be advantageous from a practical or an economical point of view. The bulking agent is mixed with the precomposted matter before the forming of the windrows.

Windrow composting: During the precomposting step, the most volatile compounds are degraded. The remaining organic material, including the bulking agent, decomposes at a lower rate. Nevertheless, the temperature in the windrows rises to 50–70° C within a few days. The exact rise in temperature over time can only be predicted in general terms, as it strongly depends on the composition of the added waste as well as the structure and the humidity of both the waste and the surrounding air. Windrow composting is controlled by turning over the windrows at intervals determined by the actual temperature in the windrows. The windrows should be turned over if the temperature goes beyond certain limits, typically 45–65° C.

During the start-up period, the windrows are turned twice a week during the first couple of weeks. During the next period, the turning frequency is decreased, until eventually the temperature increase after turning the windrows is insignificant. The part of the process that takes place in the matter during the first three or four months after mixing it with the bulking agent is, for practical reasons, referred to as composting. This is the period when the windrows are turned over at continuously decreasing intervals.

Because of the heat produced during the process, a substantial amount of water evaporates from the organic matter, thus tending to dry the material. As a humidity content of more than 40% is required for the process, water has to be added when the windrows are turned whenever the humidity drops below this value.

The subsequent part of the process is referred to as maturing. During this period, the degradation rate is low and the process in the piles does not require turning any more. This period lasts approximately two to three months. During this period, the compost is allowed to dry below a roof. The low humidity obtained by these measures will contribute to the final stabilization of the product.

Screening of compost: Plastic bags and other nonbiodegradable substances mixed with the organic waste delivered to the plant are removed from the compost before the product is suitable for use. As the degradable matter has decomposed during the process, the compost appears to have developed a finer structure than the nondegradable matter. Based on this difference, the bulk of the unwanted materials like plastics and metals are sorted out by mechanical screening. The screen is equipped with an interchangeable mesh of approximately 20 mm, in order to optimize the sorting process. In order to take advantage of the reduced volume of the compost, screening takes place before the maturing step.

If future experience proves that screening, as a compromise between several possibly conflicting interests, is more advantageous after the maturation process, such modifications can easily be implemented both from a technical and a process point of view. The final compost product is packed in bags or sold as bulk material and used as fertilizer in gardens and parks.

Disposal

The Metropolitan Municipality landfill site is an engineered landfill in Kham Bon District, which is 17 km from the Municipality. It plans to transfer operations to a new site about 40 km further away. However, the proposed site has raised objections from the local people and as a result, the existing site will be used for another five years. Since the landfill has been in operation for so long, there are a large number of scavengers living inside the landfill, including children, elderly adults, and stray dogs.

More than 200 tons of solid waste is produced each day in Khon Kaen Municipality, of which 0.25 tons are from hospitals and clinics and contain toxic chemicals, radioactive elements, and pathological substances. This waste, when dumped with other municipal wastes in the open land, poses a serious threat to the health of the city's people. Khon Kaen Municipality (KKM) is responsible for collection and disposal of solid waste generated in the KKM area.

Disposal of Other Waste

The remaining waste is disposed of at the landfill. However, by sorting out the organic part, the remaining waste is mainly dry and it is easier to pick out recyclable materials. In this way a small increase in the recycling percentage of dry waste is expected in the long run. Scavenging the dry materials takes place by street and community scavengers and municipal collection crews.

The incinerator for infectious waste disposal is located next to the landfill. The Municipality collects all infectious waste in a special truck. The collection and disposal fee for infectious waste is higher than for nonhazardous waste and many of the small infectious-waste generators are not willing to pay for this service.

Green Productivity (GP) and Other Waste-Minimization Approaches

The study of the solid-waste stream movement in an area of Khon Kaen municipality has as its objective to analyze the database concerning the solid waste of the communities in Khon Kaen Municipality. This database is used to determine the management plans for solid waste in the future. It was created from the interview forms of houses and services in Khon Kaen Municipality, along with data about the general- and hazardous-waste rates and waste that can be recycled.

At the moment the database studies the most common waste, such as garbage, plastic, paper, rubber, leather, textile, wood, leaves, and glass from their source (houses and services) to the general-waste landfill and recycling factory. This database will lead to management planning for solid waste in the areas of Khon Kaen Municipality.

According to the study, more than 90% of the houses and services uses Khon Kaen Municipality's collecting service. Only 13.6% of the houses separate solid waste before disposal, 47.2% separate wet solid waste from dry, and 37.6% only separate recyclable solid waste. Among the services, 44.2% separate solid waste before disposal and 98.6% separate recyclable solid waste.

Future Strategies

Planning the System

In Phase 1 of the IUEMP project an inventory was made of the waste quantities and composition in Khon Kaen as well as an estimate of collection. The survey showed that approximately 50% of the waste was organic. Based on the study, three scenarios were presented for a future waste-collection system. Based on these studies, it was proposed to implement a new solid-waste system with source separation and to treat the organic waste in a composting plant.

In Phase 2 it was decided to select a pilot area in which the new system would be implemented in order to gain experience before extending the system to other parts of Khon Kaen. Sam Liam communities were selected, comprising approximately 2,500 households corresponding to 10,000 people.

In addition to Sam Liam, the Aor-Ji-Ra market in Khon Kaen was also selected to be part of the pilot area. The market contains approximately 150 stalls producing organic waste. Moreover, Phase 2 included the establishment of a pilot composting plant for treating organic waste collected in the selected pilot area and market.

Project 1—Preparation of Strategic Environmental Development Plan: The plan comprises a Comprehensive Urban Development Framework (CUDF) to provide the basis for future development in the Khon Kaen planning area and a Municipal Environmental Action Plan based on an Environmental Management System (EMS) which has been set up. The EMS has been detailed for hazardous waste, which is one of the selected target subjects included in the system.

Project 2—Installation and introduction of GIS/MIS systems for environmental planning and management: A GIS unit has been set up in the municipality to provide the basis for implementing the system. Implementation was initiated in a pilot area, and expansion to the remaining part of Khon Kaen has been started. A citizen-registration database and a GIS-based tax-collection system have been added to the IT system.

Project 3—Improvement of the existing landfill including an improved working environment: During Phase 1, the Royal Thai Government provided funds for landfill improvement and construction of an infectious-waste landfill site. The visible output of Phase 2 is improved working conditions for the municipal staff including improved staff facilities and housing.

Project 4—Introduction of a new sorting and collection system for solid waste in a pilot area: The project has been implemented in the pilot area of Sam Laim and the Aor-Ji-Ra market in close cooperation with the communities and the market. The waste is sorted into an organic fraction and a remaining fraction, including recyclable materials. The Sam Laim area comprises approximately 10,000 citizens and 150 market stalls producing organic waste. The total amount of organic waste generated from both areas is approximately 5 tons per day.

Project 5—Design and construction of a pilot composting plant: A composting plant has been established to treat organic waste from the pilot areas. The plant is located at the existing landfill and comprises receiving facilities including a shredder, a precomposting drum, windrow composting, a maturation building, sieving, and packing equipment. Citizens close to the plant have been informed through a public meeting and through informational material.

OBSERVATIONS AND RECOMMENDATIONS

Recommendations for improvement are discussed below.

A public relations campaign should be intensively implemented via various types of media, e.g., posters, brochures, mobile announcements, and the establishment of public reaction stations, to encourage public understanding for all solid-waste disposal-related issues including legislation and establishing a pilot model of a solid-waste-free area.

Improve and provide the necessary equipment and machinery such as collection vehicles and solid-waste landfill disposal machinery to solve the existing environmental problems.

Increase service whenever the equipment and machinery are fully available and effectively operating. The service-fee collection should be relatively increased.

Increase the service-fee collection by zoning and marking a list of households, retail shops, and mobile vendors. This will also help give a correct evaluation of the service fee and facilitate the work of the fee collection unit of the Finance Division.

Add more manpower to the available positions.

Encourage collaboration among the responsible units to secure effective solid-waste disposal management, such as the following.

- Public Relation section: Provides information on cleansing, legislation, and regulations
- Cleansing section: Collection and transport of solid waste
- Security Section: Issues fines for improper disposal
- Income Collection and Development section: Collection of the service fee along the map zoned by the cleansing section; carrying out research, evaluation, and analysis
- Sanitary Engineering division: conduct research on machinery performance efficiency in order to decide on replacing equipment or machinery, and evaluate the operation to find the solution for nonfunctional cases

Increase the Municipality income: Increasing responsibilities for environmental-pollution management, including solid-waste disposal, wastewater treatment, and other related services will cause expenses, but income is not increased accordingly with the increasing expense for vehicles. Moreover, the tendency has been for taxes to decrease, particularly the tax on automobiles and other wheeled vehicles. The Khon Kaen Municipality currently receives THB17–18 million a year in taxes on automobiles and wheeled vehicles.

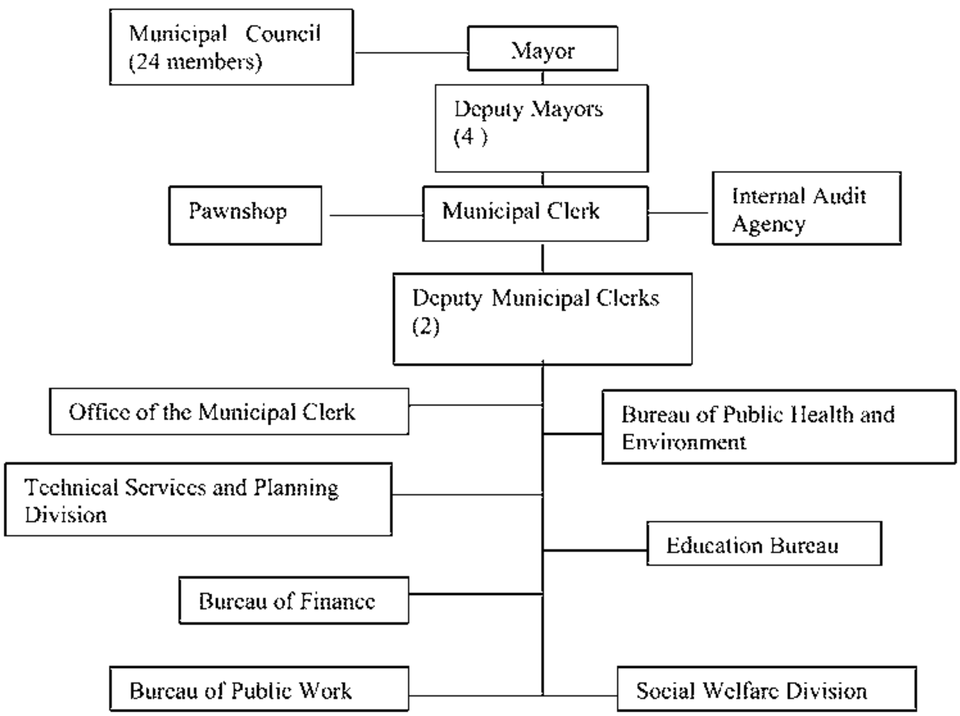

Figure 10.1: Khon Kaen Municipality Administrative Structure

Box 10.1: Effective Microorganisms
The study aimed to determine an appropriate measure for community garbage reduction. The trial was laid out in a completely randomized design with three replications. The five treatments in the experiment were EM 250 ml, 5 ml, 1 ml, 0.5 ml, and 0 ml in each 10 kg of community garbage. The community garbage was collected from the market in Khon Kaen Municipality. The results indicated that the treatment with EM 250 ml in 10 kg of garbage was the most effective treatment for community garbage reduction (98.74%), while there was not a significant difference when compared to the treatment with EM 5 ml and 1 ml, which reduced 98.35% and 97.86%, respectively. The significant difference is found when compared to the treatment of EM 0.5 ml which reduced 97.28% ($p < 0.05$). However, it is not a significant difference when compared to the treatment without EM, which reduced 98.60% ($p < 0.05$). The treatment of EM 250 ml in 10 kg garbage produced the highest wastewater from 20.147 kg on the first day to 5.731 kg the 28th day. There is not a significant difference when compared to the treatment of EM 5 ml and 1 ml, which increased the amount of waste water from 2.016 kg and 2.232 kg to 5.377 kg and 5.433 kg, respectively. The significant difference is found when compared to the treatment of EM 0.5 ml and without EM, which increased the amount of wastewater from 2.082 kg and 1.883 kg to 5.254 kg and 5.070 kg, respectively. During the first week of the experiment, the average temperature in the experiment bins for all treatments was 1–2° C higher than the atmosphere. In the second week, the temperature in the experiment bins steadily decreased until the end of the experiment when it was 2–4° C lower than the atmosphere. Furthermore, the pH of the garbage increased from 4.24 on the first day to 5.54, 5.96, 8.15, and 9.35 at the 7th, 14th, 21st, and 28th day, respectively. The result of chemical components in organic solid waste from the 1st day to the 28th day revealed that carbon reduced from 47.75% to 39.71%, hydrogen reduced from 5.37% to 4.47%, sulfur reduced from 2.45% to 0.73%, and nitrogen increased from 2.53% to 3.18%.

