Municipal Solid Waste Management in Asia

Asian Regional Research Program on Environmental Technology (ARRPET)

Asian Institute of Technology

MUNICIPAL SOLID WASTE MANAGEMENT IN ASIA

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Preface

The Asian Regional Research Programme on Environmental Technology (ARRPET) funded by Swedish International Development Cooperation Agency (Sida) is aimed at research programs on environmental concerns relevant to Asia. The issues covered include wastewater, air pollution, solid and hazardous wastes. The project is coordinated by the Environmental Engineering and Management Field of Study of the Asian Institute of Technology (AIT), Thailand involving National Research Institutes (NRIs) in eight countries.

This report is the outcome of the research carried out for the solid waste sector in the first phase of the project on Sustainable Solid Waste Landfill (SWLF) Management in Asia under ARRPET. Four NRIs: National Engineering Research Center for Urban Pollution Control, Tongji University, China; Centre for Environmental Studies, Anna University, India; Faculty of Agriculture, University of Peradeniya, Sri Lanka; and Faculty of Engineering, Kasetsart University, Thailand representing the respective countries have been coordinated by AIT for a joint research on various aspects to investigate suitable methods related to sustainable SWLF management. Of the four NRIs, China and India represent the most populous countries in the world with wide variations in geographical features, lifestyles and living standards, and a burgeoning urbanization leading to myriad problems of municipal management primarily due to the urban shift of the rural population. Sri Lanka and Thailand, on the other hand represent smaller rapidly industrializing countries with potentials for accelerated development. Whatever be the scenario, the urban environment in these countries has been deteriorating due to the menace of solid waste.

This publication is a compilation of the research conducted to assess the existing Municipal Solid Waste Management (MSWM) situation in the four countries by the respective NRIs. It includes the significance and issues of MSWM with the current scenario *vis-à-vis* the emerging trends in these countries. Recommendations have been made to encompass new directions and strategies that can be adopted to help the study countries reach the goal of Integrated Solid Waste Management (ISWM) paving way for a sustainable environment. The report highlights the lacunae specific to each country and each sector of solid waste management with emphasis on the technical, managerial, legal, economic and financial aspects together with the participation of the citizenry for making the desired goal a success.

This study has identified the existing solid waste management practices along with the policy and institutional limitations among the four study countries. It is anticipated that this initial report on the comparative study will provide a useful guidance for the government agencies and policy makers for urban planning and development in general, and for the MSWM in particular to organize their priorities for planning and implementation of sustainable approach to urban waste management. The issues towards attaining the goal of integrated solid waste management have been discussed to enhance the sustainability of the deteriorating environment.

On behalf of the NRIs and ourselves, we take this opportunity to thank Sida for facilitating this phase of an important and opportune research and to AIT for the congenial atmosphere for carrying out this study. We look forward to the adoption of integrated methodology for MSWM in the study countries as well as in other Asian countries.

In conclusion, we express our sincere gratitude to the following experts for critically reviewing this report with their valuable suggestions prior to its publication:

- Mr. Tang Jia-fu, Deputy Director of Environment Sanitation Department, Shanghai, China;
- Mr. A. D. Bhide, Director Grade Scientist (Retd.), National Environmental Engineering Research Institute (NEERI), Nagpur, India;
- Dr. S. Pilapitiya, World Bank Consultant, Colombo, Sri Lanka;
- Mr. Paisan Padungsirikul, Director of Solid Waste and Night Soil Division, Pollution Control Department (PCD), Thailand;
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Executive Summary

Municipal solid waste management is an important part of the urban infrastructure that ensures the protection of environment and human health. The accelerated growth of urban population with unplanned urbanization, increasing economic activities and lack of training in modern solid waste management practices in the developing countries complicates the efforts to improve solid waste services. The changes in consumption patterns with alterations in the waste characteristics have resulted in a quantum jump in solid waste generation. Although the urban residents of the developing countries produce less solid waste per capita than the high-income countries, the capacity of the cities to collect, process or reuse and dispose solid waste cost-effectively is limited.

This report intends to highlight the prevailing conditions in the management of municipal solid waste (MSW) in four countries (China, India, Sri Lanka and Thailand). It is an attempt to compare their technical, economic, health and legal aspects of MSW. It also discusses the stakeholders and their services in resolving the solid waste issues. MSW as described in this report refers to all domestic refuse and non-hazardous wastes such as commercial and institutional wastes, street sweepings and construction debris though in some cases it also refers to night soil, and ash and clinkers from domestic coal consumption.

The first chapter looks at the general overview of the study countries, recent trends of municipal solid waste management (MSWM) and its significance. The second chapter compares the prevailing scenario of MSWM in the study countries with respect to technical, managerial, economic and financial, health and legal aspects. It discusses the roles of the stakeholders and their services at national and local levels for the effective management of MSW with case studies and success stories. Chapter three deals with the recommendations put forward for new directions and strategies on different aspects of MSWM in each study country as the most appropriate options to reach a sustainable solid waste management system. The last chapter describes the proposed sustainable solid waste management framework which could represent the future steps to be taken for achieving the goal.

The generation of municipal solid waste in the study countries differs according to economic status, population density, urban lifestyles, food habits, geographical conditions and other socio-economic and cultural factors. For instance, daily per capita solid waste generation in China ranges from 0.6 - 0.9 kg, India from 0.3 - 0.6 kg, Sri Lanka from 0.4 - 0.8 kg and Thailand from 0.5 - 1.0 kg. The major portion of the waste generated is dominated by food wastes. The average paper and plastic contents in the MSW are lower than 15% and vary according to the level of urbanization and formal/informal sector recycling activities.

Presently, these countries have to cope with the generation of large quantities of diverse solid waste stream, especially in the urban and semi-urban areas and most often, this effort lacks technical backing, adequate manpower and stringent policies for an adequate and astute solution, whether it is for collection, transportation or disposal. Interestingly, in some urban areas the solid wastes are of little concern due to the perfect blending of public participation and local authority. Some private enterprises have also made significant investments on the MSW generated in the study countries.

General awareness of waste management is low amongst most common people. Source separation of waste is restricted to some urban areas, selected cities and pilot projects. Wastes generated are not formally segregated prior to disposal except for some selected cities and urban areas, due to lack of storage facilities, unscheduled collection frequency and lack of civic responsibilities. Informal segregation of the solid wastes is carried out largely by the scavengers and itinerant waste pickers (driven solely by poverty), and up to some extent by the collection crew. They play an important role in resource recovery but often are not fully organized and are unaware or unconcerned of the environmental health and safety issues.

The collection system generally varies widely from mechanized operations to labor intensive. A large portion of the waste still remains unattended which poses an immediate concern and a potential threat to the local environment. Majority of the collection vehicles and containers are not fitted with compactors, necessitating transportation of loose waste that imposes constraints on the collection capacity. Handcarts, tricycles, tractor-trailers and other low level mechanized systems are being employed in a larger scale to collect waste from the collection units. Besides the collection fleet, financial constraints and lack of technical expertise severely limit the effectiveness of solid waste collection and transportation in most areas of these countries.

The most prevalent way of disposing MSW in the study countries is open dumping which is the easiest and the cheapest method of removing waste from the immediate environment. In some cases, the wastes are burnt to reduce the volume and minimize the attraction of animals and vermin. Other waste disposal options practiced are composting, incineration and sanitary landfilling.

A wide range of individuals, groups and organizations in the study countries are involved with MSWM as service providers, intermediaries and regulators. They play a potential role as generators, regulators and legislators in providing the key to effective national waste management policies and strategies. Of recent, the scenario has gradually changed to sustainable environmental policies and increase of manpower capabilities through education and training, though financial constraints, enforcement mechanisms and a lack of community participation becomes the major barrier in improving the standard of waste management services. The budget allocated for different facilities are not clearly defined and in most cases, it covers collection, transportation and daily wages, leaving a handful amount for the final disposal and treatment.

Health and safety issues also arise due to improper handling of MSW during its transportation, disposal and in scavenging. The poor data maintenance tied with the bureaucratic approaches often fails to judge the health impacts in real life caused by improper MSWM. Hence a sustainable approach to the waste management has been proposed, keeping in view the present status of the MSW in the study countries as well as the possible approaches that can be taken up for effectual integrated system. A few case studies from developed countries have been included to highlight successful methods of waste abatement. The strategies are based on tackling the MSW related problems with upstream and downstream approaches using Cleaner Production concepts, simple pre-treatment of waste before landfilling and Mechanical-Biological Treatment.

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List of Acronyms and Abbreviations

4Rs	Reduce, Reuse, Recycle and Recovery
ADB	Asian Development Bank
BDO	Design Build and Operate
BETL	Burns Environmental Technologies (Pvt.) Limited
BMA	Bangkok Metropolitan Administration
BOO	Built Own Operate
BOOT	Built Own Operate Transfer
CBO	Community Based Organization
CEA	Central Environmental Authority
CEIF	Community Environmental Initiatives Facility
CMC	Colombo Municipal Council
CP	Cleaner Production
CPCB	Central Pollution Control Board
CPHEEO	Central Public Health and Environmental Engineering Organization
CPHI	Chief Public Health Inspector
DEQP	Department of Environmental Quality Promotion
EC	Environmental Council
EFC	Environmental Fund Committee
EIA	Environment Impact Assessment
ERTC	Environmental Research and Training Center
Exnora	EXcellent, NOvel and RAdical ideas
GCA	Greater Colombo Area
GDP	Gross Domestic Product
GTZ	Deutsche Gesellschaff fur Technische Zusammenarbeit (GmbH)
HDPE	High-density Polyethylene
IEC	Information, Education and Communication
IED	Institute for Environment and Development
ISWA	International Solid Waste Association
ISWM	Integrated Solid Waste Management
ITDG	Intermediate Technology Development Group
JICA	Japan International Cooperation Agency
KCDC	Karnataka Compost Development Corporation
LA	Local Authorities
lb	Pound
LDPE	Low-density Polyethylene
LOI	Loss on Ignition
MBP	Mechanical-Biological Treatment
MBWT	Mechanical-Biological Waste Treatment
MC	Municipal Councils
MGB	Mobile Garbage Bins
ml	Milliliter
MoEF	Ministry of Environment and Forests
MONRE	Ministry of National Resources and Environment
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management
NEA	National Environment Act

NEB	National Environment Board
NFPO	National Forum of People's Organization
NGO	Non-Governmental Organization
NIMBY	Not In My Back Yard
NRI	National Research Institute
NSSWM	National Strategy for Solid Waste Management
OECF	Overseas Economic Cooperation Fund
OEPP	Office of Environmental Policy and Planning
oz	Ounce
PAO	Provincial Administration Organization
PCC	Pollution Control Committee
PCD	Pollution Control Department
PET	Polyethylene Terephthalate
PHD	Public Health Department
PHI	Public Health Inspector
PIL	Public Interest Litigation
PP	Polypropylene
PPP	Polluter Pays Principle
PRC	People's Republic of China
PS	Pradeshiya Sabaha
PVC	Poly Vinyl Chloride
R&D	Research and Development
RDF	Refuse Derived Fuel
Rs	Rupees
SDAO	Sub-District Administrative Organization
SWM	Solid Waste Management
TAG	Technical Advisory Group
THB	Thai Baht
UC	Urban Councils

CHAPTER 1

URBANIZATION AND MUNICIPAL SOLID WASTE MANAGEMENT

1.0 Introduction

The problem of municipal solid waste management (MSWM) has acquired an alarming dimension in the developing countries during the last few decades. The quantity of solid waste generated has increased significantly and its characteristics have changed as a result of the change in the peoples' lifestyles due to swift industrialization and urbanization. Rapid population growth and increase of economic activities combined with a lack of training in modern solid waste management practices complicate the efforts to improve the solid waste service (ISWA & UNEP, 2002). Improvement of MSWM practices is a subject of concern for public health and environmental protection agencies in most developing countries. Compared to high income countries, the urban residents of developing countries produce less per-capita solid waste, but the capacity of the developing countries to collect, process, dispose or reuse it in a cost effective way is limited. The wastes generated by human settlements and the associated problems are similar in the developing nations with variances between regions and locations based on geographic, socio-cultural, industrial, infrastructure, legal and environmental factors. This chapter highlights the issues and the changing scenario of the MSWM in four Asian countries, *viz.* China, India, Sri Lanka and Thailand with the former two being the most populous countries with wide variations in terrain and socio-economic conditions while the latter two represent the newly agro-industrializing nations. This comparative study attempts to make a representation of the developing countries in Asia with regards to MSWM.

1.1 Significance and Issues of Municipal Solid Waste Management

The new millennium has heralded a change in the global focus on sustainable development with awareness about sustainability in most developing countries and the price one has to pay for neglecting the issue. Despite this, tons of solid wastes remain unattended under the existing system and those collected are disposed in open dumps providing free access to scavengers and animals without regard to environmental health and safety. MSWM services in most developing countries are unsatisfactory and the most common problems associated with it in these countries are lack of:

- institutional capability with technical expertise;
- financial resources; and
- legal provisions and role designation.

Figure 1.1 indicates the causes and effects of municipal waste generation and how it can be abated. The main lacuna observed has been due to the overlap of administrative functions and enforcement of legal provisions for environmental control at the national, regional and local levels. Further, the outmoded MSWM laws and regulations undermine effective management of wastes in large cities. Monitoring of the SWM services by the civic authorities in contrast to the cities of industrialized countries are not satisfactory. Thus mismanagement of solid waste has resulted in environmental problems like the use of wetlands as disposal sites, ground water contamination, air pollution, decreased values of properties, affect on the ecosystem and damages to landscapes due to soil erosion.

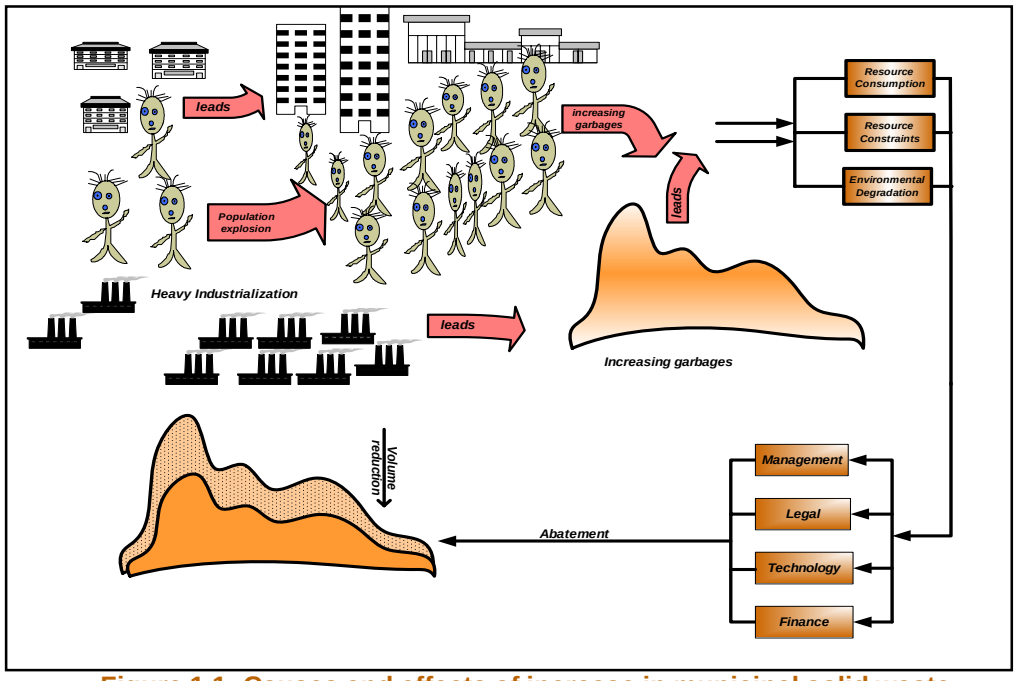


Figure 1.1: Causes and effects of increase in municipal solid waste

The administrative problem is further aggravated without clarity of role designation in the management hierarchy for effective enforcement of the existing environmental regulations. The process of decision-making is relatively slow and complicated by the existing bureaucratic system. Community initiatives to separate and collect valuables from the waste stream for processing, reuse or resale could improve MSWM significantly with low financial inputs, but these activities are generally not formalized and supported by the municipal authorities. As MSWM is a complex task that depends as much upon the organization and cooperation between households, communities, private enterprises and municipal authorities as it does upon the selection and application of appropriate technologies for waste collection, transfer, recycling and disposal. Under such circumstances, the management of municipal solid waste (MSW) in the urban habitats becomes important for the developing nations and the major environmental concerns are:

1. Ever increasing demand for land required for solid waste disposal;
2. Unsanitary disposal of high moisture content wastes in open dumps leading to surface and ground water contamination by run-offs from dumpsites;
3. Poor monitoring of the existing non-engineered landfills leading to the seepage of leachate causing ground and surface water pollutions;
4. Uncontrolled release of landfill gases from dumps/non-engineered landfills contributing to global warming phenomenon;
5. Open dumping of biomedical wastes that could trigger epidemics and other hazardous wastes (oils, used batteries, discarded paints, spent chemicals) and carcinogens like asbestos causing significant adverse impacts on the environment and human health;
6. Air pollution by dioxins, particulates and hydrocarbon emissions from local incineration plants or by open burning due to incomplete combustion of commingled waste and its plastic derivatives;
7. Occupational hazards to MSW workers, scavengers and waste pickers; and
8. Aesthetic nuisance due to odor, noise, dust and appearance especially by littering of the disposables and infestation by scavenging animals and pests on uncollected garbage or at the dumpsites.

1.2 Current Scenario of the Study Countries

The following paragraphs present the current status in MSW generation in the countries targeted for this study.

1.2.1 China

China is the most populous country in the world with over 1.27 billion people and an urban population comprising about 38%. Its Gross Domestic Product (GDP) grew by 10% during 1981-91, by 8% in 2000 and by 7.3% in 2001 (World Bank, 2003). The urban environmental pollution, especially municipal solid waste has become a serious problem due to the accelerated economic growth and rapid urbanization during the last two decades. Its vast territory, geographical variance and varying economical status have resulted in inconsistency in the general characteristics of the waste stream of the mainland. Of particular significance is China's excessive use of unwashed coal (where cleaner fuels are not available or affordable) which leads to the generation of clinkers in the MSW stream and other major environmental problems. The collection and disposal of MSW has increased from about 40 - 65% from year 1995 - 1999. Figure 1.2 shows the total MSW generated in China within the last five years and the quantum jump is seen between 2000 and 2001.

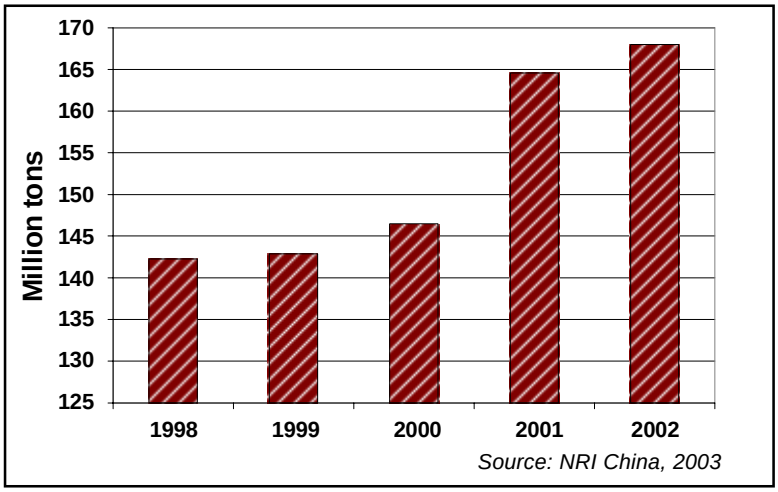
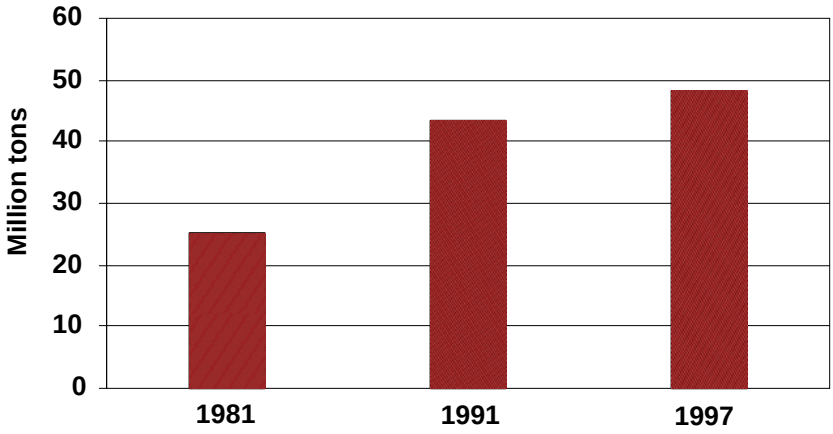


Figure 1.2 Municipal solid waste generations in China

1.2.2 India

India is next to China in its total population of about 1.03 billion (2001) with a total area of more than 3.2 million sq. km. The urban population accounts for 28% and its economy has been growing at a steady rate of 5.7% per annum for 1981–91 and at 5.9% during 1991–01 (World Bank, 2003). After its independence in 1947, India has witnessed a remarkable progress in human and economic development and its rapid urbanization over the past few years has caused significant environmental impacts. The rate of increase in the generation of urban MSW attributable to changing lifestyles, food habits and general living standards is disproportionately higher to the population growth. Absence of national data for MSW generation (UNEP, 2001b) due to several reasons further weakens its policy to improve MSWM but over the years several studies have been carried out in the municipalities and metropolis to determine waste generation and its forecast. Figure 1.3 indicates the recorded urban municipal waste generated for 3 years of the economic growth periods. Even though India is emerging as one of the leading developing countries, whilst its inadequate policy and technological measures continue to remain a daunting issue of environmental concern to the country.

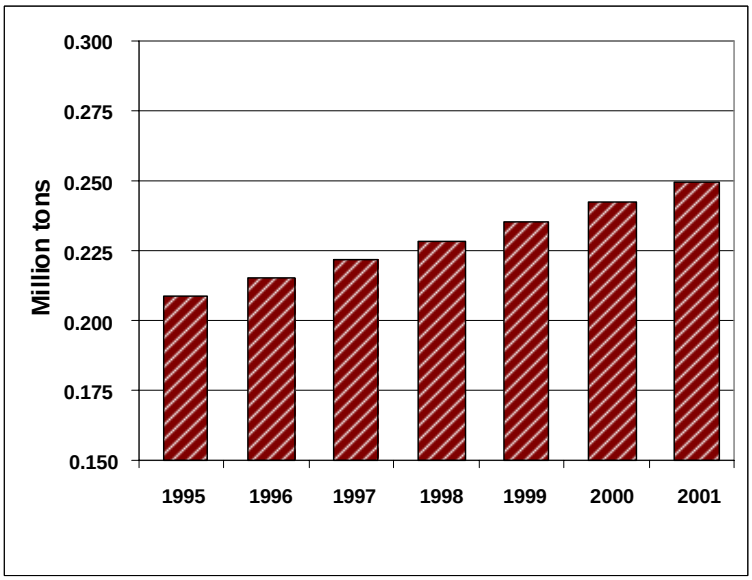


Source: NRI India, 2003

Figure 1.3 Recorded urban municipal solid waste generated in India

1.2.3 Sri Lanka

This island nation in the Indian Ocean located to the south of the Indian subcontinent has a total area of 65,610 sq. km. Its urban population accounts for 23% of its 19.6 million inhabitants. Sri Lanka is mainly an agrarian country with an economic growth rate of 3.9% per annum during 1981–91 and 4.9% during 1991-01 (World Bank, 2003). Management of waste, both liquid and solid has become a critical environmental concern particularly in the urbanized areas of Sri Lanka. With the changing consumption patterns fostered by improved living standards, the quantity of solid waste has been increasing over the years. Rapid economic changes resulting from the introduction of more liberal and growth oriented industrial policies during the last two decades have not been balanced by necessary investments in urban infrastructure facilities, particularly the urban SWM sector. In Sri Lanka, the heterogeneity of the waste causes serious threat to the workers and the general environment. Source separation of MSW has been recently adopted with some pilot projects that have shown promising results. Figure 1.4 shows the MSW generated in the Colombo Municipal Council (CMC), the capital city which indicates a steady increase in waste generation between 1998 and 2000.

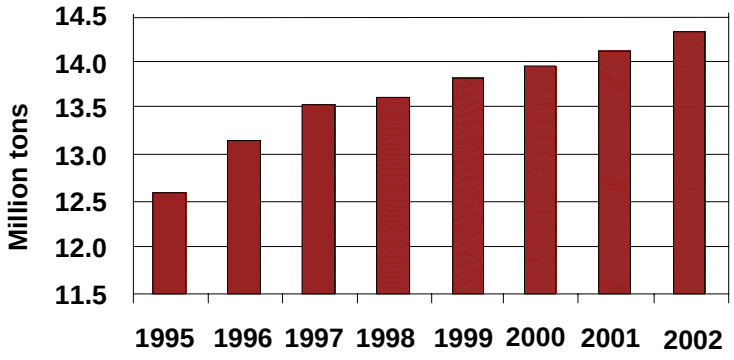


Source: NRI Sri Lanka, 2003

Figure 1.4 Municipal solid waste generations in Colombo, Sri Lanka

1.2.4 Thailand

Thailand is one of the newly agro-industrialized countries of Southeast Asia located centrally in the Indo-China peninsula with a total area of 514,000 sq. km. Of the total populace of about 63.6 million, the urban population accounts for about 22%. Its economic growth rate was 8.2% during 1981-91 and 4.6% in 2000 (World Bank, 2003). The urban dwellers are concentrated in the metropolis of Bangkok, the capital that has a registered population of about 6.6 million and a growth rate of 0.72%, and has lesser concentration in other cities and municipalities. The solid waste generation in Thailand has witnessed a rapid upward trend parallel to its economic growth and industrialization. For the year 2000, the solid waste generated in the country was estimated to be approximately 14 million tons as shown in figure 1.5 that indicates an increasing trend. Until the last decade, open dumping was widely practiced throughout the country particularly in provincial areas. The existing law does not have provisions for integrated SWM and measures to promote waste reduction as well as channeling of hazardous waste from the waste stream.



Source: NRI Thailand, 2003

Figure 1.5 Generation of municipal solid waste in Thailand

1.3 Emerging Trends and Changes

Developing countries are now directing their attention to legislations for land use and environmental control and this is the primary step in MSWM with the creation and revamping of the environmental agencies. Where municipal bodies have failed to provide the necessary waste collection systems, the people themselves participate in the form of non-governmental organizations (NGOs) and community based organizations (CBOs). The role of these bodies has increased in the past few years in various projects with positive results.

1.3.1 China

China has initiated a number of environmental protection measures in its urban areas which can be enumerated as follows:

1. It has issued a technical policy of MSW treatment and pollution prevention that focuses mainly in the organizing of waste recycling and source reduction, composting, incineration and sanitary landfill which would decrease the harmful affects of MSW disposal.
2. China has issued an industrial development policy for MSW treatment which encourages different enterprises to invest build, own, operate and manage SWM projects.
3. The 'three-in-one' project initiated in Changzhou city in Jiangsu province has integrated the three main MSW disposal techniques in one factory - composting, incineration and landfilling.

4. The Chinese Government has planned to invest US$ 10.8 billion in SWM during its Tenth Five-Year Plan (2001-2005), of which US$ 2.4 billion would be used to establish regional and provincial hazardous waste treatment plants. the Ministry of Science and Technology has emphasized major areas for research and development to improve SWM technologies, which are:
    a) Equipments for MSW treatment and disposal (incineration and landfills); and
    b) Technology for treatment, disposal and utilization of special category solid waste (hazardous chemicals, electrical equipments and hospital wastes).
5. It has implemented waste segregation and collection pilot programs mainly in 8 cities (Beijing, Shanghai, Nanjing, Hangzhou, Guangzhou, Shenzen, Xiamen and Guilin) targeting not only residential areas but also other sources of municipal waste generation.
6. Vermicomposting of biodegradable has been initiated in some communities and larger restaurants of Shanghai and Beijing.
7. The system of buy-back of valuable wastes (newspapers, cans, plastic bottles etc.) is present in some cities and is being extended to others with local governments taking measures to reduce wastes at the source and organize high standard recycling.

1.3.2 India

The scenario in India indicates a general awareness to initiate a proper SWM system throughout the country during the second half of the last decade as indicated below:

1. The Bajaj Committee, appointed in 1994 drew up a long term strategy to be adopted and made several recommendations in all aspects of SWM. The Ministry of Health and Family Welfare and the Central Public Health and Environmental Engineering Organization (CPHEEO) jointly organized a national workshop in April 1995 which underlined the necessity to improve the SWM as a priority.
2. A Public Interest Litigation (PIL) was filed in the Supreme Court of India in 1998 to direct the central and state governments, and the local bodies to improve the MSWM practices which resulted in Barman Committee Report that reviewed all aspects of MSWM and authorized the governments to exercise powers under the Environmental Protection Act, 1986 (Chandrasekar, 2002).
3. The Ministry of Urban Development has published Manual on Municipal Solid Waste Management as a torch bearer for the civic bodies and user agencies for proper implementation of rules and management of solid wastes (CPHEEO, 2000).
4. The Ministry of Environment and Forests (MoEF) issued the Municipal Solid Waste Rules in 2000 that identified the Central Pollution Control Board (CPCB) as the agency to monitor the implementation of these rules with municipalities required to submit annual reports to this agency regarding SWM practices (CPCB, 2000).
5. The CPCB under the MoEF has completed a survey to assess the current status of MSWM in the metropolises and Class I cities of the country. Moreover, the Supreme Court of India has directed the formation of a Technical Advisory Group (TAG) in 2000 for improving SWM practices in the country.

1.3.3 Sri Lanka

Realizing the importance of a system to preserve its pristine environment on the island, Sri Lanka has adopted the following measures:

1. The National Environment Act (NEA) enacted in 1980 was amended in 1988 (Amendment Act No. 56) to establish the Central Environmental Authority (CEA) whose powers, functions and duties relate to the protection, management and enhancement of the environment with the regulations. It would not only maintain control of environmental quality but abate pollution and other related matters.
2. The National Strategy for Solid Waste Management (NSSWM) was launched by the Government in May 2000 to manage solid waste from generation to disposal, and identify strategies of waste avoidance, reduction, re-use, recycling and final disposal.
3. Many SWM projects by various stakeholders have currently been implemented which include some international organizations and NGOs that are actively involved in community based projects in different parts of the country. These projects have focused on community based backyard composting, plastic and polythene recycling, waste separation at source and low-rate composting systems. The Arthacharya Foundation recently initiated a CBO of women to introduce source separation of residential MSW into recyclables and biowaste components. It provides barrels to promote household composting.

1.3.4 Thailand

Similar to the other three nations, Thailand has moved ahead with competent strategies for MSWM and the measures are enumerated hereunder:

1. The Environmental Act was enacted in September 1992 and revised in order to improve environmental quality in Thailand.
2. The Public Health Act enacted in 1992 provides the powers and duties of local authorities to oversee suitable living conditions with codes for SWM that prohibits illegal dumping and directs the local authorities to collect, transport and dispose solid wastes.
3. The establishment of the National Environment Board (NEB) consisting of the Cabinet receives financial support from the Environment Fund.
4. It adopted a new concept of "Environmental Conservation and Pollution Control Area" that has notably changed the role of environmental management agencies from a mere advisory capacity to a comprehensive role for planning, policy setting, regulatory and promotional activities.
5. A national MSWM plan was developed for the entire country in 1997 which primarily aims to establish appropriate criteria for SWM (collection, transportation and hygienic disposal), locating of appropriate land by provincial authorities to serve as long-term landfill sites and to designate them in urban plans.
6. The revised constitutional law in 1997 decentralized the authority to provincial administration, municipalities and sub-district organizations for public cleanliness.
7. Thailand had begun the development of engineered landfills for safe disposal of solid waste with minimum impact on the environment under its new laws and regulations.

1.4 Conclusion

This review of the current situation of MSWM in the study countries indicates the burgeoning urbanization and the fast pace of industrial development that contributes to the issues of the MSW in urban areas. The increase in the GDP and the changing lifestyle of the people in these four countries has increased the solid waste generation, which requires to be handled effectively to avoid significant environmental problems. The changes in the outlook on issues of MSW in all four countries present a challenge to the legislative and environmental bodies to keep pace with effective legal provisions and for the urban civic bodies to coordinate their activities for efficient management of the MSW. These changes are a representative of the emerging scenario in the whole of the developing region of Asia. Detailed discussions on the current scenario and recommendations from this study are given in the following chapters.

CHAPTER 2

PRESENT SCENARIO OF MUNICIPAL SOLID WASTE MANAGEMENT

2.0 Introduction

The developing countries have now begun to acknowledge the environmental and public health risks associated with uncontrolled dumping of wastes. That has occurred mainly due to inadequacy in the capacity building of the personnel associated with the MSW and lack of guidelines for technical aspects of SWM. Often these guidelines and training materials are based on technological standards and practices adapted to the conditions and regulations of industrialized countries which cannot suit the different technical, economic, social, and climatic conditions of developing countries (Zurbrugg, 1999).

The present scenario in the four countries of China, India, Sri Lanka and Thailand is given to highlight the technical and management issues. The technical issues encompass waste generation, composition and characterization, collection, transport, processing and disposal while the management aspects comprise implementation of legal provisions, economic and financial issues.

As part of the technical issues, source segregation and separation activities are discussed with new initiatives, specific case studies and success stories. Waste collection and transport, processing of MSW by composting techniques and incineration are discussed along with the steps taken by these countries in particular places for waste minimization and recycling. The involvement of the formal sectors in the form of private organizations, NGOs and CBOs and the informal sector comprising of municipal workers, scavengers and waste pickers is discussed with examples.

The stakeholders of MSW and their services for each country are illustrated with the hierarchy of management, involvement of the private sector, NGOs, CBOs and local bodies along with the informal sector finds mention with illustration of their activities. Several success stories and ventures enable a clearer picture of the present scenario in the study countries.

The economical and financial aspects indicate the present focus of the civic bodies and the environmental concerns of the government as well as their lacunae in their respective systems. Other issues finding mention are the legal aspects and the environmental health issues.

2.1 Overview of Technical Issues

The MSW generated in the four countries vary from each other due to different geographical locations, economic status and population density. It was observed that the characteristics of MSW collected from any area depends on a number of factors such as food habits, cultural traditions of inhabitants, lifestyles, climate, etc. Source separation of waste is restricted to certain urban areas and general awareness of waste management is minimal. The collection system varies widely from mechanized operations to labor intensive ones. A part of the waste remains unattended which is a potential threat to the local environment. There is a lack of general data on solid waste; the overall technical management and methods used requires to be updated. The following discussions are based on singular investigations by the research institutes of the respective countries to highlight the prevailing issues of MSWM.

2.1.1 Waste generation

Rapid urbanization of the developing countries has increased the urban population significantly resulting in growth of industrial enterprises for the production of different consumer products. As a result, huge amounts of solid waste are being generated daily from urban areas that have put pressure on environmental management. The total urban MSW generated in the study countries is given in Appendix A. The primary fraction of the wastes generated is dominated by biodegradable portions, which either ends up in barren land or in some non-engineered landfills. There are great variations in the per capita solid waste generated in the study countries due to geographical locations, climatic factors, economic disparity and consumption pattern. Figure 2.1 indicates the range of MSW generation in the four countries.

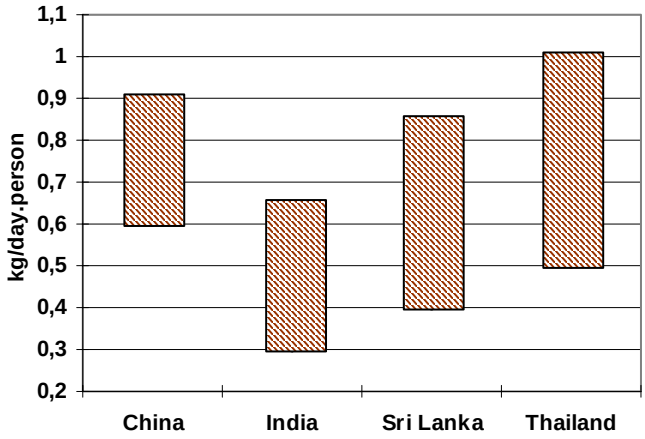


Figure 2.1 Per capita MSW generation variations in the study countries (2002)

China

The generation of solid wastes in China is influenced by geographical factors, the level of economic development and urban population density. Variation in the quantity of the waste generation is due to the improved living standards and the diversified consumer habits. The amount of solid wastes generated has been increasing at the annual rate of 6.5% from 1986 to 1999 but the disposal systems are only gradually being upgraded. Overall, the generation of MSW increased linearly from 1984 - 1988, and leveled off gradually from 1989 - 1991. The current average per capita solid waste generation in the urban areas is about 0.63 kg/day. In 1999, the annual solid waste generation from China reached 143 million tons and at the current pace of urbanization, it is estimated that the total MSW would reach above 180 million tons by 2005. According to the Ministry of Construction, the total MSW collected in 32 metro cities in China has been recorded as 90,000 tons per day. The collection in the urban areas could be considered close to 100% whereas in the rural areas it is much lower.

India

Most of its urban population of India is concentrated in the Class I cities (population of more than 100,000). Per capita waste generation rate increases with the size of the city and varies from 0.3 to 0.6 kg/day and the annual per capita increase in waste quantity is about 1.33%. The average daily per capita waste generation is 0.2 kg for communities with population 100,000 to 500,000 and increases to 0.5 kg for cities with population exceeding 5 million. In 1999, the total MSW generated from 23 metro cities was estimated to be 30,000 tons per day which could be more as most of the municipal authorities do not weigh the refuse collection vehicles but estimate the quantities on the trip basis.

Sri Lanka

The quantity of solid waste has also increased over the period of years in Sri Lanka with changes in consumption patterns. Analysis of data has revealed that the per capita per day waste generation on the average was 0.85 kg in Colombo Municipal Council (CMC), 0.75 kg in other Municipal Councils (MC), 0.60 kg in Urban Councils (UC) and 0.40 kg in Pradeshiya Sabahas (PS) - the smallest local administrative unit. The primary sources of the MSW are households, markets and commercial establishments while the secondary sources are industries and hospitals. Like other developing countries, this sharp rise in the MSW generation is mainly due to the improved living standards, population growth and urbanization. The data available that would help estimate the total quantity of municipal solid waste generated in the country was not entirely accurate, since the collection values ranged between (10 - 15)% except for Colombo, Dehiwala-Mt Lavinia and Kotte which have a little higher values of 30 - 40%. Daily waste collection by Local Authorities (LA) is estimated at 2683 tons. However, the total MSW generated in Sri Lanka is assumed to be around 6,400 tons per day (UNEP, 2001).

Thailand

According to land use and zoning, the sources of solid waste generated in Thailand are from the domestic (80%), industries (5 - 10%), commercial establishments (5 - 10%) and tourism (less than 5%). The regional solid waste generation rate was measured between 0.5 and 1.0 kg/capita/day by Pollution Control Department (PCD) in the year 1996 and by the year 2005 the average waste generation is anticipated to reach around 1.5 kg/capita/day. This increase takes into account the current rate of economic growth and higher consumption of commercial products. The total amount of MSW generated in the year 2000 was approximately 14 million tons, comprising 24% from Bangkok Metropolitan Administration (BMA), 31% from municipalities, 45% from rural area (outside the municipalities).