At present, the Ministry of the Interior is considering a plan to upgrade the sanitary district to a municipality.

Income from taxes on automobiles and wheeled vehicles in Khon Kaen Province will be equally shared among more than four Municipalities (the existing ones). Therefore, the improvement of any fee and income collection is particularly dependent on the land and housing tax, the locality maintenance tax, vat and specific business tax, etc.

- Legislative fee for a deep-well
- The fee for registration rights and land-title laws 1 and 2 can be an income source for the Tambon Administration Organization. The housing and land taxes can be improved. The locality maintenance tax in the Municipality area should not be exempt.
- *The Ministry of the Interior's legislation to revise the income provision to the Municipality:* The tax provision is divided into 90% for the government's budget and 10% for local income. The local income is divided into 60% for Bangkok, 25.43% for the Municipality, 5.5% for the Sanitary District, and 7.07% for the Provincial Administrative Organization (Chuwong Chayaboot, Thai Locality Administration). This tax provision should

be revised to an optimum proportion, such as a reduction of the tax provision to Bangkok.

- The companies or businesses that have industries or business offices located in the province while the main office is in Bangkok should pay tax to the province.
- Budget preparation for the Cleansing Unit should be separated from the Public Health Unit to facilitate budget analyses. System analyses of expenses for the collection and disposal of solid waste should be rapidly processed, which will help in making decisions about the budget allocations, particularly for replacing equipment and machinery.
- Additional income to the Municipality, particularly from the tax items and fees, fines, and permission papers, should be considered. Some number of the nonregistered population earns additional income in the retail business. Encourage the people who live in the Khon Kaen Municipality area to register in the census record. The number of registered persons in the census record is used as a base for the general supporting budget provided by the Ministry of the Interior at approximately THB150 per person. Moreover, transferring the fee for registered vehicles to Khon Kaen will generate additional income to the Province.

11. VIETNAM

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INTRODUCTION

The rapid economic development in the world in general and in Vietnam in particular has resulted in the difficult task of identifying ways and means to manage the increasing amount of waste generated. Some of this waste can be extremely hazardous and if not properly managed, can cause serious environmental damage. A number of incidents of groundwater contamination, surface water contamination, air pollution, fires, explosions, and poisoning due to hazardous waste have been reported worldwide. These incidents have prompted governments to enact legislation to control the generation and disposal of solid waste.

Solid waste is generated in all sectors of the community, including households, industry, hospitals, commerce, and agriculture. Solid waste can cause immediate, short-term, and long-term adverse effects to the environment and living conditions. Solid-waste management is therefore essential. Effective waste management can also provide opportunities for businesses in terms of increasing financial benefits, enhancing market competitiveness, and reducing the cost of hazardous-waste treatment.

Vietnam is a developing country. As the country advances, the amount of waste is increasing and the effective management of this waste has become an important issue. The Vietnamese government has taken preliminary steps to control waste generation. However, these efforts are facing constraints such as a lack of financial resources, facilities, manpower, infrastructure, and legislation. It is therefore necessary to review the current solid-waste management situation, especially in areas related to the sources and quantities of waste generated and the current methods of storage, collection, transportation, treatment, and disposal in order to progress to the next management phase. This also assists in eliminating the possibility of pollution from waste to the surrounding environment.

This study reviews the legislation, regulations, and policies for solid-waste management in Vietnam. The sources and quantities of waste generated as well as their impacts on the surrounding environment are identified. The current methods of storage, collection, transportation, treatment, and disposal are described. It also provides information on the infrastructure for waste management and details the waste minimization programs in Vietnam.

A case study of solid-waste management in Hanoi is examined. The specific details relating to the generation, transport, treatment, and recovery of waste in Hanoi are discussed. In particular, the generation of waste within the food and beverage industry in Hanoi is investigated. The importance of the organic-waste component in food and beverages is identified and the opportunities for recovering this waste stream are discussed.

COUNTRY PROFILE

Physiography and Climate

Vietnam is located in southeast Asia bordering the Gulf of Thailand, the Gulf of Tonkin, and the South China Sea, alongside China, Laos, and Cambodia. Vietnam extends 1,650 km from north to south but the country is only 50 km across at its narrowest point. The nation has a total area of 329,560 km^2 of which 325,360 km^2 is land, and water covers 4,200 km^2. The landscape varies throughout Vietnam with low and flat deltas in the south and north, highlands in the central region, and mountainous region in the far north and northwest. Vietnam's main rivers are the Red River in the north and the Mekong River in the south.

Demography

Vietnam has a population of 83 million (July 2004); almost 80% of the people live in rural areas. The average population density is 251 persons per km^2. Of the total population, 30% are below 14 years and about 6% of the population is above 65 years. The life expectancy is 70.35 years.

There are various ethnic groups in Vietnam, Kinh (Vietnamese) being most populous. Other groups are Chinese, Hmong, Thai, Khmer, Cham, and other ethnic minorities based in the mountainous region. Vietnamese is the official language and English is favored as a second language. Buddhism is a main religion but there are several million Roman Catholics and a smaller number of Protestants and Muslims.

Governance

Vietnam is a socialist and communist country. The government of Vietnam is currently divided into four levels of administration: the national level, the provincial and urban authorities (64 provinces and 4 urban authorities, Hanoi, Ho Chi Minh City, Hai Phong, and Da Nang), urban precincts and rural districts, and urban wards and rural communes (2,366 wards and 8,859 communes). Each commune contains five villages. Every level of administration has an executive branch and a people's committee, a legislative branch and a people's council.

Economy

The Vietnamese economy is based on the agriculture, industry, and service sectors. While the industry and service sectors provide larger contributions to the GDP, agriculture remains the main occupation, employing 63% of the labor force. Agricultural products include rice, corn, potatoes, and rubber. Food processing, garments, shoe making, and machine-building are the major industries. Vietnam mainly exports rice and fuel, to a total of USD15,100 million. Export partnership has been established with the United States, China, Japan, Australia, and Germany. The import items include food, fuel, energy, and other capital goods and amounts to approximately USD16,000. The GDP (in 2001) was USD32.7 billion, growing at 7% per year.

Due to the government's market liberalization policies, dramatic changes have occurred in the Vietnamese economy such as changes in the composition of the GDP and employment and in the direction and composition of foreign trade. But Vietnam is appearing to lose its price competitiveness, both regionally and globally. Exports, though strong, are showing signs of fatigue with a decline in direct foreign investment. The Vietnam government's priority is to maintain a stable microeconomic environment, financial sector, and SOE (State Owned Enterprises) to any stock exchange rate. Vietnam continues to receive loans and other contributions from various international agencies to support its development activities. Vietnam's external debt is in the order of USD14.5 million.

Environmental Profile

In 1993 the National Environmental Agency (NEA) was established under the Ministry of Science, Technology, and Environment (MOSTE) to manage environmental protection activities throughout the country. An Environment Management Division was also established in

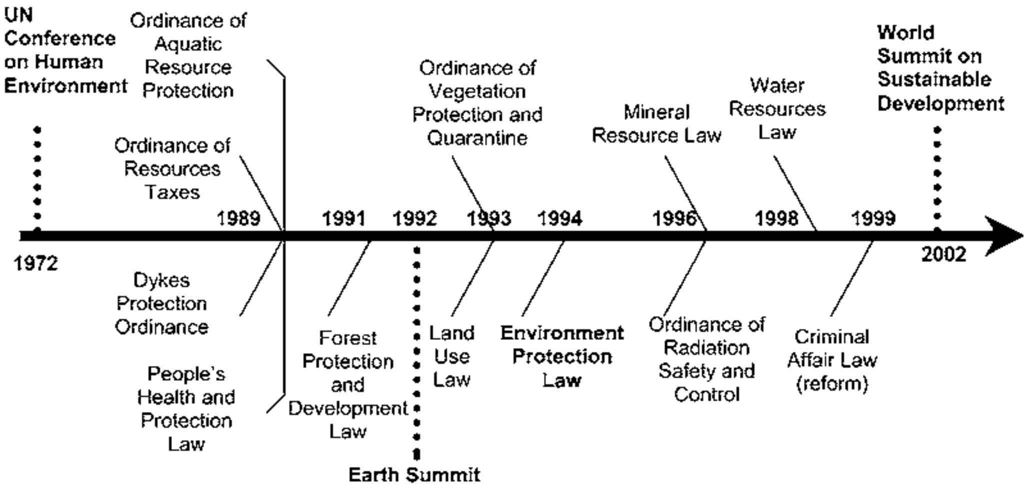

Figure 11.1: Timeline of Laws and Regulations in Vietnam

every province/city under the Provincial Departments of Science, Technology, and Environment (DOSTE).

National Environmental Regulatory Framework

Policy

In 1985, the Vietnamese government developed the National Program for Environmental Protection, and with the help of the IUCN, published the National Strategy for Natural Resource Protection. In 1990, the State Committee of Science (now MOSTE) developed a National Plan for the Environment and Sustainable Development.

Laws, Regulations, and Standards

The Environmental Protection Law was established in 1994. In addition to this legislation, there are many other laws and decrees that relate to the environment. They are depicted in Figure 11.1. There are also numerous standards relating to the ambient and working environment.

Environmental Situation Analysis

The agriculture sector in Vietnam uses various types of chemicals. Approximately 15,000 to 25,000 tons of pesticides and chemical fertilizers are used every year. The results of pesticide, herbicide, and chemical fertilizer consumption in agriculture have caused damage to the agricultural ecosystem, including reductions in the populations of aquatic species and birds.[1]

The service sector in Vietnam includes activities such as tourism, shopping, restaurants, hotels, and hostels. Every year, there are approximately 1.5 million foreign tourists and 6 to 8 million domestic tourists visiting Vietnam. Annual profits from tourism and the service sector reached VND6.8 billion in 1998.[2] The shops, restaurants, and hotels are concentrated in the

[1] Vietnam: Annual Report on the Environment, 1997.
[2] Vietnam Economic Report, 1998.

cities and towns (around bus stations) and near harbors and industries. The increasing number of hotels, restaurants, and shops in recent years have caused environmental problems.

Every year the government allocates a budget for environmental protection. Annually, the national government spends a budget of USD10 million for basic environmental investigation and monitoring activities in different regions. Some large projects oriented toward environmental protection are also supported by international organizations (UNDP, UNEP, ADB, and WB) or by agencies from foreign countries (JICA, SIDA, and CIDA, etc.). The National Environmental Agency has held many environmental training courses, workshops, and conferences. The national and local media are also expanding coverage of environmental issues on television and radio and in public newspapers. Many universities in Vietnam have courses relating to environmental fields.

OVERVIEW OF SWM

Impacts of MSW

Environmental Impact

The main environmental impact issues associated with solid waste are due to its inappropriate disposal and the subsequent potential impact on surface and ground water. In Vietnam, these waters are used for drinking, domestic purposes, agriculture, and aquaculture. Therefore, pollution of these resources may have potential health impacts on the local population and cause severe environmental damage. In essence, the main areas of concern with respect to municipal solid-waste disposal relate to the following issues.

- Groundwater contamination due to the uncontrolled, long-term storage of waste, disposal on site, disposal in a nontechnical dumpsite, or use of waste to fill in vacant areas
- Potential contamination of surface water resulting from a discharge of waste without adequate treatment, or as a result of poor housekeeping practices, or from the emission of toxic chemicals from burning or incinerating of waste
- The potentially corrosive nature of some hazardous waste can damage drainage systems and pollute the natural environment.