2.1.2 Waste composition and characterization

The composition of MSW differs for different countries and regions, and developing countries have generally high food and yard wastes, whereas developed countries have a large fraction of paper and plastic content (Dhussa *et al*, 2000). Identification of waste composition is crucial for the selection of the most appropriate technology for treatment, taking essential health precautions and space needed for the treatment facilities.

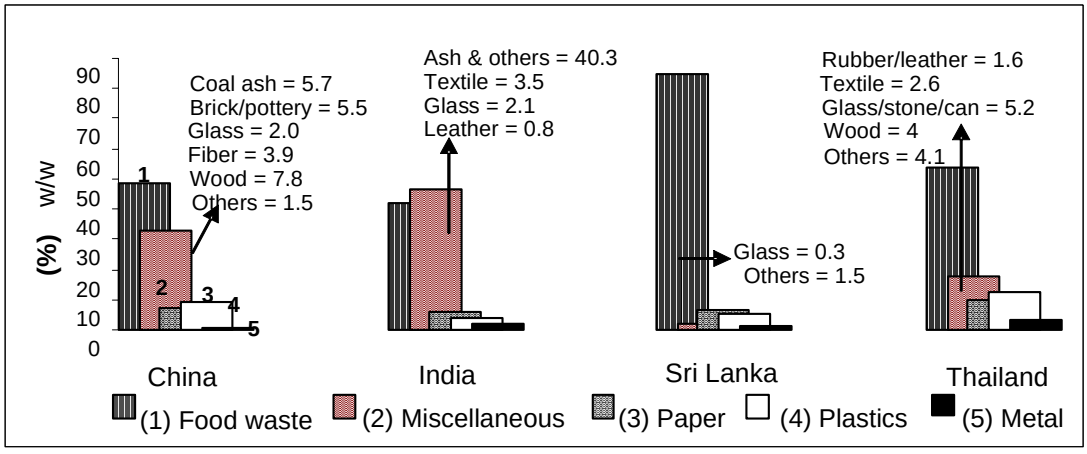


Figure 2.2 MSW compositions of the study countries

Figure 2.2 indicates that the major portion of the waste generated is food waste and composting technology would be an appropriate waste processing option. It also shows that waste processing is an indispensable stage prior to the prevailing disposal system. Furthermore, capital investments on incineration and on sanitary landfills with regard to inorganic content might not be a suitable option on a large scale.

China

There is a great variation in the MSW composition in China according to the size, economic status and the location of the municipality (Box 2.1). Kitchen residues account for about 40% of MSW from eastern regions, 33% for middle regions, 34% for western regions, and more than 43% for big cities. Clinker content in medium or small cities is relatively higher, generally more than 30% but in mega cities like Shanghai and Guangzhou, the content is less than 10%. Table 2.1 provides a cursory glance at the MSW composition of some selected cities. The moisture content of the MSW collected in the bigger cities is found to be about 39 - 49 % and for the medium and smaller cities around 30%. The average moisture content of the MSW is about 37%, the bulk density lies in the range of 460 - 480 kg/m^{3}and the average calorific value is 3312 kJ/kg with the exceptions to mega cities (Beijing, Shanghai etc.), which have a calorific value of 4000 - 6000 kJ/kg. The bulk density of MSW also varies from city to city; ranging between 280 and 503 kg/m^3. The clinker content of the waste is associated with the nature of the fuels used by the citizens and was the major component in the past; it is now decreasing due to the utilization of other fossil fuels. The MSW generated in recent years have higher calorific value and moisture content (Figure 2.3) with lower bulk density.

Box 2.1 Calorific value of Chinese MSW

The calorific value of MSW in 143 cities in China increased from 1905 kJ/kg in 1993 to 2781 kJ/kg in 1996. On the other hand, calorific value of MSW from certain cities reaches 5401 kJ/kg while for provincial level cities 3452 kJ/kg, for regional cities 2789 kJ/kg, and for county level cities only 1314 kJ/kg. The average calorific value of solid wastes from eastern, middle, and western regions is 3415 kJ/kg, 2292 kJ/kg, and 1516 kJ/kg respectively. The calorific values of waste from most cities cannot meet the requirement for self-sustainable combustion.

Source: NRI China, 2003

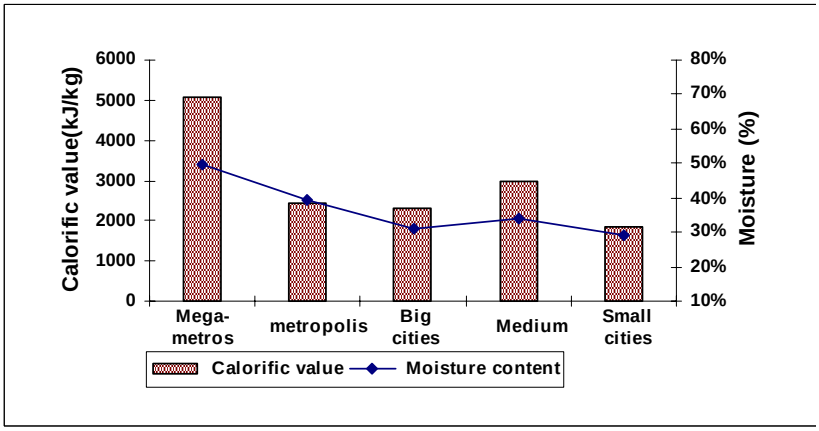


Figure 2.3 Calorific value and moisture content of urban MSW in China

Table 2.1 MSW compositions of selected cities in China (2002)							
MSW Composition	**Beijing**	**Tianjin**	**Dalian**	**Chengdu**	**Chongqing**	**Shanghai**	**Metro Average**
Kitchen Remnants	50.79	78.43	66.72	14.54	14.48	68.15	48.37
Coal Ash	33.61	0.54	-	-	-	-	5.69
Brick, Pottery	0.57	0.44	5.61	15.01	9.8	1.12	5.54
Paper	4.91	8.84	7.37	6.56	7.87	9.11	7.27
Plastics	5.88	8	12.1	3.18	14.45	13.26	9.23
Glass	0.74	0.97	3.44	1.3	1.53	3.33	2.00
Metal	0.04	0.21	0.93	0.65	0.58	0.86	0.50
Fiber	0.64	1.2	2.1	14.81	2.24	2.91	3.87
Wood	2.79	1.13	1.73	21.79	17.7	1.26	7.76
Others	-	-	-	22.15	25.49	-	7.94

Source: NRI China, 2003 ,

India

In the Indian MSW, the biodegradable fraction is normally high as compared to other fractions, essentially due to the use of fresh vegetables (Table 2.2). The high biodegradable fraction of refuse in the tropical climate warrants frequent collection and removal from the collection units. The ash and dust content of the MSW is quite high due to the inclusion of the street sweepings, drain silt, and construction and demolition debris. The proportion of ash and fine earth reduces with increase in population and improvements in the road surfaces. The high ash and earth content increases the density, which is between (330 - 560) kg/m^3. The paper content in the Indian MSW generally varies between (3 - 10)% and rises with the increase in population. The quantity of waste paper in India is much less, as the wasted paper is either reused as packaging materials for food items sold by roadside hawkers or is picked up for use as a fuel. Textiles, plastics, rubber, leather and metal contents are lower than paper content essentially due to the large scale recycling of these constituents.

Table 2.2 MSW characteristics in Indian metropolis (2002)								
Metropolis	**Characteristics (% by Wt.)**							
	Paper	Textile	Leather	Plastic	Metal	Glass	Ash, others	Compostable matter
Bangalore	8	5	-	6	3	6	27	45
Kolkata	10	3	1	8	-	3	35	40
Chennai	10	5	5	3	-	-	33	44
Delhi	6.6	4	0.6	1.5	2.5	1.2	51.5	31.78
Mumbai	10	3.6	0.2	2	-	0.2	44	40
Other metro cities*	3-10	1-9	0.2-3	1.1-10	0.35-1	0.2-10	35-53.4	30.40-58

* See Appendix A for other Indian metro cities

Source: NRI India, 2003

Table 2.3 Average chemical composition of urban MSW in India (2002)									
City /Town	Moisture %	pH	N %	% P as P_2O_5	% K as K_2O	O.Matter %	Carbon %	C/N	C. Value (kJ/kg)
Kolkata									
Residential	40-45	7-7.3	0.5-0.6	--	0.35-0.4	31-35	17.5-19.5	31-37	4650 - 5815
Commercial	40.2	7.21	0.427	0.617	0.312	39	21.6	50.8	--
Industrial	51.35	7.16	0.676	0.579	0.6785	40.14	22.3	32.94	--
Delhi									
Residential	16	8.5	0.6	0.65	0.4	36	21	34	5930
Commercial	16	8.4	1.12	0.84	0.64	42.35	24.56	21.92	7000
Industrial	14.25	8.55	0.66	0.68	0.31	31.9	18.5	30.9	5580

Source: NRI India, 2003

Study of the organic content of the MSW has been done for two metropolises of Delhi and Kolkata which ranges between 20 - 40%. The nitrogen, phosphorus and potassium of the MSW range between 0.5 - 0.7, 0.5 - 0.8 and 0.5 - 0.8% respectively. The calorific value ranges between 4650 – 7000 kJ/ kg as shown in table 2.3.

Sri Lanka

The major portion of the MSW stream in this country is dominated by organic waste fraction generated from households, markets, and slaughterhouses (Table 2.4). The organic portion consist of king coconut shells, banana stalks and logs, tree cuttings, saw dust, wood chips and paddy husks. The organic wastes are further grouped into long term biodegradable and short term biodegradable, the former being those which cannot degrade easily within 2 - 3 months and is initially used as a bulking material in the composting of the short term biodegradable portion of the MSW, which could degrade within 1 - 2 months or even less.

Table 2.4 MSW compositions of select cities in Sri Lanka (2002)							
Cities	Biodegradable (short term)	Biodegradable (long term)	Polythene and other plastics	Metal	Wood	Glass	Paper
Batticalo	46.79	10.61	8.26	2.90	17.12	2.20	16.45
Colombo	68.15	11.63	6.69	1.85	5.02	1.64	5.99
Galle	41.76	20.25	8.23	4.79	11.18	4.33	9.41
Jaffna	54.85	8.62	7.21	8.49	5.58	2.21	12.80
Kandy	54.83	17.95	4.02	4.46	6.36	5.35	11.08
Matara	56.81	18.60	6.90	3.07	5.78	2.07	8.50
Nuwara Eliya	60.53	9.73	8.46	2.12	8.92	2.90	8.72
Polonnaruwa	35.52	25.10	8.47	3.57	7.63	3.68	16.04
Trincomalee	27.98	20.06	4.33	12.51	22.04	1.85	18.04

Source: NRI Sri Lanka, 2003

The moisture content and organic fraction of MSW stream is significantly high and has low calorific values. In the Greater Colombo Area (GCA), the heterogeneity of the MSW characteristics impedes employing a unique solution for proper treatment.

Thailand

Table 2.5 indicates MSW composition in Thailand where food waste ranges between 38 - 67% whereas paper and plastic waste constitute 2.8 - 24% and 4.5 - 21% respectively. The remaining portions of wastes are rubber, cloth, yard waste, glass, stone, can and metals.

Table 2.5 Composition of MSW in Thailand (2002)

Municipality	Food	Paper	Plastic	Rubber and Leather	Cloth	Yard waste	Glass, stone and can	Metal	Others
Chiang Mai	59.32	10.96	11.58	0.95/3.55	1.42	2.49	3.19/0.42	5.64	0.75
Nakhon Ratchasima	44.6	17.2	10.66	1.6	1.28	1.26	1.05	1.05	21.3
Khon Kaen	52.2	1.69	4.06	4.72	7.55	2.83	13.94	6.6	4.41
Hat Yai	56.5	5.25	14.2	1.46/1.20	0.73	11.23	2.58/0.39	3.5	3.14
Rayong	38.6	9.74	13.39	-	3.41	6.47	6.32	5.45	1.4
Chonburi	63.25	5.25	4.5	1.88/3.13	1.25	5.76	25/5.0	5	2.48
Pathumthani	49.6	4.5	24	2.00/1.90	5.5	6.5	1.70/1.00	2.9	0.4
Samutprakarn	51.21	23.86	8.89	0.37	1.75	4.89	2.37/3.45	1.06	2.16
Pattaya	64.3	2.8	20.89	1.10/1.66	1.1	1.14	1.10/1.20	1.47	3.27
Phuket	49.1	15.2	12	0.50/0.50	3.1	1.2	10.20/2.50	1.2	4.5
Udonthani	67.2	11.4	10.5	0.8	1.6	0	6.1	0.8	1.6

Source: NRI Thailand, 2003

Table 2.6 shows the characteristics of MSW recorded by different municipalities in Thailand. The MSW generated can be categorized into two groups, high and low moisture content. The high moisture content (40 – 70%) is generated from tourist spots located in east, north, south and central part of Thailand, whereas MSW generated from the northeast provinces has low moisture content (20 - 22%).

Table 2.6 Characteristics of MSW in Thailand (2002)

Municipality	Density (Kg/m^3)	Moisture (%)	Calorific Value (kJ/kg)	Ash (%)	Loss on Ignition (%)
Chiang Mai	215	47	5660	27.3	90
Nakhon Ratchasima	200-250	20	3019	-	76.6
Khon Kaen	176	22	4686	-	73.05
Hat Yai	200	57	4799	17.1	90.6
Rayong	244	46.7	2302	20.6	67.3
Chonburi	350	59.0	3643	27.4	85.5
Pathumthani	245	49.0	5329	18.8	94.0
Samutprakarn	170	65.0	2062	10.2	20.8
Pattaya	207.5	70.0	3830	30.9	93.0
Phuket	260	40.0	4300	6.3	81.6
Udonthani	204	20.0	4439	-	91.5
Average	227	45.1	4006	19.8	78.5

Source: NRI Thailand, 2003

Thus, the above clearly indicates the general characteristics of the MSW in Asia, which on the whole has a higher organic fraction and presence of recyclable materials that would warrant the use of appropriate technology for processing, treatment and ultimate disposal which are discussed in the following sections.

2.1.3 Source segregation

Waste separation is the key mechanism for the reduction in waste quantity. Further, it also helps to promote beneficial reuse of the wastes. However in the study countries, it is not practiced widely and effectively except for certain urban areas, where public pressure and general awareness promotes this environmentally sound practice.

China has been practicing source segregation increasingly since the turn of the millennium. The Ministry of Construction has selected and declared 8 cities for a pilot project. In Shanghai alone the program has covered more than 1800 residential areas. Segregation is done into hazardous, dry and wet wastes. Beijing has launched a similar program to bring about Green Olympic in 2008. NGOs like the Earth Village actively participate in the source segregation programs A system of buy back of the valuable wastes has been implemented which has helped people to earn money from the waste as well as it has prevented the disposal of valuables in the landfills. This system is being expanded to incorporate other cities.

Figure 2.4 Segregated recyclables and reusables in China

In Thailand, this strategy has been concentrated in the domestic areas, factories, shops, shopping malls, academic institutes and government offices by setting up laws and regulations for separating into wet and dry wastes before disposal. There are some areas where MSW is being separated in three different ways for degradable, recyclable and hazardous wastes. An informal method practiced is the separation of paper, plastic, glass and metal by iterant waste buyers or the municipal collection crew. Finally the scavengers at the transfer stations and disposal sites collect the valuables. For easier collection and reduction in waste contamination, separate color-coded bins are provided at the generation points. In Bangkok, the wastes are classified into 3 different categories according to the collection techniques. These bins are identified by the color code used for each waste category as given in figure 2.5.

1. Green bin for organic wastes (food, vegetables, etc.) to be disposed off in landfills.
2. Yellow bin for recycle wastes (plastic, glass, metals, etc.) collected for recycling.
3. Gray bin with red lid for household hazardous wastes (herbicide, insecticide, batteries, fluorescent tubes) which are collected, stored and sent for disposal in hazardous waste landfills.

Figure 2.6 shows the collected recyclables to be sent to the recycling units.

Figure 2.5 Color coded bins -- green, yellow and gray used in Bangkok.

Figure 2.6 Segregated waste for recycle in Thailand

In Sri Lanka, waste separation at source is still not practiced in a large scale though some NGOs have successfully initiated and implemented various projects and workshops in different parts of Sri Lanka, especially in low-income urban areas (Box 2.2).

Box 2.2 Case Studies: Waste separation in Sri Lanka

1. Maharagama Pradeshiya Sabha has been running an integrated SWM project since 1998 that as of March 2000 involved about 1600 households. Under this project, each household is given four different coloured plastic bags free of charge for plastics/polythene, paper/cardboard, metal/glass, and coconut husks. People have generally been willing to cooperate by sorting their waste into different categories. The bags are collected twice a month for sorting and the waste which cannot be recycled are dumped. The sorted wastes are sold to private organizations and the money from the sales is used to fund additional plastic bags for collecting MSW.

2. National Forum of People's Organizations (NFPO) has developed a pilot program for source separation targeting 500 low/middle income households at Madapatha, Piliyandala. Each participating household was required to pay Rs. 30 per month (US $ 0.31) to cover the labour costs for the collection of the source-separated waste.

3. Abans Environmental Services Ltd has been conducting a small-scale source separation of refuse collection scheme for approximately 90 - 100 households along three streets in a high-income area of Havelock Town, Colombo 5, since June 2000.
(http://www.buildsrilanka.com/Listings/Services/L_Ser_Jani_005.htm)

4. Seth Sevana is an NGO currently undertaking a pilot project involving 1280 families in the Moratuwa area for source separation of household wastes into different components with funding from the Community Environmental Initiatives Facility (CEIF). It hopes to extend this project in the future to cover 8000 families generating an extra 15 tons/month of plastic waste for processing in its plastic recycling factory.

Source: NRI Sri Lanka, 2003

2.1.4 Waste collection and transport

In most cities of the developing countries, a significant portion of population does not have access to waste collection services and only a fraction of the generated waste is actually collected (Schubeler, 1996). The collection systems are relatively inefficient as the collection vehicles and containers are not fitted with compactors, necessitating transportation of loose waste and hence, creating a constraint on the capacity of the collection system. Handcarts, tractor-trailers and low level of mechanization are being employed to collect the waste from communal bins and other collection points. On top of that, financial constraints and the lack of technical expertise severely limit the effectiveness of solid waste collection and transportation in most areas of the study countries. Shortages of storage bins, collection vehicles, non-existent or inadequate transfer stations and traffic congestion are the other technical factors affecting collection efficiency resulting in low waste collection rates. It was estimated that 20 - 50% of the solid waste generated in South Asia remains uncollected, even though more than half of the local operational expenditures often goes towards waste collection (UNEP, 2001b).

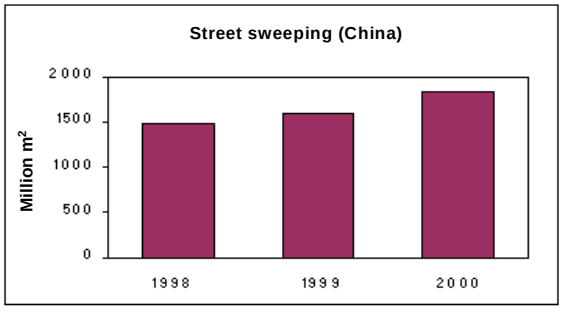
China

In China, the modes and equipment used for collection mainly includes stationary dustbins, rubbish platform and stockpile collection. Many cities have now abandoned the mode of dustbin collection to avoid the malodor of solid wastes. Variations in the collection system are highly related with the

local government's policy and the environmental consciousness of the residents. At present new waste facilities have been put into operation like collection and compaction stations designed to serve 6000 - 10,000 households. They also function as waste recycling and onsite organic waste treatment centers. The rate of bag collection system has increased annually, from 9.5% in 1991 to 31% in 1996. Data from 143 cities revealed that the bag collection system prevails in those cities with higher administrative status and faster economic development. Even though transportation facilities of MSW have been recently enhanced but still cannot meet the demand of the prevailing waste scenario. Most of the facilities employed for collection and transportation of wastes are outdated or with very low mechanical efficiency. In a nutshell, the prevailing collection and transportation system practiced in most of the cities are inadequate in comparison to the country's economic prowess. Boxes 2.3 and 2.4 highlight the street sweeping in China and India.

Box 2.3 Street sweeping in China

The Public Report of Environmental Status in 2002 in China stated that the total area of street sweeping accounts for about 2134.5 million m^2. Out of this manual cleaning accounted for about 83.9% and 16.1% for mechanized cleaning. According to the municipal public facility accounted in 2001, there are 44,846 environmental sanitary machines (2133 cleaning vehicles; 2457 washing vehicles; 5034 dung vehicles and 28,433 waste transporting vehicles). These vehicles are unable to meet the demands quantitatively and functionally.



Source: NRI China, 2003

Box 2.4 Street sweeping in India

The absence of adequate storage capacity for the refuse generated and poor discipline among the generators is the cause of continual roadside dumping of the waste. Street sweeping is the most common method of primary collection of all types of municipal waste as most of the waste is being disposed off on the streets. Not all roads and streets are swept on a daily basis. Only certain important roads and markets are swept daily; many others on alternate days or twice a week, and some are swept only occasionally or not at all. The road length to be swept by a cleaner is not standardized as adhocism prevails in this regard. There is no yardstick prescribed. At some places sweepers are allotted work based on the road length that varies from 100 meters to 5 km; whereas in some places, it is on the basis of square meters which ranges from 3000 m^2 to 10,000 m^2. At some places, it is based on population with one sweeper per 500 to 1000 populations. Equipment and tools given to the sweepers are inadequate and inefficient. Figure 2.8 shows both mechanized and manual street sweeping in India.

Source: NRI India, 2003

India

The waste generated at the household level generally accumulates in small containers (often plastic buckets) until there is sufficient quantity to warrant disposal into community bins built by the civic bodies. The wide variety of types and shapes commonly encountered within a community creates difficulty in establishing and operating an efficient solid waste collection system. Mostly the community bins are of open masonry construction or open enclosures. Commercial sectors like shops, offices, hotels etc use the community waste bins. Containers used for household storage of solid wastes are of many shapes and sizes, and are fabricated from a variety of materials. Their wastes are also collected along with the household wastes except in a rare number of commercial complexes where they pay a negotiated fee to the municipality for collecting waste from their premises. It was estimated that the efficiency of waste collection in most major cities in India lies

between 50 – 90% (INSEAD 2002). Heaps of garbage around street corners are a common sight in most major cities due to lack of discipline and coordination among the waste generators who dispose their waste into the community bins and the municipal collection crew who collect the wastes.

For the transportation of the collected MSW, open trucks of 5 - 9 tons capacity are commonly used. In smaller (rural) towns bullock carts, tractor-trailers, power tillers, tricycles and handcarts are mainly used. Figure 2.7 shows transfer of wastes from a hardcart into a community bin. These vehicles are being used for the primary collection of waste from the streets as well as for the collection of wastes from the dustbins.

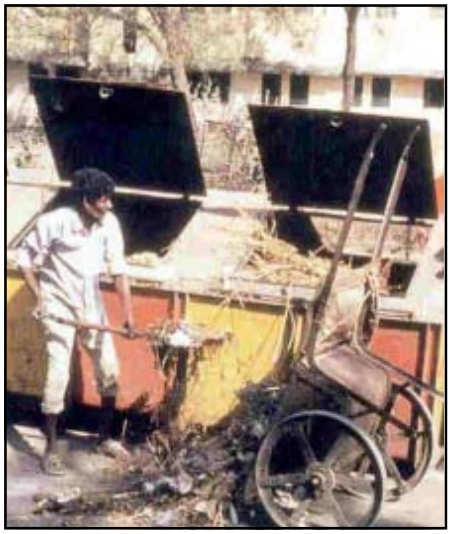


Figure 2.7 Transfering waste from a handcart to a community bin, India

These trucks are also used to transport the waste either to the compost yard or to the landfill sites popularly known as dumping grounds. In few cities, compactor vehicles are being used. These vehicles are able to provide a compaction ratio of 1.25 - 1.5. The majority of MSW transport vehicles employed are quite old. The average trip distance is less than 20 km. Mostly municipal vehicles transport the waste, though in some large towns, private vehicles are also hired to augment the fleet. For longer distances, the waste is transported in large capacity refuse vehicles that are both economical and convenient. Transfer of waste from smaller vehicles to larger ones is carried out at the transfer stations available only in a few metropolitan cities. In Mumbai, a split-level transfer station has been employed with a capacity of about 500 tons of waste per day from dumper placer to bulk refuse carrier. In some cities, split-level transfer stations are used to transfer the waste from bullock carts and smaller vehicles to larger ones, which transport the refuse to the disposal sites. The prevailing transfer stations need extensive modifications to ensure their sanitary operation. The critical issues of waste collection and transportation include the following:

- The fleet of vehicles is not utilized optimally.
- Wide variations in the output of the vehicles ranging from bullock cart to lorries.
- Waste handling is done manually and loading/unloading is time consuming, which reduces the productivity of the work force and the vehicles.
- Transportation fleet does not synchronize with the types of dustbins provided.
- Double handling of waste becomes inevitable.
- The present system is a potential health hazard for the workers as all types of wastes including infectious hospital waste and human excreta are disposed off in the common dustbin.
- Arrangement for separate collection of infectious hospital wastes is practically non-existent.
- Dustbins are not cleared daily but many are cleaned once or twice a week or even less frequently giving rise to unsanitary conditions.

Figure 2.8 (a) Mechanized (b) Manual street sweeping in India

Sri Lanka

Of the total MSW generated only 10 - 40% is collected and the rest remains either piled up on the streets or dumped in low lands. When considering the waste collection and transportation in Colombo municipal area, it is found that the most viable point of collection for MSW in semi-residential areas is in the curb/entrance. Figure 2.9 shows trash collection from the street and community receptacle.

SWM practices in various local authority areas differ greatly. A regular solid waste collection system exists in the Dehiwela-Mt. Lavinia, Moratuwa and Kotte areas. However, in some of the smaller jurisdictions, collection systems are virtually nonexistent. Solid waste is presently collected at the rate of about 1100 tons per day. The ratio of waste collected to generated ranges from approximately 93% in CMC to as little as 5% in some of the smaller urban areas (ADB, 1999).

Figure 2.9 Waste collection in Sri Lanka

The Municipal Councils, Urban Councils and the Pradeshiya Sabhas employ the following types of vehicles to transport waste according to their quantity and affordability. Box 2.5 briefly explains the privatization of Colombo garbage.

- Compactors (8 m^3 and 12 m^3);
- Tippers (11 m^3);
- Tractors and trailers (3.4 m^3);
- Two-wheeled tractors and trailers; and
- Handcarts and wheelbarrows.

Box 2.5 Case Study of Privatization of Colombo Garbage

A state of the art system is now turning Colombo's mounts of garbage into compost. Every day 711 tones of solid waste is dumped at Blumandal, the amount generated by the residents within the limits of the Colombo Municipality. With the steady rise of the population of Colombo and other areas, the Ministry teamed up with other organizations and municipal councils to find long-term solutions, one of which was the Colombo Environment Improvement Program inaugurated in 1990 with foreign aid.

CMC has given the task of handling Colombo garbage to the Burns Environmental Technologies (Pvt.) Limited (BETL), which has been dumping the garbage in its 35-acre plot since 1990. In 1998, the CMC privatized garbage collection in the Fort and Pettah area as a pilot project that is operating successfully. Fifty percent of the city's waste collection is now under private contract with Abans Environmental Services. BETL is operating a modern composting plant at Sedawatta. This plant is the single largest MSW unit in the country that manages the site as per international standards for about 800 - 900 tons/day.

Source: NRI Sri Lanka, 2003

Thailand

With the essential policy reforms, Thailand has made improvements in all functional elements of the MSW management system. For onsite storage, durable plastic wheeled bins are replacing oil drums (Box 2.6). In residential areas, the range of containers includes 60, 120 and 240-liter plastic bins while larger containers employed in commercial areas are 4 m^3 or 8 m^3 steel containers. The typical collection fleet in Thailand comprises of side-loaded trucks (10 - 12 m^3 capacity), pick-up trucks (3 - 4 m^3), and container hauling trucks (6 - 7 m^3), and currently the side-loader trucks undertake the MSW collection in the regional part while collection vehicles, especially compaction trucks of 10 - 20m^3 capacities are employed in large cities. Although the application of transfer stations is not so popular but at some transfer points, the wastes collected by smaller vehicles are being transferred to larger trucks, and similarly from a compactor truck to a higher density transport vehicles which improves transportation performance. At present, the only operational transfer stations are in Bangkok are with the following capacities:

1. On-Nuch station 3500 tons/day (Figure 2.10)
2. Nong Khaem station 2800 tons/day
3. Tha Raeng station 2300 tons/day

Figure 2.10 On-Nuch transfer station, Bangkok, Thailand

Apart from the above, there are a few smaller transfer stations e.g. in Pathumthani (300 tons/day) and Nakorn Srithammart (50 tons/day), but they are not fully functional or not in operation.

Box 2.6 Mobile garbage bins (MGBs) in Thailand

Single MGB with a capacity of 240 liter can service up to 10 households on a daily collection basis, thus compactor trucks can be loaded at the rate of 4 MGB/ton of truck capacity. If the collection frequency is reduced to every second day or 3 times/week then there needs to be provided twice as many communal MGBs. There could be a 50% reduction in collection time if MGBs are placed side-by-side and thus able to be loaded together. If the MGBs are spaced out to provide more convenience for residents then there will be little saving in collection time. Collections should be undertaken daily, where practicable. It is noted that this may not be possible in some sanitary districts with smaller populations. The main advantage of MGBs is that they can be quickly loaded using a hydraulic power loader or manually by two men.

2.1.5 Processing of MSW: Composting

From the composition of the MSW generated in the study countries, processing of waste becomes an unavoidable stage before disposal. Chemical and biological transformation processes can be used to reduce the volume and the weight of the wastes and to recover conversion products and energy. Composting of solid waste is the most prevalent method applied in these countries either for treatment or for recovering valuable materials.

China

In China, 10% of the MSW collected is composted as a way of processing and also as a mode of MSW disposal (UN, 2000). Generally, the application and development in composting of MSW in China can be divided into three phases: introductory phase from 1950s~1960s; research phase from 1970s~1980s and application phase from 1990 onwards. The technology for systematic composting has been improved lately. M/s Beijing Taisan Green Industry Ltd and the Huagongting humus compost office in Yunnan province have both used the composting of solid wastes to make combined organic-inorganic fertilizers, whose component varies according to the requirements and the compositions of the soil. In Shanghai, an aerobic composting plant with a capacity of 1000 tons/day has been in operation recently and another unit for anaerobic digestion (500 tons/day) is being planned by a private enterprise. The available but outdated and limited state-of-the-art equipment somehow affects the composting on a large scale. Only few plants for disposing MSW can operate normally throughout the year as most plants are operated intermittently. The main barrier in promoting composting despite public opposition is economic restraints.

India

The larger proportion of organic matter in Indian MSW indicates the suitability of biological processing. Composting was a prevalent practice of processing in the past especially initiated as Bangalore and Indore methods in the respective places. However, due to the non-availability of adequate space in the urban centers and poor segregation of wastes, these manual composting systems have been practically discontinued. Although a total of 10 mechanical composting plants were set up under a central scheme of MSWM in different parts of the country, only one in Delhi is under operation. All others were closed down due to mechanization problems, lack of consumer

acceptability of the product and absence of consumers in the vicinity. Apart from that, over the recent years many private companies and enterprises have invested in composting of urban MSW and in general handle about 100 – 300 tons/day. For instance, M/s Sunrise Enterprises has set up its own plant on private land and is receiving 300 tons of waste per day. The Bangalore City Corporation has entered into an arrangement with a private enterprise M/s Sunrise Enterprises and Karnataka Compost Development Corporation (KCDC) which is receiving 150 - 200 tons of waste. Another private entrepreneur M/s Terra Pharma is also managing to get another 70 - 80 tons of waste. In addition to this, NGOs *viz.* Swabhimana and Exonora are also collecting kitchen waste for converting into fertilizer through vermi-culture.

Box 2.7 Success story of commercial composting

M/s Excel Industries Ltd are able to produce compost, which they sell as "bio - organics soil enrichner," from their plants set up recently at Kolkata, Bangalore and a few other places. They have set up several centralized composting plants in India, with capacities ranging from 35 - 500 tons per day. Most of these plants run on a "build-own-operate" basis or as joint ventures with local or state agencies. These plants have been successful in marketing their compost and have been able to sustain their production. Excel Industries is now planning to set up a few more municipal (Kolkata, Jaipur, Jallundhar, Pondicherry, etc.) and industrial (vegetable processing industries) organic waste composting plants in the near future. Excel has a nationwide distribution and sales network for its agro-chemicals, which confers a distinct advantage in marketing its Celrich compost, as it can reach farmers easily. According to Excel Industries, farmers for growing sugarcane, grapes and bananas buy about 95% of Celrich. These farmers cut their chemical fertilizer consumption by more than 25 per cent. According to the company's own estimates, a 500 tons/day plant will require a capital investment of Rs. 60 million (or about US $1.7 million) exclusive of the land cost. This amount includes a five per cent turnkey fee and commission charges and approximately 8 – 10% towards working capital. Normally, about 35% is spent on developing the site and infrastructure. The overall production cost is estimated to be in the range of Rs. 1200 - 1400(US $ 25 – 30) per ton of compost. Typically a 500-tpd plant employs about 50 skilled staff and 20 unskilled workers, and the direct operating costs are estimated as Rs. 500 - 600 (US $ 10.4 – 12.5) per ton of compost. The interest and depreciation on capital investment are estimated to be about Rs, 400 - 600 (US $ 8 – 12). Depending upon transportation distance and other local overheads, the selling price varies between Rs. 1600 - 2000 (US $ 33.5 – 42) per ton of compost.

Source: NRI India, 2003

Sri Lanka

In Sri Lanka, windrow composting was most widely used in the processing the MSW and about 5% of the collected MSW are processed in various households and central composting systems (UN, 2000). Regarding its operation, household level composting has proved more successful than centralized composting projects. The limited success of centralized composting was due to its unsuitable location and public protest against the malodor and contamination of water bodies. CEA is currently supervising a large-scale MSW composting plant under CMC (Box 2.8). The composting plant at Horona, is producing about 20 tons of compost per month using market waste and feedstock. Lately, University of Peradeniya has developed an Inclined Step Grade composting system of 6 - 8 tons/day capacity suitable for medium to large-scale operations. The local authorities are initiating various composting projects throughout the country as listed in table 2.7.

Box 2.8 CEA in composting

Under the directive of the CEA, the CMC opted for a large-scale MSW composting project in Colombo. Initially BETL with the technical cooperation of Excel Industries, India established a 600 MT/day plant. In order to improve the quality of compost, BETL has now engaged the Solid Waste Management Research Unit of the University of Peradeniya to apply the latest findings on composting and supporting technologies of the AIT-Sida project. The estimated collection of the CMC has reached 800 MT/day and aerated static pile systems is the most feasible solution for processing various waste streams to obtain different grades of compost from high quality for agriculture use and lower grades for parks and landscape features. The stabilization and maturity phases are carried out at Blumendal and the final sorting, separations and sieving are done at Sedawatta. In this integrated system, unrecyclable materials are disposed in a semi-engineered landfill in Anamaduwa 140 km from Colombo. The CMC pays a tipping fee of Rs. 550/ton (US $ 5.7) with 5% annual increment and the contract has been signed between CMC and BETL for processing and final disposal for a period of 25 years. The composting facility does not accept hazardous, industrial and liquid wastes (sewage sludge).

Source: NRI Sri Lanka, 2003

Figure 2.11 Windrow composting in Rathnapura, Sri Lanka

Table 2.7 Compost projects based on the use of MSW

Local Authority	Current	Feedstock
Colombo MC	150 compost bins	Kitchen/green waste
Dehiwala - Mt. Lavania MC	150 compost bins	Kitchen/green waste
Mortuwa MC	1500 barrels	Kitchen/green waste
Kolonnawa UC	20 barrels	Kitchen/green waste
Ja-ela UC	18 barrels	Kitchen/green waste
Wattala UC	30 barrels	Kitchen/green waste
Maharagama PS	2300 barrels	Kitchen/green waste
Kesbewa PS	Centralized plant	Market waste, dung and coir fiber
Mahara PS	15 barrels	Kitchen/green waste
Matale MC	Centralized plant	Market waste
Ratnapura MC	-	Market waste
Balangoda UC	-	Market waste
Dambulla PS	-	Market waste

Note: MC- Municipal Council; PS- Pradeshiya Sabha; UC- Urban Council

Source: NRI Sri Lanka, 2003

Thailand

In Thailand, about 10 percent of the MSW are composted. The only large-scale composting plants under operation are that of BMA employing Jersey (multiple floors) type and rotating compost drum, each with a capacity of 1000 tons per day. However, the plants are not currently in use due to high operating cost and unpopularity of compost product with the end users (farmers) due to contamination by impurities caused by poor source separation of wastes. There are few other small-scale composting plants located in the municipalities but so far limited successful practices have been reported.

Box 2.9 Case Study: Vermicomposting in Thailand

The residents of Barommatrilokanat 21 community make compost by using tiger worm that reduces the volume of household waste. The making of compost begins from separating household waste into three categories: organic matter, recyclables and general garbage. The organic waste is collected in plastic bins and brought to the community composting center where it is dumped in circular cement or cement and brick enclosures used to house the worms. It takes three to four months to turn a batch of waste into compost. This compost is rich in humus that helps improve the structure and quality of the soil - makes clayey soil more porous and fertile and helps it retain water better.

This compost that costs about Baht 5/kg has become a source of extra income to the people in Barommatrilokanat 21 community.

Source: NRI Thailand, 2003

2.1.6 Processing of MSW: Incineration

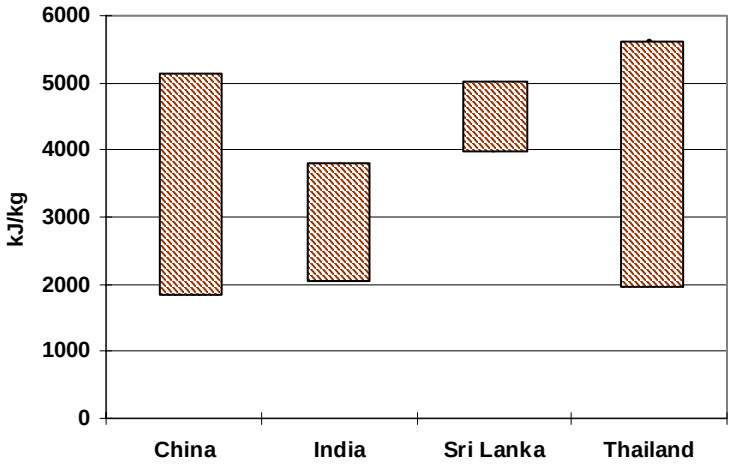


Figure 2.12 Calorific value range of MSW in study countries

In developing countries, waste incineration facilities are constrained by the high capital, operating and maintenance costs, and increasingly stringent air pollution control regulations (UN, 2000). It is difficult to incinerate wastes in many developing countries due to their high moisture and low energy content. In addition, the technical infrastructure required to maintain incineration facilities, including the pollution control equipments, is generally not widely available in most of the developing countries. Other elements that are often lacking include trained personnel, constant

availability of technologically advanced testing and repair facilities, and a well-organized system to ensure availability of spare parts (UNEP, 2001b). The low calorific value of the MSW in the study countries clearly reveals the impracticability of incinerating both technically and environmentally (Figure 2.12). Generally, the minimum calorific value required for a sustainable combustion ranges between 5024 – 5861 kJ/kg of MSW (www.no-burn.org).