The World Bank estimates that the potential impact on human health due to all types of industrial pollution, including the disposal of industrial discharge to surface water, accounted for 0.3% of Vietnamese GDP in 1996. Future costs are anticipated to rise sharply as a consequence of Vietnam's industrialization, to 1.2% of the GDP by the year 2010.

Solid waste is often disposed of directly into water bodies. Additionally, wastewater from industrial zones in both Hanoi and Ho Chi Minh City are discharged without treatment into the extensive series of canals and rivers. Since these are the cities' storm-water drainage systems, all watercourses are therefore polluted due to the discharge of untreated or partially treated industrial and domestic waste. High rates of urbanization and industrialization will increase the serious problem of urban water pollution. Hospitals also discharge large amounts of wastewater into the drainage system and then into surface water systems.

In Vietnam, there have been a number of reported oil-spill incidents, which provide an indication of the potential problems that may arise due to the spillage of oils into surface water bodies. For example, in Ben Tre oil traces were found at levels of up to 35 mg/L at a prawn hatchery. The disposal of hazardous waste into surface water bodies has been reported in some areas such as Ha Bac, Dong Nai, Binh Chanh, Viet Tri, Thai Nguyen, and Van Dien. Almost all municipal water supply systems are inadequate and produce low water quality. About 30% of municipal water is from groundwater. In Hanoi, there are signs of high concentrations of fecal contamination and inorganic and organic nitrogen in the wells. This can be partly attributed to inappropriate disposal of solid waste.

There are also significant cases of atmospheric pollution due to improper waste management.

- Polluting air emissions result from point or diffuse releases or from burning or incineration.
- Solvents are commonly disposed of by evaporation.
- The asbestos-cement roofing-sheet production facility in Dong Nai Province disposed of more than two tons per day of sludge on-site, without any form of pollution-control measures.

Health Impacts

The mortality and morbidity rate profile in Vietnam shows that high levels of diseases are associated with the water supply and sanitation. The disposal of untreated waste and the incidental discharge of oil and other chemicals into rivers and the underground water supply systems contaminate the drinking-water resources and kill the fish and bottom animals, which are consumed by the local people. Some health impacts have already been observed as a result of pollution incidents relating to the uncontrolled movement of pesticide residues. An increased risk of diseases due to metal poisoning and cancer because of exposure to carcinogenic agents (polycyclic aromatic hydrocarbon) exists in communities. Occurrences of heart disease, infections of the respiratory and digestive system, and dermatitis may also arise.

Direct Impacts to Communities

As there are often no absorbing systems under the landfills, the ground water is heavily polluted, which has a direct impact on the water wells of the communities around the landfills. These communities are also required to bear the very bad odor generated from the landfills. In addition, the landfills attract flies, cockroaches, rats, and stray animals that cause illnesses. This happens in particular during the rainy season when the landfill area gets waterlogged and muddy. The Vinh Loc landfill in Binh Chanh district has no fences and the ground water is polluted. This has affected the nearby rice fields.

National SWM Regulatory Framework

The following list provides an overview of the legislation relevant to solid-waste management in Vietnam.

- Directive No. 199/TTg dated 3 April 1997 on "Urgent measures to manage solid waste in urban and industrial areas"
- Circular No. 1350/TT-KCM issued in 1995 by MOSTE gives instructions to implement Governmental Decree No. 02-CP dated 5 January 1995, which defines the commodities and services permitted and banned from commercial businesses under certain conditions on the domestic market
- Decision No.155/1999/QD-TTg dated 16 July 1999 by the Prime Minister promulgating regulations on hazardous-waste management
- The regulation on clinical-waste management issued by the Ministry of Health in 1999

The current system of legal documentation is inconsistent and inadequate. There is a lack of necessary legal instruments, instructive documents, and especially an absence of a system of national standards (TCVN) for solid waste. Besides, existing legal documents in different areas sometimes overlap each other and even conflict with the legal documentation on the environment, hampering the work of environmental protection and waste management.

Major orientations for solid-waste management policies include the following key issues.

Solid-Waste Collection

- Encourage the formulation of private companies, cooperatives, private- and state-owned enterprises working on the collection, transportation, and treatment of solid waste. Apply favorable financial policies and provide support from the governmental budget to solid-waste treatment companies.
- Employees working directly with solid-waste collection, transportation, and treatment should be put in the heavy and hazardous working category. Hence, wage policies, a hazardous allowance, and labor protection must be given proper consideration.
- Waste picking should be considered a profession. In general, waste pickers are very helpful for solid-waste management since they recover a large proportion of the waste for recycling and reusing. This work needs to be organized and managed.
- Impose decisive fines for violating the law on environmental protection or the regulations on urban sanitation. In addition, provide proper incentive schemes to encourage good habits among the citizens.

Minimization of Solid Waste

- Encourage the application of new and cleaner production processes and technologies.
- Minimize solid-waste generation through the strategies of optimal use of raw materials, changing product formulas, reducing packing materials, and changing consuming habits.

Solid-Waste Recycling and Reuse

- Enhance the recovery of used products to reuse them for the same or different purposes.
- Encourage production facilities to recycle solid waste by collecting the used products in order to reprocess and redistribute them into the market in their original form or as new products.
- Reusing and reprocessing solid waste can be done in concentrated industrial zones based on an information system for waste exchange.

Solid-Waste Disposal

The existing disposal facilities for the open dumping of solid waste should be improved to become sanitary landfills. It is necessary to construct new sanitary landfills with large capacities that can be used for at least 20 years. These landfills should also include an area designed specifically for toxic and hazardous waste disposal. The construction of a toxic-waste disposal plant should conform to international standards.

Budgets should be allocated to construct central treatment facilities for solid waste, including facilities to dispose of hazardous waste. Treatment facilities for hazardous waste should be created by applying chemical/physical treatment, stabilization, or solidification. Facilities for the treatment of biomedical waste should be created by applying the thermal treatment process or sterilization method.

SWM Situation Analysis

Urban and industrial waste has become a critical issue in big cities in Vietnam, particularly in the industrial concentrated areas. According to an investigation into solid waste in Vietnam, the amount of industrial solid waste was 48.7% to 53.3%, while domestic waste is about 45.5% to 50.3%.

In 1997, the total amount of urban solid waste generated was 11,727 tons per day, of which only 45% to 55% was collected. A higher solid-waste collection rate was achieved in the big cities. The rates of solid-waste collection in Ho Chi Minh City, Hai Phong, and Hanoi are 70%, 65%, and 63.5%, respectively. The collected solid waste is disposed of in landfills and only small amounts are used for composting. The remaining uncollected solid waste is buried or dumped into lakes, ponds, and rivers. Hazardous waste from industries and hospitals is not subject to special management, which poses a serious risk to public health.

The pollution of water bodies and the atmosphere as a result of municipal solid waste is a significant problem in Vietnam. Solid waste is commonly disposed of directly into waterways, which adversely impacts the water quality. In regional areas, this is of particular concern since the water bodies are the main source of the water supply needed to sustain the activities of the communities. In some cases, solid waste causes the contamination of drinking supplies. Additionally, solid waste can cause atmospheric pollution as a result of inappropriate odors and pollutants.

National Strategic Plan for Solid Waste Management

The principal environmental strategy statement for Vietnam is the National Plan for the Environment and Sustainable Development (NPESD). This was approved by the Council of Ministers in 1991. The strategy contains a recommendation that regulations be prepared for the use, handling, and disposal of solid waste. Following is the status of solid-waste management in Vietnam.

Quantification and Characterization

National waste-generation rates are provided in Table 11.1. The waste-generation rates for the northern Vietnamese cities are presented in Table 11.2.

Agricultural Waste

The major waste and residues from agriculture are animal manure, crop residues, and the residue of agrochemicals. Manure waste is generated by pigs, cows, and buffaloes. The quantity of this waste has not yet been estimated since it is often recycled in-situ. Crop residues are

Table 11.1: Waste Generation and Collection in Vietnam

Types of Solid Waste	Generated Waste (tons/day)	Collected Waste	
		%	tons/day
Domestic waste	14,525	55	7,988
Sewer sludge	822	90	734
Construction waste (debris)	1,798	55	990
Biomedical solid waste	240	75	180
Industrial solid waste	1,930	48	930
Total	19,315	56	10,822

Source: Vietnam State of the Environment Report, 1998.

Table 11.2: Quantity of Generated and Collected Domestic Solid Waste in Urban Areas in Northern Vietnam in 2002

Province/City	Generated Solid Waste (tons/day)	Collection Ratio (%)	Collected Solid Waste (tons/day)
Hanoi	1,756	80.0	1,405
Hai Phong	636	78.6	500
Hai Duong	108	50.9	55
Quang Ninh	381	40.0	102
Total	2,881	71.6	2,062

Source: Data from monitoring by CEETIA, 2000–02.

mainly from coffee, rubber, tobacco, and coconut plantations. The quantity of such waste is not currently known. The applications of agrochemicals are increasing. However the concentration of agrochemicals in the soil is still lower than the permissible limit.

Municipal Waste

Solid waste is generated from several major sources: household waste, industrial waste including hazardous waste from the processing activities of the industries and other manufacturing units, biomedical waste from hospitals and clinics, sewage and sludge from municipal sewer systems, commercial waste from restaurants and business areas, and construction and demolition debris from construction and rehabilitation work.

The generation rates of solid waste depend on the category of urban area and ranges from 0.35 kg/capita/day to 0.80 kg/capita/day. The average quantity of solid waste generated from towns and cities increased from 16,237 tons/day in 1996 to 22,210 tons/day in 1998. The collection efficiency was 40–70% of generated waste in big cities and 20–40% in small towns. The amount of sewage sludge received for dumping into landfills was estimated at 822 tons/day.

The specific gravity of solid waste plays a decisive role in choosing the collection equipment and transport mode. It averages 400–580 kg/m^3 in Hanoi, 420 kg/m^3 in Da Nang, 580 kg/m^3 in Hai Phong, and 500 kg/m^3 in Ho Chi Minh City. The composition of urban solid waste is very diverse and has a specific characteristic for each town depending on the living customs, civilization level, and development rate. Generally the composition of waste consists of a high moisture content, low calorific value (900 kcal/kg), organic content (50.27% to 62.22%), and significant amounts of soil, sand, and fragments of brick, stone, etc. Information on the solid waste's composition is important to ensure that appropriate treatment technologies are selected. The composition of domestic waste is shown in Table 11.3.

Hazardous Waste

The generation of hazardous waste from hospitals is estimated at about 50–75 tons per day (comprising 22% of hospital waste). The general composition of biomedical waste in Vietnam is provided in Table 11.4. The average bulk density of hospital waste is 150 kg/m^3, the water content is 42%, and calorific value is 2,150 kcal/kg.

According to the statistical data in the four big cities, Hanoi, Hai Phong, Da Nang, and Ho Chi Minh City, the amount of industrial solid waste is about 15–26% of municipal solid waste. Within industrial solid waste, about 35–41% is hazardous waste. The composition of

Table 11.3: Composition of Solid Waste in Various Locations (percentage of weight)

Composition	Hanoi	Viet Tri	Ha Long	Thai Nguyen	Tay Ninh
Organic compounds	53.0	55.50	49.20	55.00	63.0
Plastic, rubber, leather	9.66	4.52	3.23	3.00	7.7–11.6
Paper (all kinds)	1.09	7.52	4.60	3.00	4.7–6.0
Metal	5.15	0.22	0.40	3.00	1.0–3.4
Brick, stone, ceramics	3.27	0.63	3.70	0.70	1.7–2.7
Soil, cobble, and other solid matters	27.90	32.13	38.87	35.30	21.9–13.3
Water	40.47	45.00	43.00	44.23	49.00
Ash	12.96	13.17	11.00	17.15	10.90
Density, tons/m^3	0.41	0.43	0.50	0.45	0.50

Source: NEA, “State of the Environment in Vietnam” 2002 Report.

industrial solid waste is very complex, depending on the raw materials, technological processes, and final products of each production center and its related services. The daily production of hazardous waste from industries in 1997 is roughly estimated as 1,930 tons per day (comprising 19% of the industrial waste). This increased to 2,574 tons per day in 1999. The hazardous waste generated from the major industry sectors in several cities in 1998 is shown in Table 11.5.