In China, the first modern incineration plant with treating capacity of 300 tons per day was installed and operated in Shengzhen in 1989 by importing the technology and equipments from Japan. Unable to meet the equipment demand from the domestic manufacturing companies, incineration plants are constructed using the technologies from America, Europe and Japan. So far, there are about 36 incineration plants in the whole country for about 2% of the MSW and this figure would increase in future. As of now Shanghai (Figure 2.13), Xiamen, Zhuhai, Nanhai, Beihai, Ningbo, Guangzhou and Beijing have constructed incineration plants to generate electricity. It has also been noted that some of the existing operational incineration plants are fitted with domestic equipments, which results in poor combustion, inconvenience in operation with no standard unit for flue gas purification.

Figure 2.13 Incineration plant in Shanghai, China

In India, incinerators for MSW are not used owing to the fact that MSW contains a high amount of sand and silt from open drainage or improper drainage, unmetalled roads, street sweepings and ash from coal burning. However, refuse derived fuel (RDF) incinerators operate in Mumbai and Hyderabad; their efficiency and accomplishments are questionable.

Thailand has two MSW incinerators of 250 and 70 tons/day capacity at Phuket and Samui Island municpalities respectively. These incinerators have been in operation since 1998 and process less than 1% of the total waste generated in Thailnd.

In Sri Lanka, as of now there are no MSW incineration plants though some locals burn the waste in enclosures and technical incineration remains vague to some local bodies.

2.1.7 Waste minimization and recycling

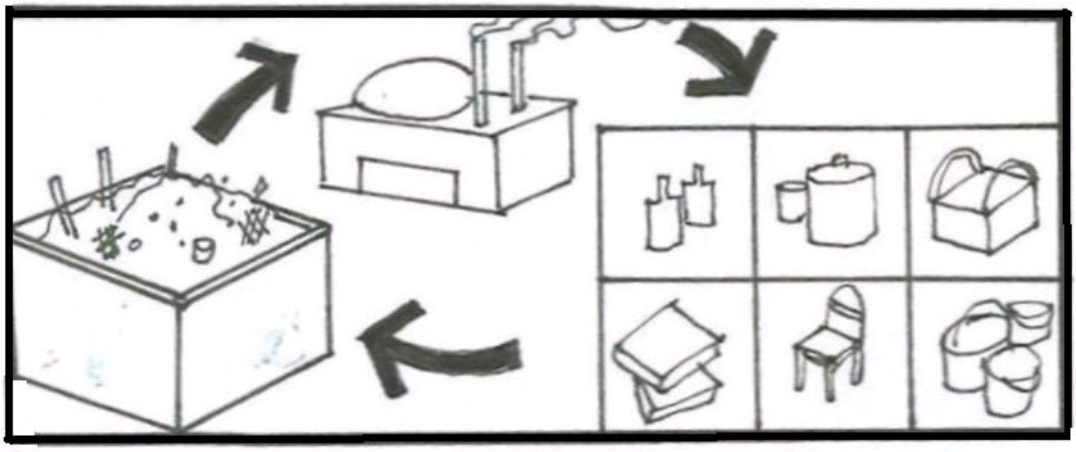
Minimizing the quantities of waste through source reduction, material recovery, reuse and recycling is increasingly being recognized as the central basis of an integrated approach to MSWM. However, the ultimate success of waste minimization might depend on cleaner

production (CP) practiced in many developed and developing countries in the region as a more efficient and modern practice than conventional waste management practices. Although CP principles in waste minimization is generally restricted to industrial solid waste generation, which in the long run might enable MSW minimization both locally and globally.

Most developing countries have various processes aimed at the recovery of materials from the solid waste stream. Local industries in some cases are strongly dependent on the availability of secondary materials for re-processing. Some of these materials include cardboard, various paper products, different types of plastics and metals. Unfortunately, the methods used to recover them are inefficient that disregard the basic principles of occupational health and safety and in some instances cause significant environmental problems such as in the recovery and reprocessing of automobile batteries at home level (ISWA & UNEP 2002).

Resource recovery or scavenging as commonly called takes place in most urban areas of the developing countries and is carried out at various stages of the waste stream in different modes irrespective of health hazards. The rate of waste recycling has increased dramatically in recent years in the Asian-Pacific Region from 10% in 1990 to 22% in 1998 (UN, 2000).

The local authorities, NGO's and other environmental organizations in the study countries have initiated various projects to promote resource recovery and reuse. However, most of them have begun with pilot activities to assess and encourage interest and willingness of users to participate.



China

The higher consumption of resources and minimal recovery adds an extra burden on the management of generated waste. Though the government has made a series of policies and measures in encouraging comprehensive utilizations of the waste, its management has not been legalized. As a result, to a certain extent sound development of comprehensive resource utilization has been negatively influenced. The State's Tenth Five-Year Plan period (2001 – 2005) included provisions for China to make laws on recycling and utilization of the resources. The reduction of the wastes generated is expected to reach 80% through the recycling of a large amount of packaging materials and launching the concept of minimizing the quantity of the waste generated in the whole society. The long-term goals (after 2050) aim to carry out comprehensive management of the waste to foster sustainable development of the whole society.

India

The socio-economic structure of the Indian society not only makes per capita generation of waste much less compared to that of the western countries but has also brought in a system of waste recycling and reusing not common to developed societies, though these systems are trailing behind. All metals, unsoiled paper, plastics, glass, cardboard etc are readily marketable and hence recycled by householders themselves or by rag (waste) pickers. Normally, by the time the waste reaches the community bins, it contains very little recyclables and consists mainly of vegetable/ fruit peels, scraps of soiled paper and plastic, used toiletries etc. The interlink between the formal and informal sectors that contribute to resource recovery, recycle and reuse are seen as highly effective. Waste pickers who sort the recyclable materials from the garbage dumped into the collection units initiate informal recycling. These materials are then directed to different industries after sorting and classification. This system takes off considerable load from the municipal services. The collection crew of the formal system is also actively involved in the informal separation and recycling of valuables from the wastes. From the rag pickers to the recycling units there is a long chain of stakeholders involving intermediaries, wholesale traders, waste recycling industries etc.

Waste recycling is intensely practiced through the informal sectors as depicted in figure 2.14. Recyclables are collected by itinerant collectors from the waste sources. Rag pickers and municipal workers collect from community storage units while the scavengers pick from the dumps. These wastes are bought by dealers who send them to the recycling units. Waste recycling through rag pickers occurs at different levels – waste generator, transfer stations and dumpsites. Resource scarcity, abundant labor and poor economic conditions contribute to the prevalence of widespread informal practices in SWM in India.

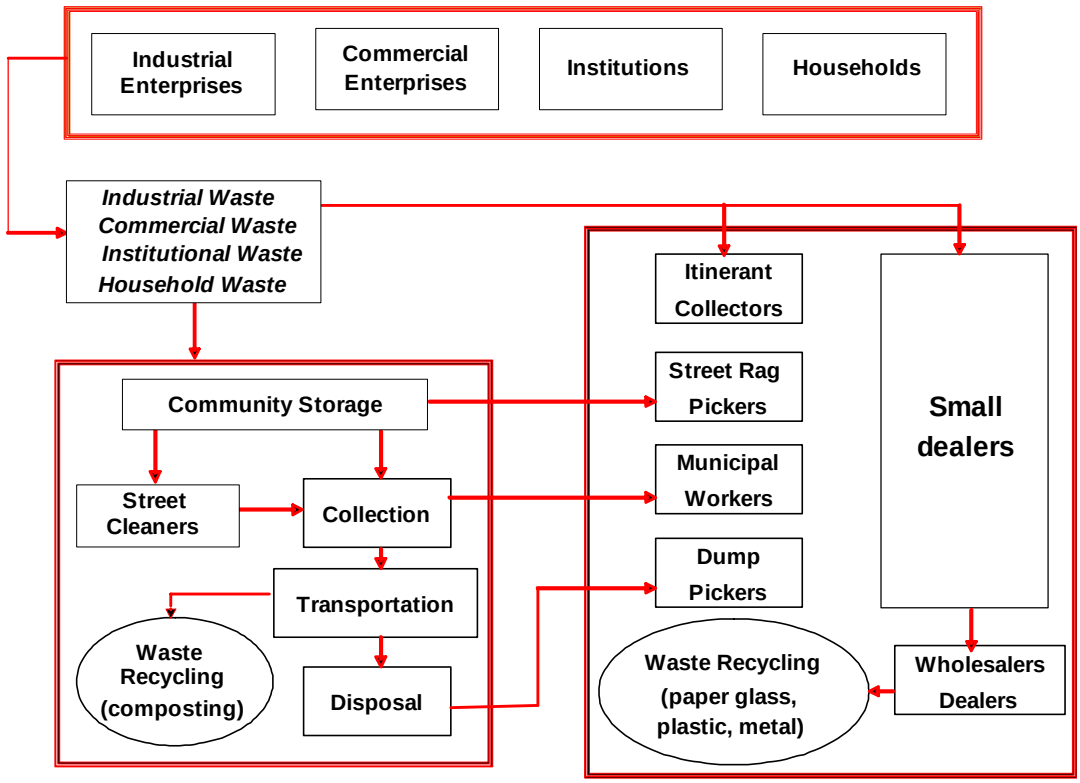


Figure 2.14 Informal systems of waste recycling (India)

Figure 2.15 Rag pickers segregating their collection in India

Waste picking tends to strew the waste around the bins and exposes the waste pickers to direct contact with decaying materials (Figure 2.15). Consequently, public health and individual health of waste pickers suffer.

Sri Lanka

In this nation, resource recovery has been developed informally for the past few years for certain type of materials. Scavengers collect glass, paper, high-density polyethylene (HDPE), low-density polyethylene (LDPE), plastics, metals, etc. Currently, recycling of materials is carried out through an informal market system. Items are recovered at various points of the waste stream - at household level, collection and transport by LA workers or at the final disposal site by waste pickers and municipal workers. The retrieved materials are sold to collection shops where they are cleaned and sold for recycling by local industrialists or exported overseas. The following materials are recycled:

Plastic - Polythene and plastic recycling is a fairly growing industry at cottage level. However, necessary coordination among the responsible organizations is lacking to the required level. HDPE, LDPE, polyethylene terephthalate (PET) and polypropylene (PP) are recycled locally. The high cost of collection of clean plastic reduces its demand though palletizing can be done and transported to recycle units. This would cut on the transport cost and preprocessing at recycling centers while adding value to the raw material from the remote areas.

Glass: The Ceylon Glass Company recycles white and amber cullet whereas green cullet is recycled on small scale by private glass manufacturers. They use 40% of recycled glass (cullet) in the manufacturing process of glass.

*Ferrous and non-ferrous metals***:** These are recycled locally and exported in bales after sorting and cleaning. The price of scrap metals is high due to the export demand.

Waste paper and cardboard - Paper recycling is done in large scale (paper mill) as well as in micro level (hand-made paper). The Vallachchanai paper factory of the National Paper Corporation runs wholly on recycled paper. A small quantity of corrugated cardboard is exported after shredding and baling. Newspapers cannot be recycled in the absence of de-inking facilities. Newspapers are re-used mainly as a packaging material.

Box 2.10 Experience of Recycling in Maharagama

The Maharagama PS encouraged by the MoEF, initiated a source segregation scheme among 2300 householders for the separation of paper, cardboard, glass, metals, plastic and polythene. In the short time that it has been in place, it is effective in reducing the total quantity of waste collected for final disposal The Ministry, in an attempt to replicate this success story in other LAs has distributed a newsletter among them giving guidance and encouragement to initiate such recycling practices.

Source: UNEP, 2001a

In Sri Lanka, resource recovery from waste stream has a crucial role to play not only in integrated SWM, but also in the process of saving the limited natural resources.

Thailand

Separate collections of biodegradable and non-biodegradable wastes are widely practiced in Thailand. It is estimated that around 40 - 60% of solid waste generated could be recycled and reused. The recycling rate of MSW has steadily increased over the years. In 1997 the total waste recycling was about 11% or 1.5 million tons (an increase by 7% from 1996). Furthermore, in 2000 about 2 million tons of solid wastes were recycled. The three main items are paper (57%), glass (19%) and plastic (15%). The recycling of the waste is mainly done by formal and informal sector since there is no existing regulation concerning waste utilization. Figure 2.16 shows the collection of recyclable cans for sending to the recycle unit.

Recently, the Royal Thai Government has made some important strategies for the management of natural resources and environment targeting recycling of solid waste in its Eighth National Economic and Social Development Plan which are:

- To reduce amount of pollution and their emission to the environment
- To promote the development of technology for waste treatment and clean technology in the production processes minimizing the negative impacts.

Box 2.11 Thailand sets recycling target

Within the framework of 8th National Economic and Social Development Plan, governmental policies has been emphasized on the reduction of pollution from waste by recycling and proper treatment of waste, promotion of clean technology in industries, support NGO and public participation in solving solid waste related problems. The target on waste recycling is to reduce solid waste generation amount from communities by 10% in 2001 and by 15% in 2006 according to Environmental Management Plan 1999-2006 by the Office of Environmental Policy and Planning (OEPP), Ministry of National Resources and Environment (MONRE).

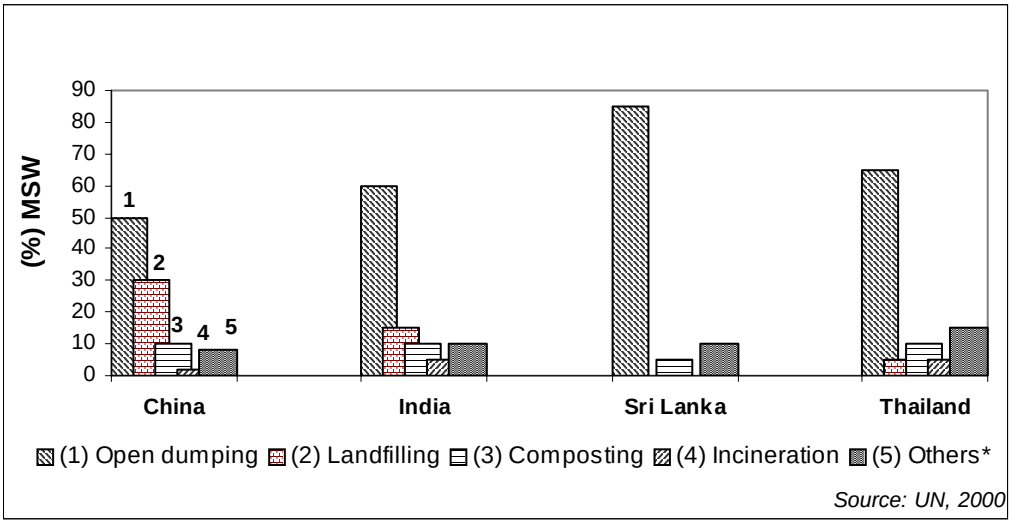
Source: NRI Thailand, 2003

Figure 2.16 Collection of recyclables in Thailand

2.1.8 Disposal of MSW

Final disposal in most of the economically developing countries is usually a matter of transporting the collected waste to the nearest available open space and discharging them. Figure 2.17 shows the disposal methods practiced in the study countries while table 2.8 illutrates the methods in some selected countries of the Asia and the Pacific Region.Open dumping is predominant except for the developed countries. Composting is not carried out to the capacity that can be achieved though almost half of the MSW can be reduced thus. Other forms of disposal like animal feeding, ploughing into soil, open burning and dumping in water bodies or wetlands contribute to environmental hazards. Waste burning is practiced to reduce its volume and minimize the attraction of animals and vermin. Despite the degradation of valuable land resources and the creation of long-term environmental and human health problems, uncontrolled disposal systems are still prevalent in most of the developing countries (ISWA & UNEP 2002). Sanitary landfilling or engineered landfilling of MSW is often misinterpreted in the developing countries, especially when it comes to covering a dumpsite by soil. In simple terms, it can be defined as an engineered facility for the disposal of MSW designed and operated to minimize public health and environmental impacts, which requires monitoring of the incoming waste stream, placement and compaction of the waste and installation of varied liners for preventing leachate infiltration (Tchobanoglous *et al*, 1993).

Financial and institutional constraints are one of the main reasons for inadequate waste disposal. Introduction of SWM user fees cover only the collection and transportation costs leaving practically no resources for safe disposal of the waste. Generally, when aesthetic values are in question most people are willing to pay for the removal of refuse from their immediate environment but are not concerned with its ultimate disposal.



**Feeding of animals, dumping in water and open burning*

Figure 2.17 MSW disposal methods practiced in study countries

Table 2.8 Disposal methods of MSW in selected countries of the region					
Country/Territory	Disposal Methods				
	Open dumping	Composting	Land filling	Incinerator	Others
Japan	0	10	15	75	0
Singapore	0	0	30	70	0
Australia	0	10	80	5	5
Republic of Korea	20	5	60	5	10
Malaysia	50	10	30	5	5
Indonesia	60	15	10	2	13
Philippines	75	10	10	0	5
Vietnam	70	10	0	0	20
Pakistan	80	5	5	0	10
Bangladesh	95	0	0	0	5
Nepal	70	5	10	0	15
Mongolia	85	5	0	0	10

Source: UN, 2000

China

Currently, China has 571 landfills, 134 composting units and 36 incineration plants. Compared to other methods, landfill technology has the advantages of low investment and operation costs, and no requirements for calorific value of wastes and hence the most prevalent mode of MSW disposal in most of the cities. Figure 2.18 shows a typical landfill in China. Industrial development and technology cannot meet the equipment demand for the proper management of the existing landfills. The existing technology and the equipments employed for waste compaction, drainage of leachate and monitoring of landfill gases are limited. Box 2.12 details the fate of MSW in China.

Box 2.12 Fate of MSW in China

Landfilling, incineration and composting are the three main methods of disposing MSW with landfill as the most popular. Just about 58% of the wastes are disposed harmlessly with 1% of the wastes being utilized. Many refuse incineration plants around the country suffer from a lack of appropriate equipments and technology and still lack strict and efficient management. Shanghai being the most economically developed city of China, has maintained an annual average growth of about 5% in MSW over the past 10 years. In 2002, about 5.6 million tons of wastes were collected and disposed and the figure is expected to reach 6 million tons in 2003. The municipal government has given increased importance to the scientific treatment of MSW. Reduction, utilization and harmless treatment of wastes list on top of the agenda in China's 21st Century Shanghai Action Plan.

Source: Waste Disposal Shanghai, 2003

Figure 2.18 A typical sanitary landfill in China

India

Waste disposal in India is practised by dumping in low-lying areas of the majority of urban centers. According to this study, 90% of the total municipal waste collected is dumped on land and 10% is composted - the latter value varies as 0 to 25% from city to city. The disposal sites are selected on the basis of their proximity to the collection areas and new disposal sites are identified only when the existing ones are completely filled. The burden that would be imposed by the increase in solid waste generation is evident from the fact that the cumulative requirement of land for disposal of MSW (base year 1997) would amount to around 1400 km^2 by 2047 (Singhal and Pandey, 2001).