Key Elements of SWM

Segregation, Collection, and Transportation

In general, solid waste is not segregated at the source. It is collected together and transported to the treatment sites. The collection efficiency is 40–67% of generated waste in big cities and 2–40% in small towns. The average collection rate is only about 53.4%. There is still inconsistency in the technology for collection and transportation, with a mix of different forms.

Table 11.4: Biomedical Waste Composition in Vietnam

Hospital Waste Composition	Percentage	Containing Hazardous Materials?
Organic waste	52.9	No
PP, PE, PVC bottles and bags	10.1	Yes
Bandages, plaster	8.8	Yes
Metal, cans	2.9	No
Glass, syringes, medicine tubes	2.3	Yes
Syringes and syringe needles	0.9	Yes
Waste paper, cartons, paper	0.8	No
Human parts for lab analysis	0.6	Yes
Soil, cobble, and other solid matters	20.9	No

Source: Ministry of Health, “Medical-Waste Management” 1998 Report.

Table 11.5: Industrial Hazardous-Waste Generation in Several Vietnamese Cities (tons/year)

Province/City	Electrical/ Electronics	Mechanical Industries	Chemical Industries	Light Industries	Food Processing	Other	Total
Hanoi	1,801	5,005	7,333	2,242	87	1,640	18,108
Hai Phong	58	558	3,300	270	51	420	4,657
Quang Ninh	—	15	—	—	—	—	15
Da Nang	—	1,622	73	32	36	170	1,933
Quang Nam	—	1,554	—	—	10	219	1,783
Quang Ngai	—	—	—	10	36	40	86
Ho Chi Minh City	27	7,506	5,571	25,002	2,026	6,040	46,172
Dong Nai	50	3,330	1,029	28,614	200	1,661	34,884
Ba Ria-Vung Tau	—	879	635	91	128	97	1,830
Total	1,936	20,469	17,941	56,261	2,574	10,287	109,468

Source: Centre for Research-Investment Consult for Rural Development, "Statistics and Predictions of Generated Hazardous Wastes and Recommendation for Master Plan of HW Treatment Plants in Vietnam," 1999.

- Solid waste from streets and public locations is collected manually, using manual sweeping and loading into handcarts for transport to transfer stations.
- Solid waste from households is collected by handcarts or waste-collection vehicles traveling through the streets according to a planned schedule.
- Solid waste from hospitals, businesses, industrial centers, and construction sites is collected and transported under specific contracts.

Some cities use an ingenious collection system that was developed in Hanoi. The handcarts have hoppers that can be lifted from their chassis and tipped into the top of a high, open-body truck. This is a very efficient transfer system, provided the carts can match their timing with the trucks' without either cart or truck having to wait a long time. More recently, rear and side loading compactor trucks have been fitted with lifting mechanisms for emptying handcart hoppers.

Treatment and Disposal of Solid Waste

Most of the solid waste generated is disposed of at open landfill sites. The rate of recovery for recycling and reuse is around 13–20%. Recovery activities are primarily undertaken by scavengers and rag pickers who collect plastic, paper, metal, and glass. The recovery rate of solid waste from sources to treatment location is rather high. However, waste-picking activities are completely spontaneous without any form of organization and management. About 1.5% to 5% of the total generated waste is recycled by composting to produce fertilizers and soil conditioners.

The existing landfill sites are not controlled effectively. They are not suitable for hazardous waste, and they often generate bad odors and leak leachate, and are potential sources of pollution for land, water, and the atmosphere. Landfill sites in urban areas of the Mekong Delta suffer from floods during the rainy season, which may lead to negative impacts on the environment. Currently there are no liners provided on the bottoms and walls of most landfills. Systems such as leachate collection and treatment, gas collection systems, cover layers on landfilled waste, and fences for landfill sites are not provided.

Toxic waste from hospitals and industries is not treated before being dumped at landfills, although several hospitals have installed incineration systems to treat biomedical waste. Waste that is not collected is disposed of directly onto roadsides or into ditches and waterways or burned in the open.

Infrastructure for Solid-Waste Management

There are approximately 870 vehicles in Vietnam that are used for the work of urban environmental sanitation. About 90% of them are old vehicles. The utilization factor is 70–80%. There are two organizations treating solid waste for fertilizer through composting, one in Cau Dien-Hanoi and the other in Ho Chi Minh City, that use technology with modern equipment. There are very few landfills in Vietnam. All landfills are uncontrolled without equipment to control emitted gases and leachate from the landfills.

Solid-Waste Management Issues

Planning and Construction of Sanitary Landfills

At present, some cities and provinces have a lot of difficulties in terms of land availability. In particular, the planning and construction of sanitary landfills should be given more consideration.

Waste Collection

The percentage of waste collection in Vietnam is currently at 60–70%. Household and street waste is collected by urban environment companies (URENCOs). They are capable of collecting about 60–85% of the waste. The rest is collected by recyclers or discharged into lakes, canals, and ponds. Industrial waste is mostly collected and treated by the industrial establishments themselves before being transported to the municipal landfills. Healthcare waste in big cities and provinces like Hanoi, Ho Chi Minh City, and Da Nang is collected contractually and treated by URENCOs. The remaining waste is collected, transported, and treated by the healthcare establishments themselves. URENCOs also collect 60% to 70% of the sludge and night soil. The rest is collected by suburban people or by companies with the necessary equipment.

Waste Treatment

Almost all municipal waste is treated at landfills. As segregation at the source is not undertaken, healthcare and hazardous waste are not treated but are dumped with domestic waste in crude open dumpsites and landfills. A small volume of waste is recycled and the volume of compost production is insignificant. Some of the waste generated by healthcare facilities is incinerated. Industrial waste in big cities like Hanoi and Ho Chi Minh City is treated and disposed of. In other cities, industries store their hazardous waste at their respective sites while waiting for treatment.

Applied Technology for Biomedical-Waste Collection and Treatment

At present, Vietnam has 826 hospitals with 104,065 beds. Of the total waste from these various hospitals, 12–15% is hazardous waste that needs specific treatment. However, there is a lack of appropriate treatment facilities. As assessed by the Ministry of Science, Technology, and Environment in terms of technical standards and gas emissions, only a few healthcare establishments have incinerators. Vietnam lacks the facilities to be able to analyze the dioxin concentration from incinerator emissions. Table 11.6 shows additional key issues in solid-waste management in Vietnam.

Presently, there are no national incentive plans for waste minimization. The National Environmental Agency is attempting to obtain funding from the government and international aid agencies to introduce such a plan. Industries that do not comply with the regulations will be fined as much as VND100 million (equivalent to USD8,000). Additionally, the Chief of DOSTE inspections has the right to fine violators and suspend operating licenses issued by the

Table 11.6: Key Issues of Solid-Waste Management in Vietnam

Component	Key Issue
Strategic Framework	The current investment in waste-management services and facilities is constrained by a lack of available finance.
	The operational budget for waste-management services is presently insufficient to ensure fully effective and sustainable service.
	Specific responsibilities within the waste-management sector have not been clearly defined and as such, development and improvements to the service are being hindered.
	There is presently insufficient socialization (involvement of the community and increased public-private partnerships) in waste-management services.
	There remains a need for increased training and capacity-building programs within the waste-management sector.
Waste Treatment and Disposal	There is at present a lack of sustainable investment in waste-disposal facilities.
	The operation and management of current waste-disposal sites are inadequate. To ensure the implementation of environmental and public health protection measures, mobilization, and an increase in the operational budget are necessary.
	The completed waste-disposal sites lack agreement on and implementation of closure plans. This should be required to ensure effective environmental and public health protection measures are in place.
	There is a lack of proper waste-treatment facilities and management skills at the landfill sites.
	The informal waste-recycling sector is active both at the source and at final disposal points but health and safety awareness are low in this sector, causing high risks to public health.
Cost Recovery	There appear to be opportunities for increased socialization of some services such as waste collection to help improve cost efficiencies.
	Cost recovery and fee collection are presently low. Improved cost recovery would assist the development of waste-management services.
Public Awareness and Education	The level of public awareness on environmental health and safety issues related to waste management appears to be relatively low.

DOSTE, confiscate the assets or equipment causing the offenses, and order the offender to pay compensation or rectify the damage caused.

The encouragement relating to waste minimization, recycling, and reuse is based on international environmental protection programs such as Cleaner Production, Green Productivity, ISO 14001, and VCEP. However, these programs normally do not provide funds to support implementation. The programs provide support through technical assistance, capacity building, and technology transferring.

GP Practices and Other Proactive Measures

Waste Minimization, Reuse, and Recycling Practices

Recycling plays a critical role in reducing waste quantities, returning resources back to use, and minimizing the financial and environmental burden of MSW management. An extensive, partially tiered system exists for waste recycling within each city/province comprising rag pickers and scavengers, small household and commercial recyclers, larger recyclers, and manufacturers who use recycled products.

It was estimated from monitoring that each city in Vietnam has up to 700 rag pickers and scavengers. They are poor, unemployed people who come into the city looking for ways to earn money. Consequently, the recycling of waste products provides an essential income to many people. The rag pickers/scavengers walk the streets of the city each day collecting all types of waste that can be reused or recycled from households, institutions, dumpsites, waste-collection points, restaurants, hotels, etc., and then sell the collected items to the recyclers. The average daily income for rag pickers/scavengers in 1996 was USD1.40, which is often greater than the income earned through agricultural practices.

The recyclers collect recyclable waste materials from scavengers and factories. They separate the waste according to type, such as paper, metal, aluminum, nylon, and plastic. The waste is then compacted or packaged and sold to recycling industries or manufacturers that use the materials in their processes. Some larger recycling operations deposit money with small recycling groups to enable them to have sufficient funds to buy waste from the scavengers and rag pickers. These larger recycling operations usually sell larger quantities of recyclable waste materials and supply secondary raw materials for manufacturers and industries.

According to the statistical data, the quantity of recyclable materials recovered by scavengers is 10 to 15 tons per day and consists of: paper (0.5 to 1.0 tons/day), rubber (1.5 to 3.5 tons/day), metal (0.1 to 0.2 tons/day), plastic (0.5 to 1.0 tons/day), glass (3.0 to 4.0 tons/day), and rags (0.5 to 1.0 tons/day).

According to other studies in Vietnam, the recyclers ranged widely in the scale of their operations from less than 5 tons per year to more than 1,500 tons per year. The sum of the total annual tonnage from the 20 recyclers was approximately 4,000 tons per year. The majority of the recyclers collected paper, plastic, ferrous and nonferrous metals, aluminum, and glass. On a larger scale, the enterprises generally have a lack of waste awareness, partly due to an absence of a classification system. There is no specific focus on waste generation or its minimization. However, some end-of-pipe technologies are used to reduce the impact of wastewater discharges. The need for pollution control and cleaner technologies have been recognized by the Vietnamese government and donor agencies. Several industrial pollution prevention (IPP) demonstration projects are underway. They are funded by the United Nations Industrial Development Organization (UNIDO) and the United Nations Development Programme (UNDP). These programs and the Vietnam Cleaner Production Center (VNCPC) will provide practical assistance on the introduction of cleaner technology.

Box 11.1: Waste-Minimization Projects in Vietnam by UNIDO, World Bank, and APO
UNIDO supports cleaner production through policy advice, information on availability, choice of clean technology, promotional programs, and environment and energy audits. UNIDO is strengthening the capacity of the provincial authorities to manage pollution by introducing areawide environmental-quality management systems in Viet Tri and Dong Nai provinces. The UNIDO funded project in Ho Chi Minh City was aimed at reducing pollution from facilities listed in the "Black Book." This book contains a list of 43 major polluting enterprises in and around the city. A total of 20 facilities, selected from a broad cross-section of Vietnam's industries (including the textile-garment, pulp-paper mill, food processing, brewery, chemical, steel, and cement sectors) were audited during the period of June to October 1996. The World Bank has initiated a number of studies in Vietnam and is currently supporting industrial pollution prevention (IPP) schemes for the policy division of NEA. Vietnam-Canada Environment Project (VCEP) is a four-year project designed to enhance the environmental-management capacities of key institutions through the provision of technical assistance, training, and equipment. The assistance covers the areas of environmental monitoring, industrial and urban pollution management, environmental impact assessment, environmental planning, and information management. The APO program on Green Productivity was launched in Vietnam in April 1998. This program was promoted at the community level. The Vietnam Productivity Centre, acting as the promoter of Green Productivity, is now marketing this concept to industries in conjunction with the environmental management system (EMS) of ISO 14001. However, this program requires a large timeframe before being widely accepted by industries.

Currently, there are some international agencies supporting waste minimization in Vietnam's industries. They are UNIDO, UNDP, United Nations Environment Programme (UNEP), World Bank, Vietnam-Canada Environment Project (VCEP), Asian Productivity Organization (APO), and Asian Society for Environmental Protection (ASEP).

CASE STUDY: HANOI CITY

City Profile

The Hanoi Urban Environment Company (URENCO) is responsible for the management of solid waste in Hanoi's urban districts. Solid waste in the outskirt districts is managed by the environmental department of the district people's committee.

Government Policies for Solid-Waste Management in Hanoi

The following laws, decrees, directives, and regulations are applicable to Hanoi for solid-waste management.

- Environmental Protection Law
- Decree of the Government No 175-CP on 18 November 1994, "Implementation of the Law on Environmental Protection"

- Government Decree No. 26/CP on 26 April 1996, "Administrative Fines for Violations Against Environmental Laws"
- Directive No. 199/TTg dated 3 April 1997, on "Urgent Measures to Manage Solid Waste in Urban and Industrial Areas"
- Decision No.155/1999/QD-TTg dated 16 July 1999 by the Prime Minister promulgating the regulation of hazardous waste management
- Regulation on clinical-waste management, issued by the Ministry of Health in 1999

Solid-Waste Generation

URENCO can collect 1,700 tons of solid waste per day, which accounts for about 85% of the solid waste generated. The solid-waste management system operated by URENCO is reflected in Figure 11.2. The rate of solid-waste collection is as follows: household waste, 60%; street waste, 10%; commercial waste, 10%; and industrial and medical waste, 5%.

Solid waste is classified according to the following waste types.

- *Municipal solid waste:* Solid waste composed of garbage and rubbish that is the consequences of activities in households and at public places, offices, and institutes.
- *Industrial/hazardous waste:* Industrial waste arising from processing and nonprocessing industries and utilities.
- *Biomedical waste:* All types of waste produced by hospitals, medical dispensaries, and clinics on their premises.
- *Other solid waste:* Hazardous waste originating from industrial operations and commercial waste originating from government buildings, schools, and police barracks.

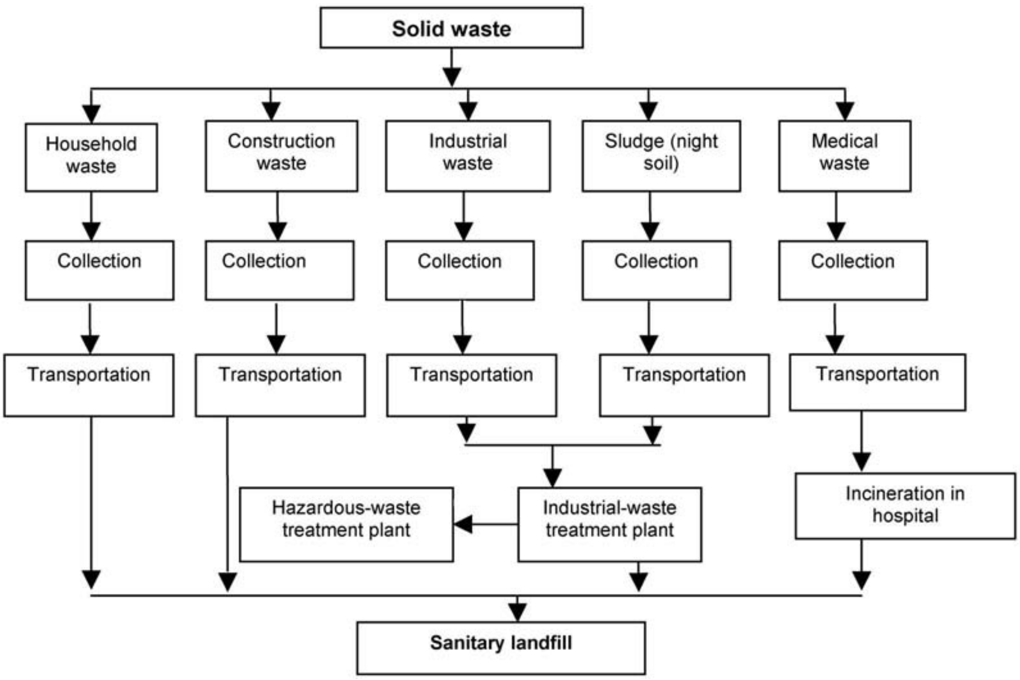

Figure 11.2: URENCO's Solid-Waste Management System

Table 11.7: Composition of Solid Waste in Hanoi

Composition	Percentage
Organic substances	41.98
Paper, cartons, boxes	5.27
Plastic	7.19
Glass	1.42
Ceramic	6.89
Bones	1.27
Metals	0.59
Other waste (10 mm)	33.67
Moisture	40.10
Density (tons/m^3)	0.38

The total solid waste generation in Hanoi is 2,999 m^3/day. Out of that, domestic solid waste (0.65 m^3/person/year) is 2,436 m^3/day, industrial solid waste is 312 m^3/day, biomedical waste is 26 m^3/day, and hazardous waste is 225 m^3/day.

Solid-Waste Characteristics and Quantification

Composition

The composition of solid waste in Hanoi City consists of organic substances, paper, cartons, plastic, glass, ceramic waste, metal, and bones. Table 11.7 shows the characteristics of solid waste in Hanoi City. Table 11.8 presents the change in the composition of waste generated in Hanoi from 1995 to 1998.

Quantification

Solid-waste generation in Hanoi City is classified into four types: household waste, construction debris, industrial waste, and biomedical waste. Table 11.9 describes the quantification of waste in Hanoi City.

Table 11.8: Changing Composition of Domestic Waste in Hanoi, 1995–98

Composition	1995	1996	1997	1998
Paper	2.2	2.9	2.3	4.2
Organic matter	45.9	50.4	53.0	50.1
Plastic	1.7	3.2	4.1	5.5
Metal, cans	1.2	1.8	5.5	2.5
Glass, ceramics	1.4	2.6	3.8	1.8
Sands and others	47.6	39.1	31.3	35.9
Total	100.0	100.0	100.0	100.0
Moisture content (%)	52.0	47.6	50.0	47.7
Ash content (%)	12.0	10.5	21.4	15.9
Density (tons/m^3)	0.432	0.416	0.42	0.42

Source: Vietnam–State of the Environment Report (SOE), 1998.

Table 11.9: Quantification of Waste

Type of Waste	Tons per Day	Tons per Year	Percentage
Household waste	1,700.0	620,500	68.0
Construction waste	750.0	273,750	30.0
Industrial waste	40.0	14,600	1.6
Hazardous hospital waste	1.5	547	0.4
Total	2,491.5	909,397	100

Key Elements of SWM

Collection

Domestic and street waste: URENCO can collect about 1,700 tons per day of the domestic, public, and street waste generated by households, offices, schools, public services, markets, streets, and parks. This accounts for 85% of the solid waste produced. The remaining waste is collected either by rag pickers for recycling or disposed of into lakes, ponds, and along embankments. Solid waste from households is collected by handcarts or waste collection vehicles traveling through the streets according to a planned schedule. Generally, solid waste is not segregated at the source.

Industrial solid waste: At present, most of the solid waste from industrial sources is taken care of by the industries. A component of toxic waste is collected and treated by URENCO under contracts. In 2003, URENCO constructed an industrial-waste-treatment plant in Nam Son landfill that contains an incinerator with the capacity of 50 tons per day. The actual operating capacity of the incinerator is 40 to 50 tons per day.

Hospital waste: Hanoi has 36 main hospitals. Each hospital signs a contract with URENCO for biomedical waste collection, treatment, and transportation. URENCO can collect and incinerate 1.5 tons of hospital waste per day.

Septic sludge: Sludge is transported to the Cau Dien composting plant to compost with garbage and produce compost fertilizer.

Construction waste: Construction waste is transported to Lam Du landfill for disposal.

A household solid-waste collection diagram is presented in Figure 11.3. The infrastructure available in Hanoi City is described in Table 11.10 and the amounts of waste collected is shown in Table 11.11.

Frequency, Time, and Rate of Collection

URENCO works in three shifts for waste collection. The first shift works from 05:00 to 11:30, second shift works from 11:30 to 17:00, and the third shift works from 18:00 to 3:00. The cost of collection is VND0.15 million per ton. The rate of collection is more than 95% in

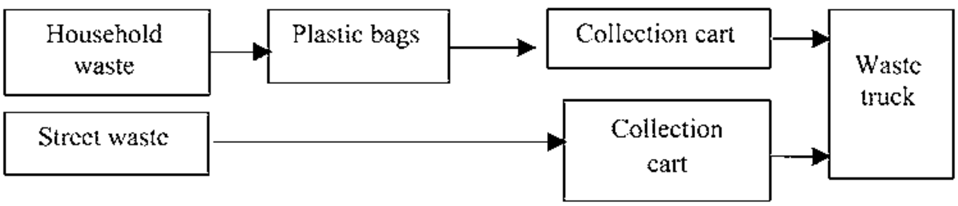

Figure 11.3 Household Waste Collection System in Hanoi

Table 11.10: Waste-Collection Facilities

Facilities	Number of Units	Volume/Weight
Collection carts	2,000	0.4 m^3–0.6 m^3
Collection bins	1,500	0.1 m^3–8 m^3
Trucks	229	2.5 tons–8 tons

Table 11.11: Waste Collection Amounts

Type of Solid Waste	Estimated Recycling Rate (%)	Amount Collected (tons/day)
Domestic waste (household, office, commercial area, and street waste)	68	1,700.0
Industrial waste	1.6	40.0
Other (hospital waste, construction waste, sludge)	30	751.5
Total	100	2,491.5

following cities: Hoan Kiem, Dong Da, Hai Ba Trung, Thanh Xuan, Cau Giay, Ba Dinh, and Tay Ho. The rate of collection is 75% in Hoang Mai and Long Bien.

Collection Fees

Table 11.12 shows the collection-fee structure employed by URENCO in Hanoi. The waste-collection fee for commercial areas such as restaurants and hotels is reflected in Table 11.13. For production houses, the waste-collection fee is based on a license tax. For the production unit in general and the industrial sector in particular, the solid-waste collection fee is VND0.29 million per ton and requires a contract with URENCO.

Table 11.12: Collection Fee

Type of Waste	Collection Fee	
	Urban	*Suburban*
Household waste and street waste	VND2,000/person/month	VND1,000/person/month
Industrial waste	According to the contracts	
Sludge	VND53,290/ton	VND53,290/ton
Hazardous hospital waste (incineration)	VND8 million/ton	

Table 11.13: Waste-Collection Fees for Commercial Operations

License-Tax Level	Waste Fee	
	Food-Provider Establishments (VND/establishment/month)	Other Commercial Establishments (VND/establishment/month)
1	180,000	90,000
2	130,000	75,000
3	90,000	60,000
4	60,000	45,000
5	40,000	30,000
6	15,000	10,000

Transportation

At present, URENCO has 200 vehicles with a volume of 3 m^3 to 8 m^3 each. These vehicles are equipped with a hydropower crane to elevate hand-pulled vehicles or small waste bins; 70 vehicles have compacting equipment. Most of them have been in use for 8 to 10 years. In addition, URENCO also received 70 vehicles from the Japanese government in 2003. The cost for waste transportation is VND129,577 per ton. Table 11.14 presents the available transportation facilities.

Treatment

Most (92%) of the solid waste is disposed of in the Nam Son landfill in Soc Son Province. Only 8% is transported to the Cau Dien composting plant to produce biofertilizer. This composting plant began operation in October 2004 with a capacity of 50,000 tons per year and produces 23,500 tons of biofertilizer per year. Currently, it is running at under 70% of the designed capacity since the quality of the compost product is not very good.