Figure 2.19 Dumpsite at Chennai in India

In most cases, the waste is simply discharged at the dumpsites sites except in the four metropolitan cities of Chennai, Delhi, Kolkata and Mumbai where bulldozers are used for compaction at the disposal site. Even in these cities, they are used only for the leveling of the deposited waste. The incoming MSW vehicles are not weighed and no specific plan is followed while filling the dumpsites. Provisions for leachate and gas control do not exist. A soil cover is rarely provided, except at the time of closure of the site. Most of the disposal sites are not fenced and the waste picking is commonly in vogue, posing problems in the operation of the sites (Figure 2.19). Open burning of MSW at disposal sites is most common for reducing the volume of wastes and for easy rag picking. Provision of water supply for drinking and fire fighting is rarely available at these sites. None of the dumpsites currently in operation in India are being operated as sanitary landfills.

Sri Lanka

The prevalent method of waste disposal in Sri Lanka is open dumping accounting for more than 85%. The MSW generated within CMC is currently disposed at landfill sites and at a number of small, uncontrolled open dumpsites (ADB, 1999). These comprise non-engineered sites where waste is tipped haphazardly without environmental protection. A majority of open dumps is in the low-lying areas - marshes and abandoned paddy fields that are filled with solid waste primarily as a means of land reclamation (Figure 2.20). A review of dumpsites of the Greater Colombo Area (GCA) was carried out under the Colombo Environmental Improvement Project in 1999 - 2000. It was found that 41 existing disposal sites in the GCA were all open dumps with the exception of one site where market waste was buried in trenches (UNEP, 2001a).

Figure 2.20 Gohagoda dump site in Sri Lanka

Some of the LAs use a daily topsoil cover to prevent the public opposition and nuisance. These dumps are used to dispose every type of waste such as industrial, hospital and clinical, and slaughterhouse wastes together with MSW without any proper segregation. None of the open dumpsites are engineered to manage the leachate and control of pollutants released from waste decomposition. There exist little or no basic operations such as leveling and covering of waste at the site presumably due to high costs involved. Soil cover is applied only at the final stage if and when there is a projected use for the land or public pressure. It is reported that the Kandy Municipal Council is in the process of providing some form of leachate treatment by intercepting and treating it in a series of ponds and re-circulating it in the dumpsite of a total area of 31 acres (UNEP, 2001a). In addition to dumpsites operated by the relevant authorities, random dumping takes place along the streets, marshes and abandoned paddy fields by private individuals. In the central part of the island, waste is mostly disposed along the roads and local authorities with regulatory responsibility exercise little control over these malpractices mainly owing to the lack of resources and stringent laws.

Thailand

The practice of open dumping is also prevalent in Thailand with about 65% of the MSW collected ending up in dumpsites. Currently, there are 96 open dumpsites (Figure 2.21), 27 landfills, 9 sanitary landfills and 2 incinerators. Uncontrolled burning of refuse is still practiced at the majority of the open dumps. These practices have led to adverse public reaction in communities adjacent to the existing and planned landfill facilities. In major parts of the country this open dumping of MSW has remained a common practice due to a lack of adequate funding, poor planning and a general lack of technical knowledge.

Figure 2.21 A typical dump site in Thailand

2.2 Stakeholders and Management of MSWM

There is a wide range of individuals, groups and organizations involved and concerned with MSWM as service providers, intermediaries and regulators in the four countries. Three groups - generators, regulators and legislators provide the key to effective national waste management policies and strategies that integrate the responsibilities of all stakeholders in making waste management a successful venture. In recent years there has been a gradual change in the environmental policies and increase of technical expertise through education and training. However, lack of funding, enforcement actions and sometimes lack of community involvement or participation appears to be the major barrier in improving the standard of waste management services.

2.2.1 National and local government agencies

National governments are responsible for establishing institutional and legal frameworks for MSWM and ensuring that local governments have the necessary authority, powers and capacities for effective SWM. In developing countries, responsibility is delegated without adequate support for capacity building at the local level. To assist local governments execute their MSWM tasks, national governments need to provide them with guidelines and capacity building measures for administration, financial management, technical systems and environmental protection. Local authorities are generally responsible for the provision of solid waste collection and disposal services. They become the legal owner of waste once it is collected or put out for collection. Responsibility for waste management is usually specified in by-laws and regulations and may be derived, more generally, from policy objectives regarding environmental health and protection.

China

Despite the gradual enhancement in its sanitation organizations, the management aspect of the environmental sanitation is relatively backward and complex with scattered established sanitation organizations. The City Appearance and Environmental Sanitation Administrative Bureau (under the Ministry of Construction) takes charge of management of environmental sanitation in all the cities. Within the province, the Construction office takes full charge of managing environmental sanitation. The Environmental Sanitation and Administration is set under the Construction Bureau on behalf of the municipal government to manage environmental sanitation of the whole city.The intricacies in the MSWM in the regions were due to the lack of proper coordination and transparency between the Ministry of Construction and the State Environmental Protection Administration of China. Also the poor feedback of information regarding the MSWM further impedes the proper functioning of these bodies. Figure 2.22 briefly describes the administrative framework of MSWM in China with the respective jurisdiction over MSWM related activities.

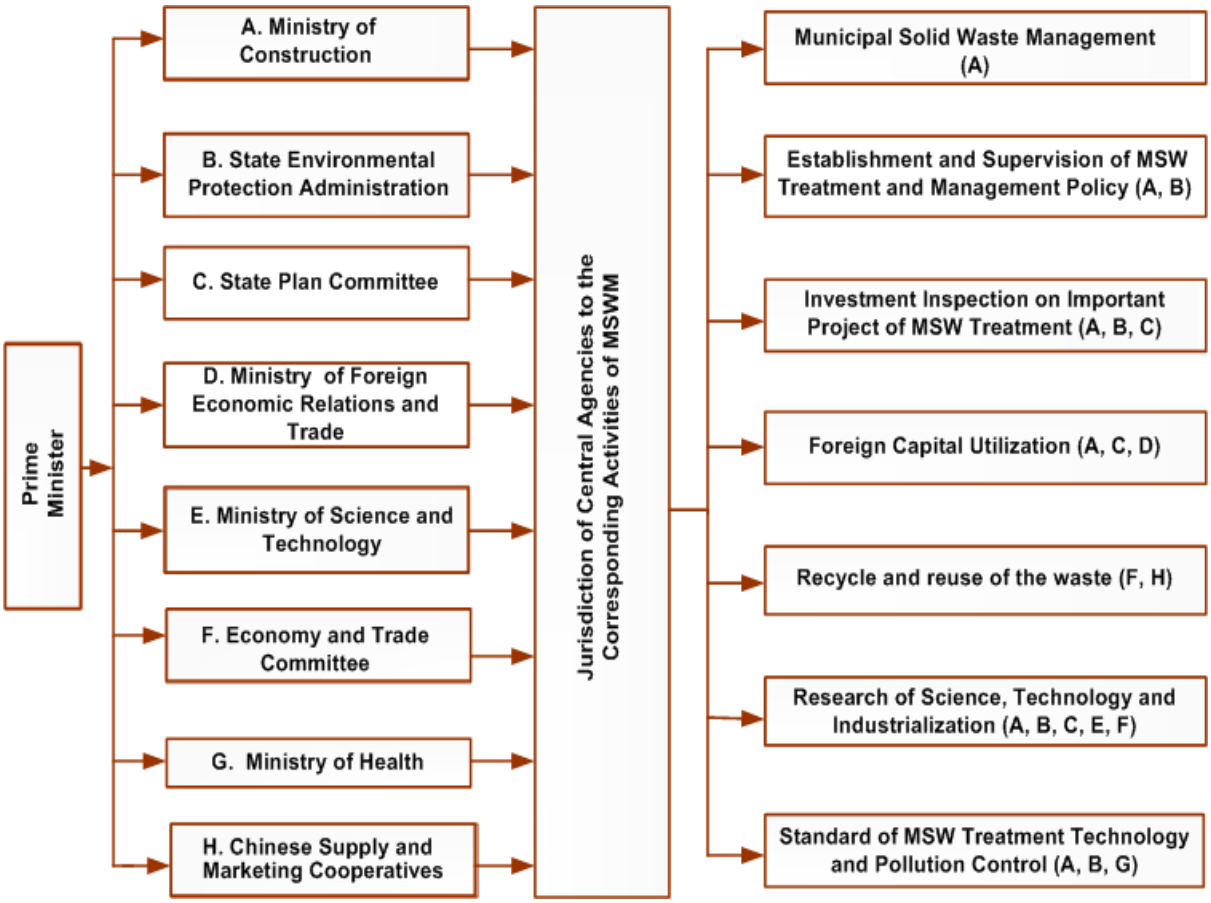


Figure 2.22 Hierarchical systems and their jurisdiction for MSWM of China

India

According to the Indian constitution, MSWM falls within the jurisdiction of the state list and the responsibility lies within the public domain of the local municipal authorities who execute the formal tasks of MSW collection, transfer and disposal with their own staff, equipment and funds. SWM is a mandatory function of the municipality. These municipal agencies are responsible for providing various services relating to water supply, sewerage, roads, power supply etc. Except for the metropolitan cities where a separate department headed by an engineer exists, the health officer is entrusted with the responsibility of SWM along with his other responsibilities. He is assisted by the engineering department, which provides and maintains the transport vehicles. The ministries responsible for different aspects of SWM are:

(i) Ministry of Health and Family Welfare;
(ii) Ministry of Environment and Forests;
(iii) Ministry of Urban Development;
(iv) Ministry of Agriculture; and
(v) Ministry of Non Conventional Energy Sources.

Figure 2.23 shows the hierarchal system for MSWM in Chennai and a similar pattern is followed in other municipalities with changes in the number of personnel.

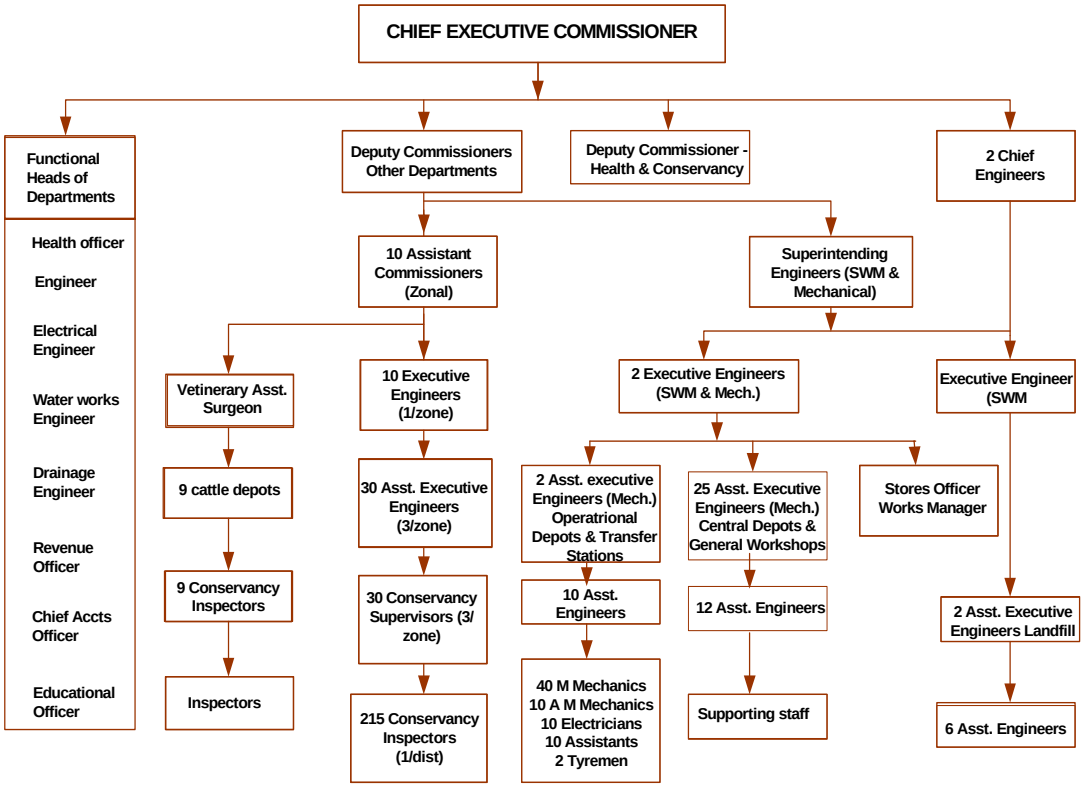


Figure 2.23 Hierarchical systems for MSWM in Chennai India

Sri Lanka

The responsibilities for MSWM in Sri Lanka is generally assigned to the Public Health Department (PHD) of each LA under the auspices of the Chief Public Health Inspector (CPHI), except for Colombo Municipal Council and Dehiwala-Mt Lavinnia Municipal Council which have established SWM departments for providing waste collection, treatment and disposal. The CPHI and Public Health Inspector (PHI) employed either by the local authorities or by the Ministry of Health are responsible for SWM besides their involvement in public health and sanitation. Figure 2.24 further illustrates the hierarchal system in Sri Lankan MSWM.

The organization and responsibilities for different aspects of SWM are split between different agencies. Primary collection crews belong to PHD workers who are supervised by a health supervisor. Secondary collection crews generally come from the Works Department or in few cases are employed by the private sector. The Works Department is usually responsible for detailing drivers of vehicles and mobile plant operators at the disposal sites. The government role in MSWM is to provide infrastructure facilities to establish proper waste collection and transportation system, and ensure the safe disposal of waste.

Thailand

The authorized government agencies for MSWM in Thailand as shown in figure 2.25 are also supported by other national and local level organizations *viz.* the National Environment Board (NEB), Environmental Fund Committee (EFC), Provincial Administrative Organization (PAO), Municipalities and Sub-district Administrative Organization (SDAO). Among these organizations, NEB established under the newly enacted environmental law is the highest decision making body concerning all aspects of environmental issues. Chaired by the Prime Minister, EFC is in charge of examining environmental projects (e.g., solid waste and wastewater management) under the Overseas Economic Cooperation Fund (OECF) assisted Environmental Fund. PAO, Municipalities and SDAO are local level supervising bodies.

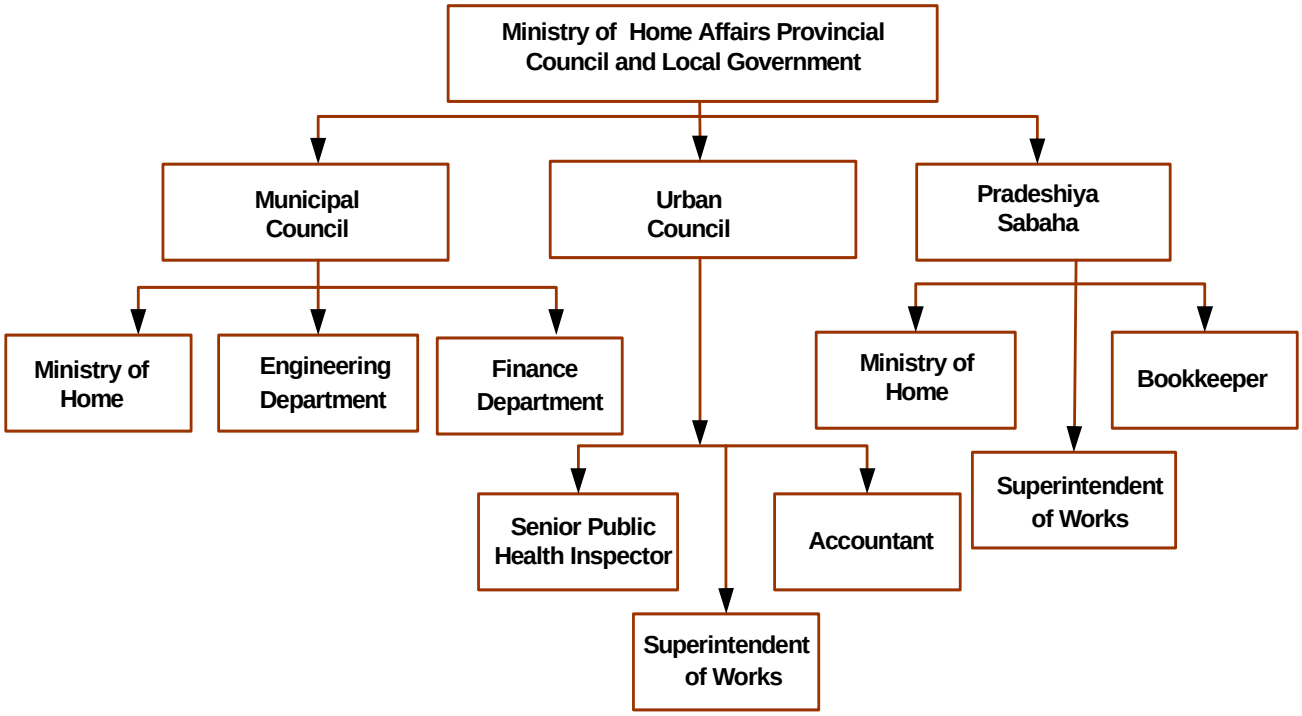


Figure 2.24 Hierarchical systems in the MSWM of Sri Lanka

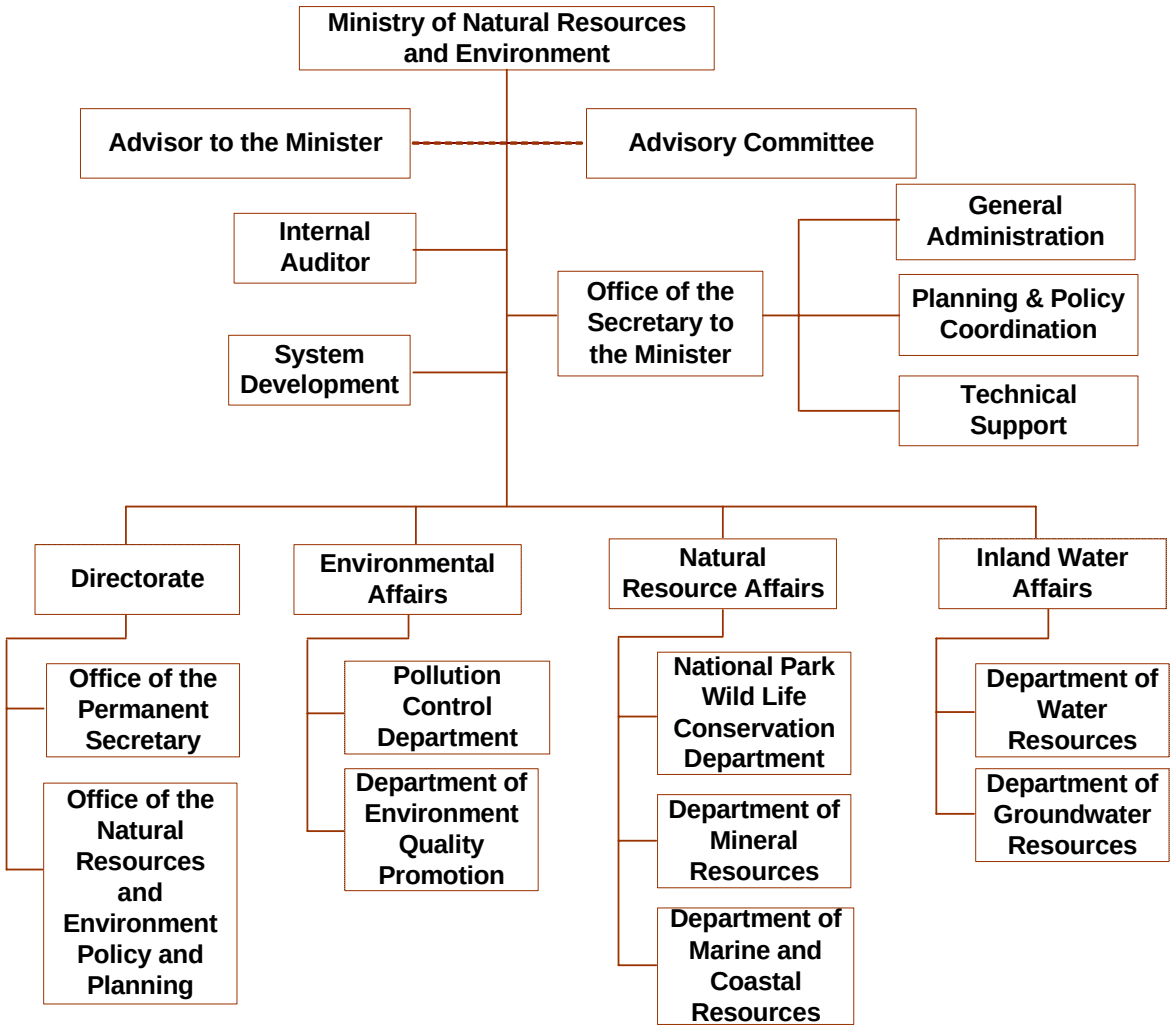


Figure 2.25 Structure of the Ministry of Natural Resources and Environment, Thailand

Locally, each sub district has its own authority responsible for MSW management and operation. These local authorities can be called either municipality or Sub-District Administration Organization on the basis of urbanization level. When SDAO are unable to perform their task, Provincial Administration Organization regulates MSW management. Bangkok Metropolitan Administration is the only local authority in Thailand involved in the whole MSWM process ranging from policy setting, planning and operation. Figure 2.26 shows the organizational structure of local authorities within the BMA.

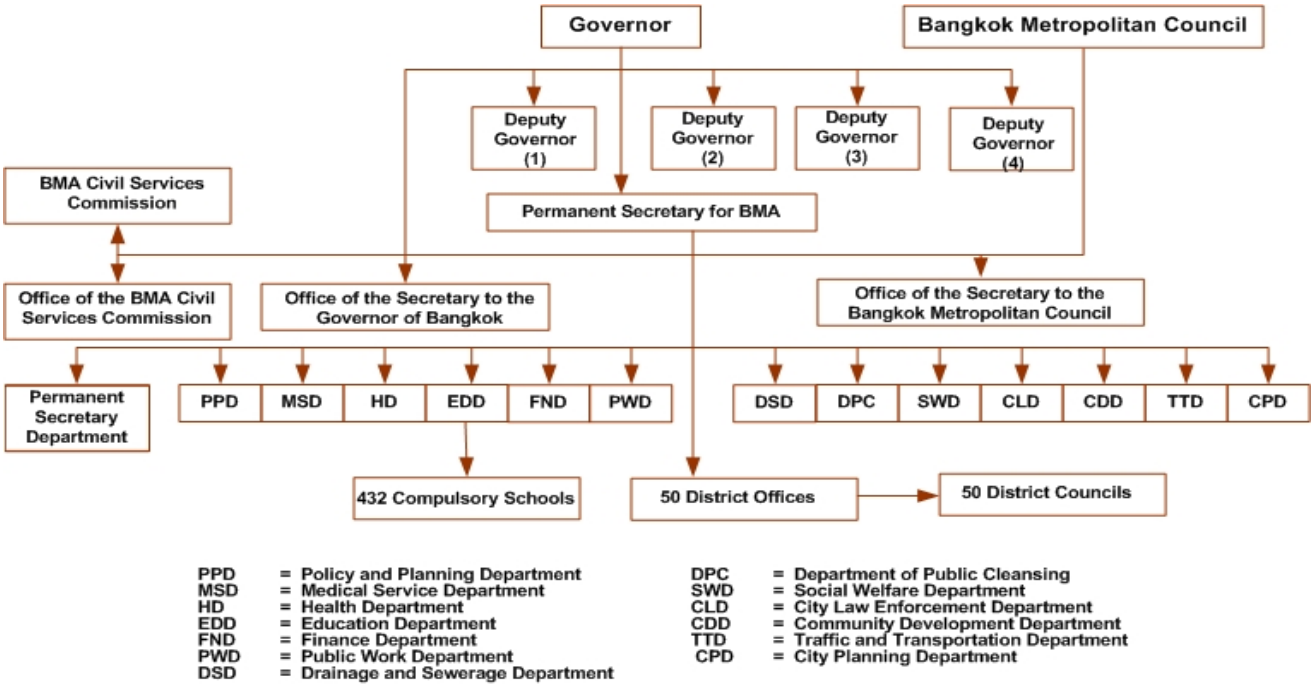


Figure 2.26 Organization structure of Bangkok Metropolitan Administration

2.2.2 *Formal and informal sector*

Formal enterprises are involved in regular waste business as they are fully legalized and registered. They operate and function as buyers from households and as itinerant buyers. The informal private sector comprises unregistered, unregulated activities carried out by individuals, families, groups or small enterprises (Schubeler, 1996). The basic motivation is self-organized revenue generation. Informal waste workers are often driven to work as refuse collectors or scavengers by poverty and absence of more attractive employment possibilities. In some cases, informal waste workers belong to religious, caste or ethnic minorities and social discrimination is a factor which obliges them to work under completely unhygienic conditions as waste collectors or sweepers. Besides social marginalization, waste workers and their families are subjected to economic insecurity, health hazards and lack of access to normal social services. The waste collection, transfer, separation, recycling and disposal activities of informal waste workers constitute economically valuable services. Informal waste workers work normally on a self-employed basis or as informally organized groups; in some cases they may be hired directly by households and by neighborhood groups. In general however, the marginalized and unstable social and economic circumstances of informal waste workers make it quite difficult to integrate their contribution into the MSWM system. As an initial step, informal workers require organizational and technical support to promote their social rehabilitation and alleviate the unacceptable socio-economic conditions in which they live and work. Through the

formation of co-operative societies or micro-enterprises, it is possible to increase job stability and earnings of informal sector workers and enhance the effectiveness of their contribution to waste management.

Waste scavengers on landfills

Even though the act of waste scavenging remains an unavoidable scene in the developing countries, but in reality, this informal private sector plays a major role in the MSWM in resource recovery either from the source or at the disposal sites. The scavengers in most of the developing countries typically sort through the waste before the authorized collection vehicle arrives. The most common materials recovered include various types of paper products, plastics, glass, and ferrous and non-ferrous metal containers. Another method of scavenging takes place during the collection process. In this particular method, the collectors themselves segregate a certain amount of the waste while loading into the vehicle. The last and the most onerous type of scavenging is the one that takes place at the disposal site. The disposal sites, particularly those located in medium and large metropolitan areas attract hundreds of individuals for the recovery of variety for materials. Generally, the scavengers in the developing countries live on or near the dumpsites. This relative closeness of the disposal site enables them the participation of their children and other family members in segregation activities. A substantial amount of MSW is recycled and reused through the primary intervention of waste pickers and second-hand markets despite the associated health hazard to the waste pickers and the degradation and devaluation of the recyclables (Figure 2.27)

Figure 2.27 Waste scavenging in China

The involvement of various informal sectors in the overall MSWM in China is schematized in figure 2.28.

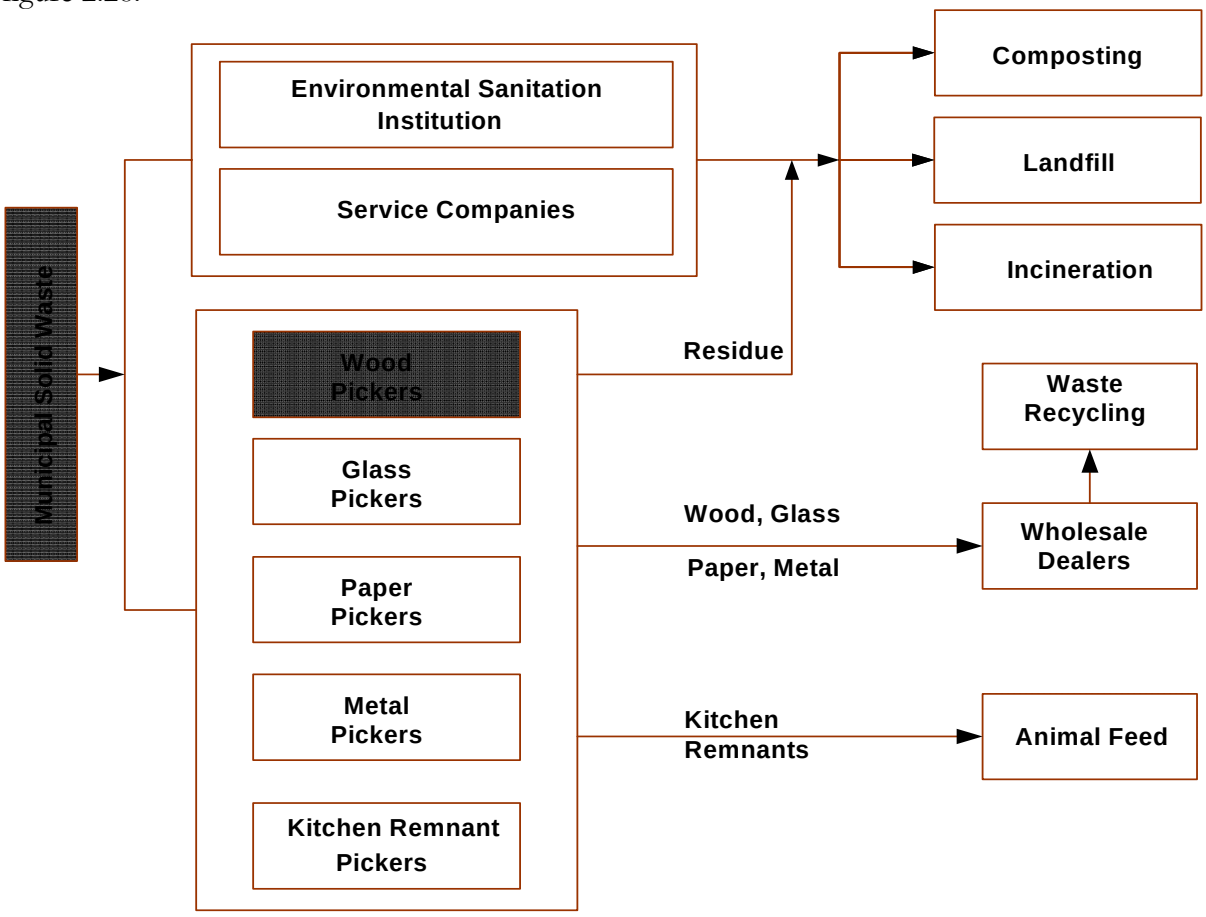


Figure 2.28 Informal sector involvements in China for resource recovery

India

Waste disposal is taken care of by the formal sector while waste recycling is carried out entirely by the informal sector in India. The municipal system handles only a fraction of the waste generated in a city, whilst a vast network of urban waste pickers deals with most of the valuable wastes. Several thousands of urban dwellers make their living on wastes which they sell to small industries that use plastics, tin cans, bottles, bones, leather, glass, metal etc recovered from MSW. In Bangalore, street and dump pickers gather an estimated 500 tons of consumer wastes daily as compared to only 37 tons gathered by municipal workers (UNEP, 2001b). Waste picking tends to cause strewing of the waste around the bins and exposes the waste pickers to direct contact with decaying materials. These people emerge from low socio-economic groups and live in conditions of utter poverty and deprivation. Further more, resource scarcity, abundant labor and poor economic conditions contribute to the prevalence of widespread informal practices in SWM in India. In addition to the rag pickers, another group of traditional waste workers called itinerant collectors go to the residential areas and collect specific wastes segregated by households by paying a nominal sum or by exchanging with goods of interest to the households.

Rag pickers who number almost a hundred thousand in Mumbai are the key players in the collection of the recyclable waste (Box 2.13, figures 2.29 and 2.30). Since these people solely thrive on this activity, the Municipal Corporation of Greater Mumbai is working to protect their interest and provide them better working conditions enabling segregation of recyclable waste, which will

fetch them a better price. The organization like Stree Mukti Sanghtana in Chembur Area has already started working on a pilot basis (Jain, 2000).

Box 2.13 Case study: Landfill mining in India

As a part of scavenging, landfill mining is an interesting aspect connected to resource recovery, upgrading of the excavated area which can be subsequently reused as disposal space. Since the waste in most developing countries has a high organic content and many of the existing sites have been used for years, the reuse of the decomposed material is already practiced at some sites by the informal sector. In Deonar Mumbai, laborers manually extract decomposed materials from a part of the site. The waste is dried, screened and the fine material is mixed with cowdung and other components before it is bagged and sold as fertilizers or compost. Coarse material is used as a cover while the inerts can be used for maintenance of access roads. Additional information however is not available on occupational health aspects, degree of waste decomposition and quality of the mined product.

Source: Zurbrugg, 1999

Figure 2.29 Landfill mining in India

Figure 2.30 Woman scavenging a dumpsite in India

Sri Lanka

Scavenging communities are active especially in the Colombo metropolitan area of Sri Lanka where they thrive on the dumped waste (Figure 2.31). Unlike other study countries, scavenging mechanism is organized neatly by a very poor segment of the population who basically live in the vicinity of these waste dumps. There exist a host of small-scale garbage collectors who travel from house to house collecting recyclable materials such as paper, glass, metals and plastic containers. This material is then sold to middle-sized garbage collectors who in turn sell the accumulated goods to interested parties. This is not a well-organized material recovery but an informal sector scavenging. Most of the small-scale operators are not aware of the recycling facilities available to them.

Figure 2.31 Waste scavenging in Sri Lanka

Figure 2.32 Dumpsite haven for animals, Sri Lanka

Most of the scavengers are between 11 and 45 years of age; some are school children. A scavenger's daily income can vary from Rs.100 – 500 (US$ 1.03 – 5.15). Most of these children support their families from what they earn. The scavenger community in Sri Lanka is said to be about 10,000.

Thailand

In Thailand, the total daily tonnage of recyclable garbage collected at source by the waste pickers is estimated to be 286 tons, about 5% of the garbage collected by the cities. The scavengers and the collection crew sell the sorted waste components to small-scale recycling shops located around the disposal site. The quantity of materials delivered to the recycle shops by the collection crew vary between 1 - 6 tons per day. The amount of materials recovered daily by the scavengers (Figure 2.33) at the dumpsite varies between 50 - 150 kg/person. In total from this informal sector, around 7.5% of the generated solid waste is being recycled.

Box 2.14 Bangkok waste transformation

In Bangkok both formal and informal sectors manufacture paper pulp, cardboard boxes and magazines from the recyclable paper. Paper products account for 55% of the total waste stream and are considered as the largest product group in the MSW. Recyclable glass (1 - 3% of the total waste stream) or cullet is used to manufacture plain glass tumblers or cups. Plastic constitutes about 10 - 15% of the waste stream. The benefit/ cost ratio of production of most of these industries were reported to be higher than 1.5. In order to enhance recycling, legislative measures need to be introduced and enforced. Currently in Thailand, there is however, no law concerning recycling. There is no incentive for the consumers to separate solid waste for recycling as the prices of waste in Bangkok are low and inconsistent.

Source: NRI Thailand, 2003

2.2.3 Non governmental organizations and other private organizations

NGOs operate between the private and governmental realms. They are motivated primarily by humanitarian and developmental concerns. NGOs may help increase the capacity of people or community groups to play an active role in local SWM by contributing to:

1. people's awareness of waste management problems;
2. organizational capacity and formation of CBOs;
3. provide channels of communication between CBOs and government authorities;
4. championing of CBO's voice in municipal planning and implementation processes;
5. transfer of technical know-how of locally active CBOs.

NGOs may also provide important support to informal sector waste workers and enterprises assisting them to organize themselves to improve their working conditions and facilities, increase their earnings and extend their access to essential social services such as health care and schooling for children. Whilst privatization basically involves the transfer of management responsibility and ownership from the public to the private sector and has proved to be a powerful means of improving the efficiency of some waste management services such as collection, haulage and disposal. Operating in various forms of partnership with the public sector, they may provide capital, management and organizational capacity, labor and technical skills (UN, 2000). This semi-formal private sector includes a wide range of enterprises varying from informal micro-enterprises to large business establishments, other CBOs and local enterprises.

China

In China and other countries in the Asia Pacific Region, they have introduced at least partial privatization into their waste management systems. For instance, Hong Kong has entered into long-term DBO (design build and operate) contracts for three major sanitary landfills and four large transfer stations as well as for the collection and treatment of chemical waste. Similarly Macao has let two fourteen-year contracts for the operation and maintenance of its waste-to-energy incinerator and for waste collection, street cleansing and beach cleaning services (UN, 2000).

Greener Beijing Volunteers is an environmental NGO and non-profit organization which originated on the internet. Volunteers gather at Greener Beijing and work together to protect the deteriorating environment. All the volunteers have contributed to the development of Greener Beijing that now has distinguished itself as the first and the most active internet-based environmental voluntary NGO in China with more than 2000 volunteers spread all over the country. Its website was established to give attention to municipal waste problems and pollution from used batteries. Greener Beijing also helped volunteers in Fujian, Liaoning and other places to promote separate collection of solid waste (http://gbj.grchina.net/gbj/enggbj.htm).

The Institute for Environment and Development (IED) was founded in 1994 in Beijing and joined the global efforts for the achievement of the sustainable development. It aims to bring about public awareness on environment and development issues through public education, information/ knowledge dissemination and research. IED works from the grassroots level with people from all walks of life. To achieve its goals, IED works in collaboration with government, academic and education institutions, media, public or private enterprises and international organizations.

Box 2.15 Success story: NGO participation - Exenora International India in SWM

Exnora (an acronym of EXcellent, NOvel and RAdical ideas) was founded in 1989 at Chennai with the primary aim of taking environmental issues to the common man and help him understand the issues better by forming CBOs. This was achieved by initially identifying the urban issue that people of all castes and classes could best relate to - solid waste disposal. This was then used as a tool to bring people together to achieve a common goal. In ten years, Exnora has experimented extensively on SWM methodologies at various levels by working individually and with other private and public organizations, and the government. The following is the summary of its experiences in SWM and the key lessons learnt.

Exnora introduced the concept of people's participation in dealing with the problem of solid waste disposal by forming people into CBOs called Civic Exnoras. It studied the solid waste scenario and identified several key issues involved in it. It then designed a system, which accommodated practical solutions to these. The more conspicuous of the problems of SWM were:

- Accumulated garbage along roadsides and overflowing dustbins, which were not cleared frequently. These wastes (mostly organic) putrefied and posed serious health problems.
- Several hundreds of ragpickers depend on these very wastes for their living by retrieving recyclables and selling them to waste recyclers.
- In this new system of SWM adopted by Exnora, the households shared the cost of employing a rag picker. They collect the waste stored inside the houses in the tricycle cart and transport it to the transfer stations, from where it is cleared by the Municipal Corporation.

Exnora had around 1000 Civic Exnoras, functioning successfully. Each of the about 3000 Civic Exnoras employs a rag picker who works for about five hours in the morning.