Segregation of Waste

Most of the districts in Hanoi do not segregate their waste at the source. The exception is Hoan Kiem District which started segregating in 2003. The waste generation in this district is 152,956 tons per day and the organic rate accounts for 47.79%. Waste is segregated into organic waste and inorganic waste at the household level in black and white plastic bags. Organic waste is transported to the composting plant at Cau Dien and inorganic waste is transported to the Nam Son landfill.

Current Treatment

URENCO recycles just 8% of the organic waste for high quality biofertilizer production that can be used in agricultural activities. For other kinds of waste, recycling activities still meet difficulties and are not properly managed. These activities are mostly done by waste rag pickers. Besides URENCO, there are private rag pickers collecting recyclable materials such as metal, glass, plastic, etc. It is estimated that the collected and recycled waste consists of 10% of the city's total solid waste.

Current Technology for Organic-Waste Treatment in Hanoi

The current technology for organic-waste treatment in Hanoi is composting. Hanoi has only one composting plant, which is located in Cau Dien. The plant was constructed in 1991

Table 11.14: Transportation Facilities

Transporting Equipment	Number	Capacity	Number of Trucks According to Condition			Years in Use			
			Good	Fair	Bad	>10	5–10	2–5	<2
Compactors	154	2.5–8.0 tons	100	54		54		30	70
Trucks	75	5 tons	75	0		27	48		
Trucks for sludge transportation	10	2.5–5.0 tons	1	9		9			1
Water trucks	40	5 tons							
Cars for management activities	19	5–30 seats	10	9				9	10
Other	20	2–6 tons	8	12		2	10		8

with funding from UNDP and is designed to produce 7,500 tons of compost per year from 30,000 m^3 of waste per year. The plant is operating well and it is meeting the requirements of the agriculture sector with its compost products. However, it is a pilot plant with a low capacity that is capable to deal with only 3% to 5% of the city's total waste.

The plant uses the forced-air fermentation method. After manual separation on a conveyer belt, the waste is shredded to reduce its size and mixed with night soil before being transferred to the fermentation rooms. Air from ventilators placed at the end of the fermentation rooms goes through PVC pipes (200 mm) into the lagoons beneath these rooms. The lagoons are covered by welded steel bars. The ventilators are automatically controlled by a temperature-controlling system so that the required 50° C and aeration in the fermentation pile are ensured.

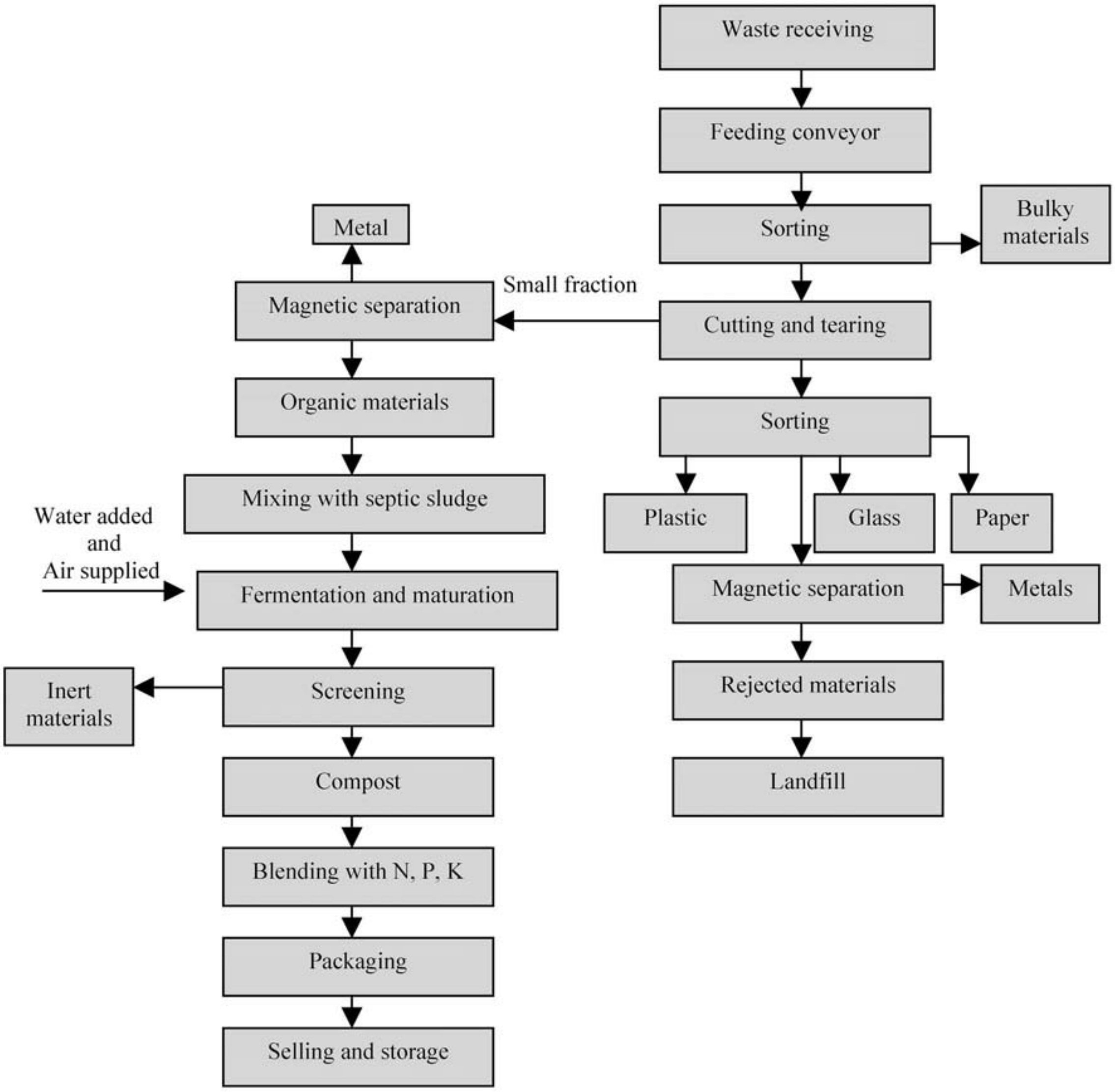

Figure 11.4: Flowsheet of the Composting Process

After this process, the waste is brought to the maturation rooms. This process takes 24 days. Manual screening is then used to separate the humus. Coarse humus goes through a purification machine to separate the fine and light humus from fine fractions of glass and sand. Fine humus is brought to the finalizing process where N, P, and K are added. It is then granulated before being packed into packages of 10 kg to 50 kg.

Disposal: General Information on Hanoi Landfill

Most of the landfills in Hanoi have been closed. Currently, only the Nam Son and Lam Du landfills are in operation. Nam Son landfill is used to dispose of nonhazardous municipal solid waste and commercial and industrial waste without hazardous substances. The landfill includes 9 refuse cells, 3 biological ponds (about 3 hectare), and a facility for treating landfill leachate. Since the Nam Son landfill is a sanitary landfill, the refuse cells are designed and constructed in an environmentally sound and safe manner, i.e., with synthetic liners (a plastic liner 1.5 mm thick) placed on the natural clay layer at the bottom and surrounding walls of the refuse cells and a drain. A system is installed in each cell to collect leachate for treatment. Detailed landfill information is presented in Table 11.15.

Difficulties and Challenges for Solid-Waste Management in Hanoi

- According to the statistical figures of URENCO, in 2003 60% of the total organic waste was rejected before going into the composting tank because the quality of the organic content was not high enough.

Table 11.15: Landfill Site Information

	Site 1	Site 2	Site 3	Site 4
Name of landfill	Me Tri	Lam Du	Tay Mo	Nam Son
Total area	8.3 ha	22 ha	6.2 ha	83 ha
Starting year	1993	1996	August 1997	May 1999
Estimated use time	Closed in July 1997	Can be used until 2014	Closed in December 1999	Can be used until 2020
Amount of disposal waste	Already full with 1 million tons of household waste	900 tons of construction waste/day	1,050 tons/day at operating time	1,700 tons/day
Distance from collection point to landfill	12 km	4.8 km	14.4 km	53 km
Disposal method	Open dump	Open dump	Open dump	Sanitary landfill
Animals at the landfill	No	No	No	Yes
Waste pickers at the landfill	Yes	No	Yes	Yes
Incinerator	No	No	No	Yes (incinerator for industrial waste treatment with the capacity of 5 tons/day, 125 kg/hr)

Box 11.2: Technical Description of the Composting Plant
Sorting Section Waste is fed into the receiving hopper of the conveyer belt or put into storage before being pushed onto the conveyer belt by bulldozer. It then goes to the separator. Paper and cardboard are sorted out on the conveyer belt. After going through the separator, waste enters a magnetic separator and shredder to be reduced to less than 60 mm in size. After being shredded, the waste is screened and mixed with treated night soil and a bioferment and moved to fermentation house.
Fermentation House After being shredded, the waste is moved to the fermentation house by conveyer belt. The existing house, with air supplied by a ventilator system, is maintained. During the fermentation process moisture is added by leachate collection and a pumping system. To ensure a high quality of decomposition, the pipe system of the fermentation houses will be reconditioned and the pumping system for leachate return to the fermentation house will be improved.
Maturation House After the fermentation process, the waste is moved to the maturation houses. Waste is arranged into windrows on a concrete floor. During this process, bulldozers are used for waste stirring to ensure even decomposition. At the end of this process, the waste is turned into humus and moved to the refining section.
Refining Section Humus is put into a screener by machine to separate inert materials, glass, plastic, and metal.
Finalizing Section The organic compost is mixed with N, P, and K, granulated, and packaged into bags of 1, 2, 5, 10, and 50 kg. After being sorted out from the waste by the separator, matters that are heavier than waste are put onto conveyer belt for separating the metal, glass, plastic, stone, and combustibles.

- There are no transfer stations at the moment. Solid waste is transported directly to the Nam Son landfill.
- There is no gas collection system at the Nam Son landfill. In addition, URENCO still has a problem with leachate treatment because of the high amount of organic waste disposed of in the Nam Son landfill. In addition, it still does not have appropriate leachate-treatment technology.
- The application of composting technology for organic-waste treatment still has the following drawbacks.
- The low effectiveness of the waste receiving and separation areas: Dry waste feeding is carried out manually without regulation. Also, the area is narrow, making the loading capacity low and unstable. In addition, the completely manual separation process is inefficient. Fine fractions of particles, glass, and metal are not completely sorted. Hence, the material projected for fermentation is impure. This means that the waste transportation cost and the recovery of materials is not satisfactory.

- The humus purification and finalization sections do not exist. Screening is done manually. The purification process is supported by a locally manufactured machine that fails to ensure product quality.

Solid-Waste Management for the Food and Beverage Industry

The survey covered 45 food and beverage enterprises (F and B) in Hanoi in three main areas: beer production companies, canned food production companies, and confectionary production companies. The total waste generation of the F and B industry is 4,280 tons per year of which 20.7% is degradable organic waste, 0.1% is corrosive in character, and 6.1% is inflammable material.

Solid-Waste Management in Restaurants and Hotels in Hanoi

The number of restaurants and hotels in Hanoi is high. The survey covered 249 restaurants and hotels in Hanoi, mostly in the Hoan Kiem, Ba Dinh, and Hai Ba Trung districts. Solid waste is not classified in most restaurants and hotels. It is put into collection bins (plastic, rubber) or plastic bags, or in suitable areas, and disposed. Organic and inorganic waste is put together except for some recyclable materials such as cans and glass.

Amount and Characteristic of Solid Waste in Hotels and Restaurants

The amount of solid waste from restaurants and hotels changes per day, per season, and by restaurant group. The average amount of solid waste from restaurants is around 68 tons per day (24,820 tons/year) of which the Hoan Kiem district accounts for more than 50%. Figure 11.5 shows the generated solid waste amount from the survey restaurants and hotels. Solid waste from restaurants and hotels has a high organic content (more than 70%). Figure 11.6 presents the characteristic of solid waste in restaurants and hotels.

Collection, Treatment, and Costs

Solid waste from the big hotels (Ha Nôûi Sofitel Plaza, Daewoo, Hilton, Melia, Sheraton, Metropole, and Sunway) and big restaurants operated by foreigners is collected and treated by private companies. For smaller restaurants, the solid waste is collected and treated by URENCO in the same way as household waste. A small portion of the organic waste (10–15%) from the restaurants is used as animal feed.

In conclusion, the amount of food waste generated every day in Hanoi is high. However, waste disposal is not a major consideration for many food and beverage operations, of which small restaurants is the largest segment. Currently, most of the solid waste from restaurants

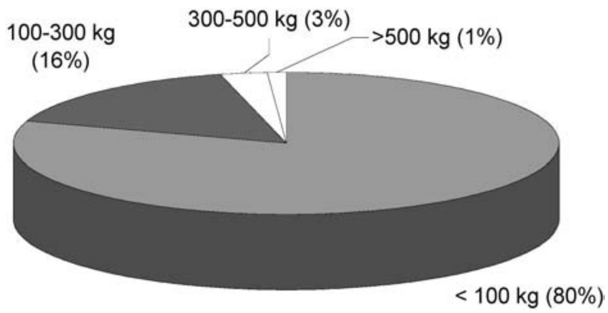

Figure 11.5: Amount of Waste Generated by Restaurants

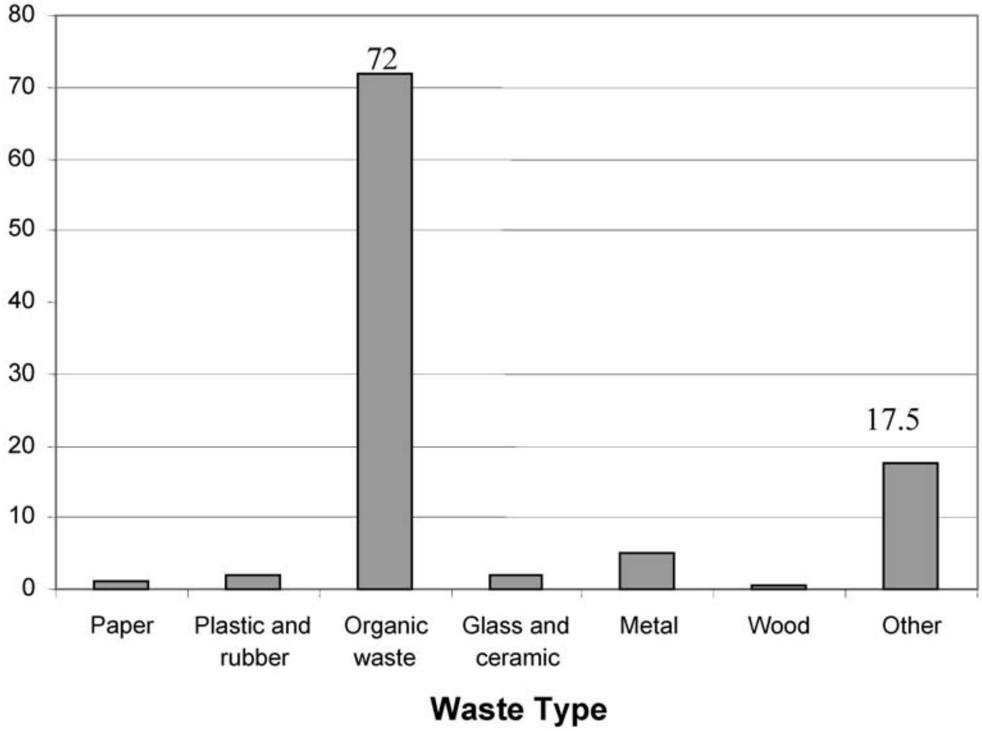

Figure 11.6: Solid-Waste Characteristic of Restaurants and Hotels in Hanoi

and hotels is not classified. Since this solid waste has a high organic content, recycling it is very important in terms of the economic and environmental aspects.

Table 11.16 shows the cost details of solid-waste management in Hanoi. Solid-waste management costs form 4–5% of the city's total expenses.

Green Productivity (GP) Practices and Other Waste-Minimization Approaches

Solid-waste management is the current hot topic, with many stakeholders involved. In Asian countries, especially in developing countries like Vietnam, solid-waste management is very important since it relates closely to community and societal aspects such as the environment, health and safety, urbanization, technology, land usage, community life, and urban management. Therefore, the application of Green Productivity, introduced by APO, in solid-waste management is really suitable and appropriate. NPOs should be the key players in terms of promoting GP projects in solid-waste management in the country.

Recovery of Nonorganic Materials

Recycling plays a critical role in reducing waste quantities, returning resources back to use, and minimizing the financial and environmental burden of MSW management. An extensive partially tiered system exists for waste recycling within each city and province of Hanoi. It comprises rag pickers, small household/commercial recyclers, larger recyclers, and manufacturers who use recycled material. The rag pickers are generally poor, unemployed women or farmers who come to the city from the surrounding provinces at times when there is less

Table 11.16: Cost of Solid-Waste Management in Hanoi
(VND thousands)

Cost	2002	2003
For waste	119,349,335	136,511,188
Collection	58,069,441	66,244,636
Transportation	55,476,560	63,243,278
Treatment	5,803,334	7,023,274
For land	8,881,610	10,435,432
Collection and transportation	8,364,927	9,314,599
Treatment	516,683	1,120,833
Other	20,170,607	11,678,443
Salaries	54,472	70,008
Total cost	148,456,024	158,695,071

agricultural activity, looking for ways to earn money. The rag pickers walk the streets of the city each day to collect all types of waste from households, institutions, dumpsites, waste-collection points, restaurants, hotels, etc. that can be reused or recycled, and then sell the collected items to the recyclers.

The recyclers collect recyclable waste materials from the rag pickers and factories. They separate the waste according to waste type, such as paper, metal, aluminum, nylon, and plastic. The waste is then compacted or packaged and sold to factories or manufacturers that use the materials in their manufacturing processes. Some larger recycling operators deposit money with small recyclers to enable them to have sufficient funds to buy waste from the scavengers and rag pickers. These larger recycling operators usually sell larger quantities of recyclable waste materials and act as agents to supply secondary raw materials to manufacturers and factories.

According to the statistical data from the URENCOs, the normal system for waste recycling in urban areas comprises scavengers, small household/commercial recyclers, larger recyclers, and manufacturers who use recycled material. According to the statistical data, there are 6,000 recyclers and scavengers in Hanoi City. These people often come from other provinces. At the Nam Son landfill, 600–700 scavengers work there. The quantity of recyclable material collected is approximately 10–15 tons per day. Table 11.17 shows the selling price of the recyclable material collected from solid waste.

FUTURE STRATEGIES

In the case of Vietnam, one of the most important contributing factors to the success of the project is the systematic, organic, synergetic, and dynamic linkage of the solid-waste-related parties from the governing council boards to executive agencies and GP teams, from the Ministry of Science and Technology (MOST), the Ministry of Natural Resources and Environment (MONRE) local government, and provincial management to districts, cities, and communities. It is important to have the participation of opinion leaders, decision makers, environmental-service providers, and government agencies. The subject for promotion is productivity enhance-

Table 11.17: Selling Price of the Recyclable Material

Recyclable Material	Generation (tons/day)	Unit	Unit Price (VND)
Aluminum	0.1–0.2	kg	14,000
Copper		kg	14,000
Iron		kg	500
Plastic	0.5–1.0	kg	1,000–3,500
Plastic bags		kg	700
Paper, cartons	0.5–1.0	kg	1,200
Rags	0.5–1.0	kg	1,000
Glass	3.0–4.0	kg	100–300
Rubber	1.5–3.5	kg	1,000

ment while protecting the environment. The support of the mass media is essential for a successful promotional campaign.

The national action plan for promoting GP applications in solid-waste management in Vietnam should include some major components.

- *GP awareness promotion:* Awareness promotion can be administered by a variety of tools, such as booklets, posters, newsletters, technical manuals, and videos. The mass media is essential in disseminating the definition, advantages, and importance of GP to the public. GP awareness can be attained through seminars, workshops, and training courses. The level of required GP knowledge is different for different groups. For solid-waste management, the major groups to be focused on for raising awareness include city planners, policy makers, consultants, local government, solid-waste professionals, practitioners, and communities.
- *Technical assistance and exchange of information:* NPOs can provide technical assistance to interested parties on GP concepts, methodologies, and applications. Through the APO Technical Expert Services (TES) program, NPOs can also exchange and benefit from technical and technological issues as well as management appraisal. The information exchange among interested parties in solid-waste management is very important. Creating a GP association and expert network can be an effective way to mobilize knowledge for problem solving. The establishment of a computer database system is necessary and convenient for information dissemination not only within Vietnam but also among the APO member countries.
- *Joint research and feasibility study for GP application in solid-waste management:* NPOs should be the facilitators of joint research and feasibility studies for GP applications in solid-waste management. The partners for research should be institutional bodies, planners, policy makers, consultants, local government, and solid-waste professionals and practitioners to make sure that GP is introduced from the early stage to the implementation stage.
- *GPDP on GP and solid waste management:* Based on the result of the research and feasibility studies, GP demonstration projects on solid-waste management should be carried out with the involvement of all the interested parties. NPOs are the key players in this activity with strong support from the APO and the experiences learned from other member countries.

Dissemination and Expansion of the GP Program

The results of the GP demonstration project should be disseminated and promoted to the public and interested parties. From this good example, a plan for the expansion of GP applications on solid-waste management can be developed by the government of each country with support from the NPOs and the APO.

The Vietnam Productivity Centre (VPC) has developed a five-year National Strategic and Action Plan (2003–08) for GP promotion and application in solid-waste management in Vietnam, as described in Table 11.18.

OBSERVATIONS AND RECOMMENDATIONS

This survey on municipal solid-waste management resulted in the following observations.

- Solid waste is generated from a wide range of industrial, commercial, agricultural, and domestic activities. Such waste can cause many impacts on the environment and humans. It can contaminate surface water, ground water, land, and the atmosphere.
- Numerous items of legislation, regulations, and policies for solid-waste management have been issued. However, law compliance is low due to the lack of stringent enforcement. Currently, there are many types of waste-management practices that have been implemented, such as land disposal management, on-site disposal/long-term storage management, and reuse and recycling. These practices have not had a significant effect due to the lack of treatment facilities, poor housekeeping, and the nonseparation of waste. Therefore, pollution by solid waste is still a problem to be addressed.
- There are some solid-waste minimization programs implemented that are partially funded by UNIDO, UNDP, UNEP, the World Bank, VCEP, APO, and ASEP. However, there is still a lack of incentives for solid-waste management.

Table 11.18: Action Plan for GP Application in Solid-Waste Management in Vietnam

		Time Frame (2003–08)					
Content of Work	Key Involved Parties	2003	2004	2005	2006	2007	2008
GP awareness promotion	VPC, local governments, practitioners, communities						
Technical assistance and exchange of information	VPC, local governments, professionals, practitioners						
Joint research and feasibility study for GP application in solid-waste management	VPC, local governments, professionals, practitioners						
GPDP on GP and solid-waste management	VPC, local governments, professionals, practitioners						
Dissemination and expansion of GP program	VPC, government, policy makers, professionals, practitioners						

- Solid-waste management in Vietnam is still under development. Municipal waste is not well classified at the source. The current treatment technology is landfills. Only 8% of the waste is recycled by a composting plant, but the quality of the product is not good due to poor organic input.
- Waste generation in Hanoi City is growing very fast. Currently, the biggest problem of solid-waste management in Hanoi is leachate from the Nam Son landfill and poor awareness on the part of the population.
- Waste from the food and beverage industry, restaurants, and hotels are still not classified and are still disposed of in the normal routine. This causes a big problem with leachate generation and also wastes a source of organic matter for composting.
- The Green Productivity program could be considered a means of minimizing solid-waste generation. Through GP implementation, enterprises and communities gain economic benefits and improve environmental performance.

Therefore, the National Strategic and Action Plan for enhancing the NPOs capabilities to promote GP for solid-waste management have been developed. This plan establishes the goals to be gained such as creating public GP awareness, researching various GP options for solid-waste management, expanding the GP program relating to solid waste based on the result of research, capacity building on GP, technical assistance, networking, and information dissemination. The plan also gives a timetable to attain the above goals.

Recommendations

In order to improve the solid-waste management situation, the following recommendations are made.

- *Use the legislative instruments for solid-waste management:* The legislative instruments can be in the form of pollution-control standards and licenses as well as more efficient regulation. This could be applied to enterprises that generate high quantities of solid waste. In addition, the existing system of pollution-control standards should remain.
- *Use economic incentives:* This can be implemented by introducing a pollution-fee system (e.g., collection and disposal fees). This directly addresses solid-waste generation and disposal. The main purpose of these fees is to provide economic incentives for applying the practices of reuse, recycling, waste-minimization, and incineration.
- *Reducing waste:* This can be considered the strategic way to solve the problem. Reducing waste should become an important part of the national strategic plan and include reducing at the communes and in industries, as well as a classification system and appropriate treatment technology.
- *Waste-audit scheme:* Through this scheme, the areas for improvement and major sources of solid waste can be identified. Based on the findings, options will be generated to minimize the quantities of waste produced.
- *Changing the communes' attitudes:* Promoting waste minimization within big cities requires a major shift in thinking and attitude from current end-of-pipe practices and uncontrolled dumping to at-source minimization.
- The solid-waste management strategy being developed for Vietnam will play a significant part in raising the overall awareness of waste, and in changing attitudes from dumping to more sustainable means of waste management.
- *Promote the application of GP in the industry sector:* GP will be an effective tool for pollution minimization. By raising GP awareness, solid waste will be managed and minimized

in a sustainable way. In addition, the cost for waste treatment will be reduced and the benefit increased. Enterprises and companies will gain a competitive advantage. Communities will benefit with improved environmental and health conditions.

• *Training and education:* Through training and education, the knowledge of solid-waste management can be disseminated. Training should include GP tools and techniques, as well as regulatory mechanisms and the financial benefits that can be derived. Training should be used to promote GP awareness in industry and in communities.

• *Encourage on-site reuse and recycling:* This method will reduce material consumption and the quantity of hazardous waste generated. As a result, material cost and waste treatment cost will be reduced.

• *Establish formal waste-management programs and plans:* Such programs should be of a “cradle to grave” nature for the management of waste.

• *Establish appropriate treatment and final disposal capacity:* This should take into account both the quantity and quality of the waste generated in Vietnam.

• *For Hanoi City:* The GP concept can be applied to solid-waste management with the application of the ecocirculation concept that originated in Japan.

• The waste of F and B industry, restaurants, and hotels should be classified and used as the source of organic matter for compost/biofertilizer or animal feed. Besides that, leachate from the Nam Son landfill complex should be treated in the correct way with the appropriate technology.

• *Implement waste-minimization through pilot and demonstration projects:* These pilot and demonstration projects can be used to raise awareness of basic waste-minimization measures. They can also help illustrate the significant benefits that can be gained from implementing solid-waste minimization programs. The projects should be sector-specific and the outputs from these programs, such as case studies and guidelines, should be disseminated to other factories to encourage replications.

• *Implement Environmental-Impact Assessment (EIA):* This is a key aspect of the planning and pollution control of new enterprises, and will play a significant role in the minimization and management of solid waste. The early identification of potential waste streams can provide the basis for developing improved waste minimization procedures.

• *Network and information exchange:* Such exchanges should include enhancing international cooperation, establishing relations, and actively taking part in international activities in order to exchange information on solid waste. It is also necessary to find support for collecting, processing, analyzing, and saving data on solid waste to be used later for the comprehensive planning of solid-waste management, technology transfer, and dissemination workshops.

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Part IV

Appendixes

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2. LIST OF ABBREVIATIONS AND ACRONYMS

Abbreviation	Full Form
ACA	Ayala Centre Association
ADB	Asian Development Bank
AFI	Ayala Foundation, Inc.
ALI	Ayala Land, Inc.
APMC	Ayala Property Management Corporation
APWA	American Public Works Association
ARI	Acute Respiratory Infection
ASEP	Asian Society for Environmental Protection
BCA	Building & Construction Authority
BMA	Bangkok Metropolitan Administration
BOD	Biochemical Oxygen Demand
B.O.L.T.	Built, Operate, Lease, and Transfer
BOO	Build, Own, and Operate
B.O.O.T.	Built, Own, Operate, and Transfer
BOT	Built, Operate, and Transfer
BRAC	Bangladesh Rural Advancement Committee
CAPS	Centre for Advanced Philippine Studies
CBOs	Community-Based Organizations
CBS	Central Bureau of Statistics
C&D	Construction and Demolition
CDM	Clean Development Mechanism
CDS	Current Daily Status
CEA	Central Environmental Authority
CEIP	Colombo Environment Improvement Program
CEPOM	Committee on Environment Policy and Management
CKV	Clean Kathmandu Valley Study Project
CMC	Colombo Municipal Council
CMU	Community Mobilization Unit
CNG	Compressed Natural Gas
CO	Carbon monoxide
CO_2	Carbon dioxide
COD	Chemical oxygen demand
COWI	Consulting within Engineering, Environmental Science, and Economics
CPCB	Central Pollution Control Board
CRC	Community Recycling Center
CUDF	Comprehensive Urban Development Framework
CV	City Volunteer
DAO	DENR Administrative Order
DAP	Development Academy of Philippines
DCC	Dhaka City Corporation

DENR	Department of Environment and Natural Resources
DFRS	Department of Forest Research and Survey
DILG	Development of Interior and Local Government
DMC	Delhi Municipal Corporation
DO	Dissolved oxygen
DoE	Department of Environment
DOST	Department of Science and Technology
DOSTE	Departments of Science, Technology, and Environment
DWASA	Dhaka Water and Sewerage Authority
EA	Environmental Assessment
ECA	Environment Conservation Act
ECNEC	Executive Committee of the National Economic Council
ECR	Environment Conservation Rule
ED	Environment Department
EDPC	Economic Development Planning Council
EIA	Environmental Impact Assessment
EM	Effective microorganisms
EMB	Environment Management Bureau
EMO	Environment Management Office
EMS	Environmental Management System
EPA	Environment Protection Act
EPA	Environmental Protection Administration
ESWM	Ecological Solid-Waste Management
FZA	Fernando Zobel de Ayala
GDP	Gross Domestic Product
GIS	Geographic Information System
GNI	Gross National Income
GNP	Gross National Product
GP	Green Productivity
GPDP	Green Productivity Demonstration Project
GPP	Green Productivity Programme
GPS	Global Positioning System
GTZ	Gessellschaft fur Technische Zusamenarbeit
HDPE	High-density polyethylene
HMGN	His Majesty's Government of Nepal
HRD	Human Resource Development
IDB	Industrial Development Bureau
IDFC	Infrastructure Development Finance Company
IEC	Information, Education, and Communication
IEE	Initial Environmental Examination
IES	Innovation for Environmental Sustainability
INR	Indian National Rupee
IPP	Industrial pollution prevention

ISO	International Standards Organization
ISWM	Integrated and Sustainable Waste Management
ISWM	Integrated Solid-Waste Management
ITDI	Industrial Technology Development Institute
IUCN	International Union for the Conservation of Nature and Natural Resources
IWCC	Industrial Waste-Control Centre
IWEP	Industrial Waste Exchange Programme
IWRS	Industrial Work Reporting System
JBIC	Japan Bank for International Cooperation
JICA	Japan International Corporation Agency
kg/m^3	kilogram per cubic meter
kj/kg	kilojoules per kilogram
KKM	Khon Kaen Municipality
KKP	Khon Kaen Province
KMC	Kathmandu Metropolitan City
KVMP	Kathmandu Valley Mapping Programme
kWh	kilowatt-hour
LAs	Local Authorities
LCE	Local Chief Executive
LDPE	Low-density polyethylene
LFS	Landfill site
LGRD & C	Ministry of Local Government, Rural Development, and Cooperatives
LGUs	Local Government Units
LHDG	Lorong Halus Dumping Ground
LMP	League of Municipalilties of Philippines
MACEA	Makati Commercial Estate Association
MAP	Management Association of the Philippines
MCBD	Makati Central Business District
MDP	Makati Development Program
MEA	Multilateral Environmental Agreements
MEWR	Ministry of Environment and Water Resources
mg/l	milligrams per liter
mm	millimeters
MMDA	Metro Manila Development Authority
MOEA	Ministry of Economic Affairs
MoEF	Ministry of Environment and Forests
MoI	Ministry of Industry
MoLD	Ministry of Local Development
MONRE	Ministry of Natural Resources and Environment
MoPE	Ministry of Population and Environment
MOSTE	Ministry of Science, Technology, and Environment
MPPP	Majlis Perbandaran Pulau Pinang (Municipal Council of Penang Island)
MRF	Materials Recovery Facility

MRT station	Mass Rapid Transport station
MSW	Municipal Solid Waste
MSWMS	Municipal solid-waste management system
MT	Metric ton
NEA	National Environment Act
NEA	National Environment Agency
NGOs	Non-Governmental Organizations
NH_3	Methane
NIC	Newly Industrialized Country
NIMBY syndrome	Not in My Backyard syndrome
NIPO	National Iranian Productivity Organization
NO_3	Nitrogen trioxide
NO_x	Nitrogen oxides
NPC	National Planning Commission
NPCC	National Police Cadet Corps
NPESD	National Plan for the Environment and Sustainable Development
NPO	Nonprofit Organization
NPV	Net present value
NRP	National Recycling Program
NSSWM	National Strategy on Solid-Waste Management
NSWMC	National Solid-Waste Management Commission
OBS	Outward Bound Singapore
OECD	Organization for Economic Co-operation and Development
OEPC	Office of Environmental Policy and Compliance
PAB	Pollution Adjudication Board
PAH	Polycyclic aromatic hydrocarbons
PBE	Philippine Business for the Environment
PD	Presidential Decree
PE	Polyethylene
PET	Polyethylene terephthalate
PEWOG	Penang Environmental Working Group
PIMC	Penang Island Municipal Council
PLGCF	Penang Local Government Consultative Forum
POPs	Persistent Organic Pollutants
PP	Polypropylene
PPP	Polluter-pay Principle
PSP	Private-sector participation
PTO	Permit to Operate
PUB	Public Utility Board
PVC	Polyvinyl chloride
PWC	Public waste collector
RA	Republic Act
RCE	Recyclable Collection Event
RDFs	Refuse Derived Fuels

REMS	Regional Environmental Monitoring Stations
RIPs	Refuse Incineration Plants
RoC	Republic of China
RWA	Resident Welfare Associations
SEC	Singapore Environment Council
SERI	Socio-Economic and Environmental Research Institute
SGP 2012	Singapore Green Plan 2012
SIDA	Swedish International Development Cooperation Agency
SLF	Sanitary Landfill Site
SME	Small and Medium Entrepreneurs
SoE	State of Environment
SO_x	Sulphur oxides
SPE	Special Program for the Environment
sq km	square kilometers
SW	Solid Waste
SWAPP	Solid-Waste Management Association of the Philippines
SWARM Plan	Solid-Waste Reduction Master Plan
SWM	Solid-Waste Management
SWMC	Solid-Waste Management Cell
SWMP	Solid-Waste Management Program
SWMRMC	Solid-Waste Management and Resource Mobilization Centre
SWMS	Solid-Waste Management Section
TAG	Technology Advisory Group
TDEP	Taipei City Department of Environmental Protection
TF	Task Force
THB	Thai Baht
TIPCO	Trust International Paper Corporation
TSWM	Tehran Solid-Waste Management
TTS	Teku Transfer Station
TWG	Technical Working Group
UAP	United Architects of the Philippines
UFMR	Under Five Mortality Rate
ULB	Urban Local Bodies
UN	United Nations
UNDP	United Nations Development Programme
UNFPA	United Nations Fund for Population Activities
UNICEF	United Nations Children's Emergency Fund
UNIDO	United Nations Industrial Development Organization
UNOPS	United Nations Office for Project Services
URENCOs	Urban Environment Companies
USAID	United States Agency for International Development
VCEP	Vietnam Canada Environment Project
VDC	Village Development Committee
VNCPC	Vietnam Cleaner Production Center

Voc	Volatile organic compounds
VPC	Vietnam Productivity Center
WACS	Waste Appraisal and Characterization Study
WB	World Bank
WDA	Waste Disposal Act
WEC	Ward Environment Committee
WEIC	Waste-Exchange Information Center
WHO	World Health Organisation
WMRAS	Waste Management and Recycling Association of Singapore
WPC	Western Provincial Council