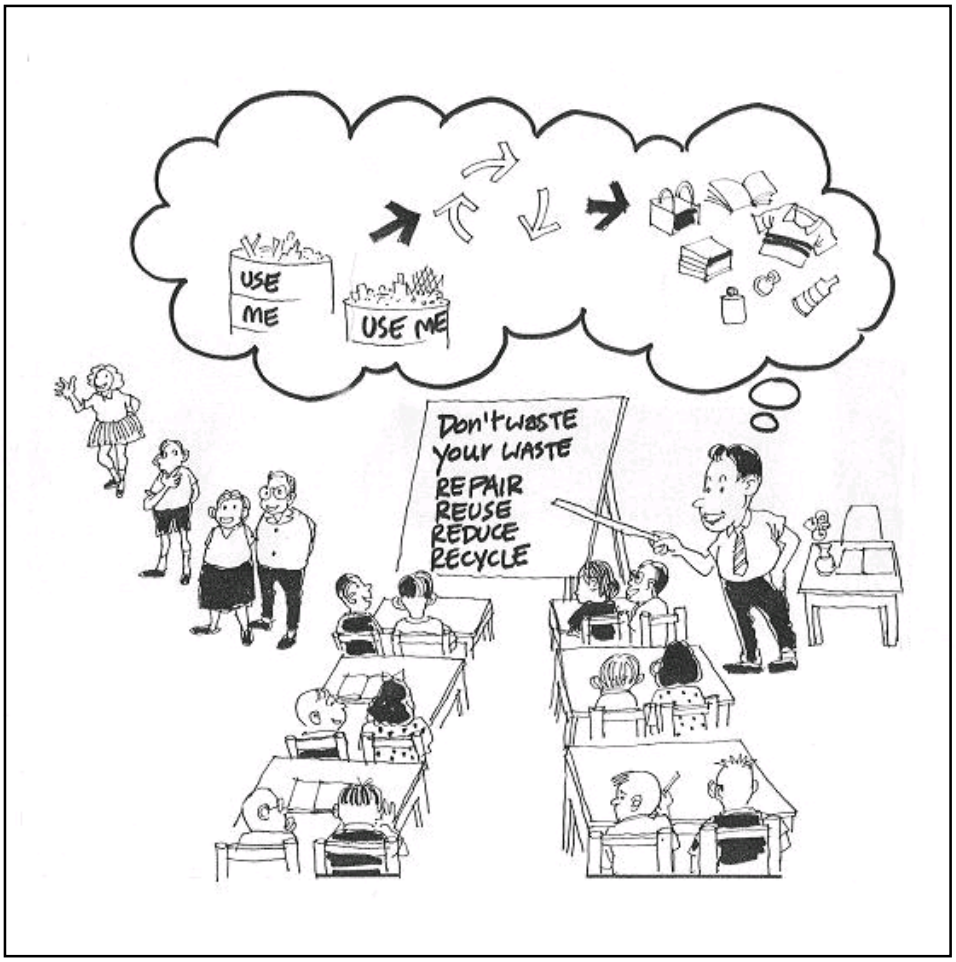
Source: http://www.unesco.org/most/asia3.htm

India

Apart from the governmental organizations and local municipalities, there exist substantial efforts from the other non-official enterprises in promoting MSWM, of which most of them are actively involved in promoting composting as discussed earlier. Box 2.15 highlights active NGO participation in India.

Sri Lanka

In recent years, Sri Lanka has gained a noticeable participation by the CBOs, NGOs and local enterprises in promoting MSWM and increasing public awareness in resource recycling and waste minimization. There are private sector enterprises for waste collection, recycling and waste treatment like Abans Environmental Services that collects waste in Colombo city. Even though there are several private recycling companies but participation in waste treatment is few. Some of the organizations and their involvement in the MSWM promotion in Sri Lanka are listed in the box 2.16.



Box 2.16 Cases of organizations involved in MSW

Arthacharya Foundation developed an effective approach to community based SWM together with poverty alleviation in various locations around the country and steps are currently being taken to expand this within towns in which the process has been established. *(http://www.mandatethefuture.org/cgi-bin/member-display.pl?177)*

Gemi Seva Sevana is a NGO, which in particular promotes vermi-composting mainly for rural/home gardens.

Intermediate Technology Development Group (ITDG) promotes the use of intermediate technology in developing countries. They have implemented several projects and trainings in the conversion of MSW into biogas. *(http://www.itdg.org/)*

National Forum of People's Organization (NFPO) mainly focuses on enhancing NGO's contribution to Sri Lanka's development by providing technical support and training, disseminating information, and initiating innovative projects in partnership with others. Some of their activities are household source separation of waste, small scale composting and biogas generation, paper recycling, networking and information sharing.

Seth Sevana, a local enterprise has successfully developed small-medium scale recycling of waste plastics into pellets/granules using both locally manufactured and imported machinery primarily from India. They process HDPE, LDPE and PP, although they are currently experimenting with processing other types of plastic wastes into plastic pillars.

Sevanatha, one of the NGOs, based in Colombo has been involved in a number of urban development projects. It promotes composting barrels 4000, of which have been provided by the local authority and have been sold by Sevanatha. They have also set up a small windrow composting plant but this is no longer operational as it was found to be economically unviable. *(www.eco-web.com/register/04876.html - 4k)*

Source: NRI Sri Lanka, 2003

Thailand

In Thailand, apart from CBO and NGO participation, waste business also plays an important role in SWM. For instance, M/s Wongpanit Group Company buys reclaimed materials from the waste pickers and scavengers (see box 2.17). The company has set up its first waste-recycling factory at Phitsanulok province in the north of Thailand. Wongpanit Group has now expanded to 8 waste recycling branches on commercial basis. Net prices for the reclaimed materials are publicly announced and posted in its website. In addition, the company is also planning to join other recycling companies such as M/s Loxley Co. in Bangkok. The main objective behind this drive was to build up more waste income-generating activities among 400 schools in Bangkok and Nontaburi areas so that the students can launch promotional campaigns and awareness activities to separate garbage.

Figure 2.33 Scavengers at Phittsanulok landfill, Thailand

Box 2.17 Success story: Profit from waste

M/s Wongpanit Company Ltd established in 1974 in Phittsanulok province is one of the biggest waste (recyclables) traders in Thailand with 8 branches throughout the country and 18 purchasing units in the city. The company's trade and service center was set up three years ago as a mobile service unit for educational institutions, government agencies as well as other communities. The enterprise buys more than 100 kinds of waste from the industries, institutions, commercial centers and the general public. This waste is recycled or sold locally and exported abroad. For example, oil and water bottles are exported to China for making fiber-cloth. Used polyvinylchloride (PVC) water pipes are exported to Burma. In 1998 the company bought waste worth more than 100 million Baht (US $ 2.5 million) and a year later this had doubled. Besides, the company holds training courses for those who are interested in learning about waste management including waste separation and recycling. The company also assists in various waste reduction campaigns throughout the country. It provides professional services for systematic SWM, distributes printed materials, promotes waste separation and reclamation, and intensely campaigns for recycling awareness.

(Further information on the Company can be obtained from http://www.wongpanit.com/ehome.php)

2.2.4 Public participation

Effective community involvement in waste management mainly depends upon the functional link between community groups and private sector enterprises. Public participation is an indispensable tool for uplifting a community. This participation should be a spontaneous involvement of people in all phases of activities through a process of mutual deliberation and negotiation. To a large extent, especially in the developing countries participation is determined by people's perception of social, economic and environmental costs and benefits of the program. Public participation towards a sustainable MSWM can be noticed in different forms such as:

- Voluntary involvement in various campaigns and solid waste management activities;
- Abiding by the laws and regulations laid by the government and local bodies, prompt payment of collection fees or other service charges;
- Practicing source separation of waste and proper application of provided facilities; and
- Raising voice against government/decision makers on their false verdicts, etc.

China

In China, the environmental conscience has improved to some extent and most of the younger generations are now aware of the negative impacts resulting from improper MSWM. According to the result of a poll in 1999, conducted by Environmental Sanitation Administrative Bureau in Shanghai, about 98% of the interviewees are concerned about environmental issues and majority of them have participated in environmental activities. The result of the poll indicated that the environmental consciousness of the younger generations, especially the students were higher than that of the elders. Over 3000 schools have been named Green Schools. About 30% of respondent customers are willing to choose more environmental friendly products irrespective of the costs. Interestingly in the year 1999, China rejected 133 large-scale projects on account of environmental consideration.

India

Despite the concerted efforts to improve MSWM operations, authorities feel that the lack of civic awareness is proving to be a major obstacle for maintaining tidiness. The problem is most acute in slums and low and middle-income areas where the residents do not make efforts to deposit their waste in the bins. Most people do not use the facilities provided by local urban bodies and litter the streets. It is a common experience that at places where local bodies have made a provision of dust bins, people tend to throw the waste outside the bin instead of using the provided facility. Even where storage arrangements are conveniently located, wastes tend to be strewn around the storage area, partly due to indiscipline and partly as a result of waste scavenging by rag pickers and stray animals (Figure 2.34). Although the municipalities have scheduled collection times with the aim that wastes be deposited by households prior to collection, the public are either not aware of or not inclined to follow instructions and deposit wastes at their convenience leading to accumulation of garbage in several areas. As a result of these poor conditions for temporary storage of wastes, in some areas NGOs have become involved in making arrangements for waste collection from households leading to improvements in local street cleanliness.

Figure 2.34 Scavenging of garbage by stray animals, India

Sri Lanka

Public participation in Sri Lanka for the MSWM is mainly promoted by the local enterprises and NGOs. They are either actively involved in encouraging local people for recycling practices or in providing technical support, disseminating information and trainings. The potential advantages of community participation and its scope vary for different kinds of infrastructure. Potentially, community groups could offer a valuable resource for the maintenance of infrastructure undertaking tasks such as waste collection, road and drain maintenance, provided appropriate arrangements for organization, supervision and remuneration can be made.

Thailand

The eagerness amongst the local people towards participation in MSWM in Thailand is significantly high, the success story of projects such as Solid Waste Exchange Project at Klong Toey community and Solid Waste Bank Project in Bangkapi district in Bangkok are testaments to the inputs by the local people (Box 2.18).

A study done by the Office of Permanent Secretary for Interior showed that approximately 90% of surveyed households considered waste separation as a part of the community's responsibility. Moreover, 95% of these people were willing to take part in other new projects relating to source separation. About 60% of the household accepted the likeliness of hike in the service fee in future.

Box 2.18 Success stories: Public participation in Bangkok

Solid Waste Exchange Project: This project 'Garbage for Eggs' was initiated in the year 1997 for the Klong Toey slum area in Bangkok. It mainly aimed at the recycling of MSW and diverting it from the waste mainstream. The recyclable wastes such as glass/plastic bottles, plastic bags, and paper/boxes were exchanged with eggs provided by the Environmental Conservation Group. The income collected from the sale of the recyclable waste was used as a budget for buying the eggs for the next exchange-batch. Over the passage of time, this project gained momentum and expanded to other 23 communities in Bangkok, Rayong province in the East and Yala province in the South. This project was recognized by the Greenpeace and gained further international recognitions.

Solid Waste Bank Project: This project was initiated by Wad Klang community in Bangkok and aimed at the development of an environmental attitude, especially in the disposal of MSW. Their targeted audiences are the younger generations of the community. This project concurrently aims to reduce the waste quantity generated by the households, the only waste accepted by the waste bank are those which are generated within the household and not from the communal bins or litters collected from the streets. Recyclable solid wastes can be deposited in the bank and can be withdrawn in the form of money or wastes. This project was very successful and this reduced the community waste to about 90 kg/d.

Garbage banks have been set up in schools by students with the help of teachers where the students can bring recyclables and exchange the same for cash or reward points for group activities or to procure sports equipment, stationery or other goods.

Source: World Bank, (2003b) - Thailand Environment Monitor, 2003

2.2.5 *Women's participation*

Women's cooperation is essential for the long-term success of any project concerning urban services. In many cultures, women are responsible for house-keeping and its immediate environment clean. Furthermore, women are the foremost users of urban services such as waste collection, water supply and sanitation. This role of women makes them ideal beneficiaries of SWM projects. They usually give to the improvement of services a higher priority than men. But their voice is seldom heard and their participation in community decision-making is minimal.

The women have their hand in the MSWM from household management to administrative works. They have shown active participation in various MSWM concerns including educational activities and workshops besides playing an important role in their own community in all the study countries.

China

In China the Women Home Environment actively campaigns to call the urban and rural women to use baskets for home shopping instead of plastic bags. This campaign also promotes source separation of waste especially the household hazardous and chemical wastes before disposing them.

In Shanxi province mothers acting as volunteer environmental protectors take their children out to clean the litters and encourage them to plant trees and grasses in their vicinity on the last weekend of each month. Further, honoring of Women's Federation in China as a member of the 500 excellent environmental organizations by the United Nations itself echoes the diverse role played by women in maintaining sustainable environment.

India

In India, women involvement in MSWM can be noticed in several activities; their maximum contribution lies in monitoring the household waste, street sweepings, scavenging, their involvement in NGO activities and other CBO workshops. For instance, the Indo-Norwegian Programme under the state government of Himachal Pradesh initiated a seven-year project in 1997 till 2003 about solid waste management, environmental planning and women's self-help groups *(http://ceeraindia.org)*.

Box 2.19 Women CBO in Sri Lanka

Initiated by Arthacharya Foundation in Galle and Hikkaduwa, the women CBO programme was based on the introduction of source separation scheme involving sorting of recyclable materials into four categories: plastics/polythene, paper/ cardboard, glass and organic waste. Under each women CBO, approximately 5 - 7 households are divided into small groups. The CBO initially provides each group with a metal barrel (200-liter capacity) free of charge for composting the sorted organic waste. The survey data showed that about 3930 kg/month of compost was produced during 2001 of which about 50% was used in the home gardens and the rest was sold. The average selling price of the compost was between Rs 10 – 25/kg (US $ 0.1 - 0.25) depending on the location and the quality of compost.

Source: http://www.mandatethefuture.org/cgi-bin/member-display.pl?177

Sri Lanka

In Sri Lanka, Arthacharya Foundation has initiated two women CBO in Galle and Hikkaduwa to promote the SWM specially focusing on recycling and home composting (Box 2.19). Women within their homes take the lead role in sorting and collecting the recyclable materials. The collected materials are weighed and sold to the recycling plants and processing industries. It was estimated that in the year 2001, recovery of about 33 tons of plastics, 19 tons of glasses and 15 tons of paper was achieved by active participation of women in the material recovery drive.

Thailand

In Thailand women have their role in MSWM both formally and informally. The involvement is seen in different stages of MSWM starting from the waste sources to scavenging. In each household, women are normally responsible for taking care of the cleanliness. They are also involved mostly in public cleaning services ranging from low level employee e.g. street sweepers, waste collectors to administrative positions. With regard to their involvement in low level work, according to the random data collected in 2002, about 93 percent of the street sweepers are women in Bangsue district of Bangkok and about 60% of the scavengers are women at Phittsanulok landfill and Sainoi (Nonthaburi) dumpsites. There is currently no gender restriction on any type of work in MSWM.

2.3 Economic and Financial Aspects

Adequate budgeting, cost accounting, financial monitoring and evaluations are essential for the effective management of solid waste systems. In the developing countries in general and the study countries in particular, most officials responsible for MSWM do not have accurate information concerning the real costs of operations, which are often as a result of unfamiliarity and lack of capacity to use available financial tools and methods (Schubeler, 1996). The budget allocated for different facilities are not clearly defined and in most cases it mainly covers collection, transportation and daily wages, leaving a smaller fraction for final disposal and treatment.

China

China uses about 1 - 1.5% of the local revenues for the management of the environmental sanitation but most of these are spent for salary and daily operation costs (MSW collection, transport and treatment) which accounts for about 85% (Figure 2.35). Only about 15% of the budget is used for the construction and renovation of the environmental sanitation facilities. There is a relatively large disparity of investment in different cities for the environmental sanitation industry. The per capita expenditure for environmental sanitation shows that bigger cities have an obviously higher value than the smaller and medium cities. As an example, the expenditure in cities directly under the jurisdiction of the central government is up to 7.62 Yuan (US $ 0.92) per capita per month while it is just 1.75 Yuan (US $ 0.2) in the mid and western Chinese cities under local/provincial governments. Figure 2.36 shows the total capital investment made in the construction of environment and sanitation facilities for the last 15 years.

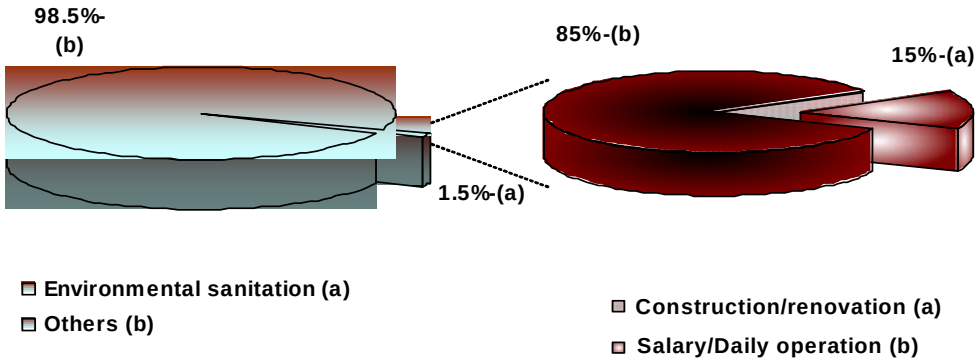


Figure 2.35 Total budget allocations for MSWM in China

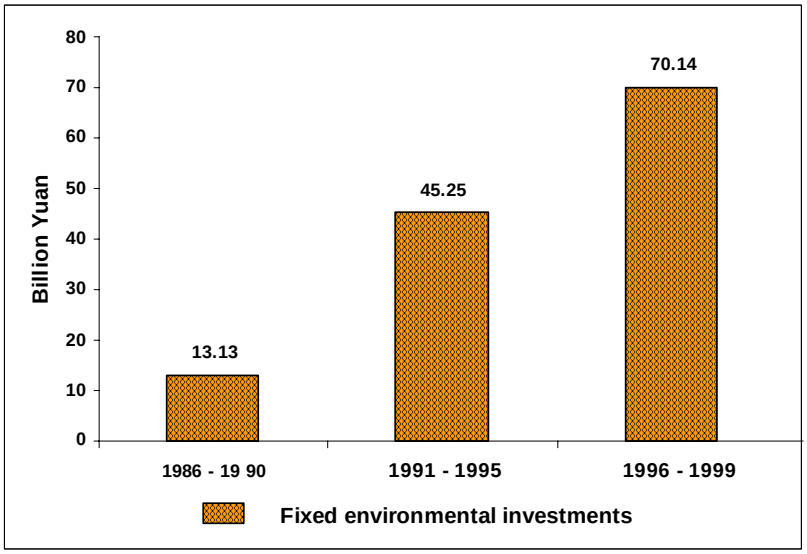


Figure 2.36 Capital investments for environmental sanitation in China

The construction of MSW disposal facilities has been delayed in most of the cities due to the shortage of sanitation funds caused by insufficient investment from the government. Although the State Plan Committee, Ministry of Finance, Ministry of Construction and the State Environmental Protection Administration have jointly formulated a policy for the collection of waste disposal fees in 2002 but it is difficult to implement it throughout the country. This policy would help solve the problem of shortage in investment.

India

In India, the expense towards SWM is usually met with the property tax collected from the residents. Compared to other municipal services, the financial allocation and attention given to MSWM is considerably less resulting in inadequate services. Figure 2.37 shows the budget allocation for MSWM. It has been estimated that the urban local bodies spend approximately Rs.500 to Rs.1500 (US $ 11.1 – 33.3) per ton of solid waste for collection, transportation, treatment and disposal. From this amount, about 60 - 70% is spent on collection, 20 - 30% on transportation and less than 5% on final disposal (Disha *et al*, 2001). A few local bodies in India levy administrative charges if any one is found dumping garbage indiscriminately in places other than those specified

one such being the Surat municipality in Gujarat. Ahmedabad Municipal Corporation has passed a resolution *(Resolution No.899 dated 03/10/1997)* for levying administrative charges ranging from Rs.50 to Rs 5000 (US $ 1.11 – 111) depending on whether the littering is by households, institutions or industry.

The major issues related to the financial aspects of MSWM in India are:

1. inadequate resources;
2. absence of national level policy and guidelines for allocation of resources for SWM;
3. poor community participation that increases public spending; and
4. lack of private sector participation.

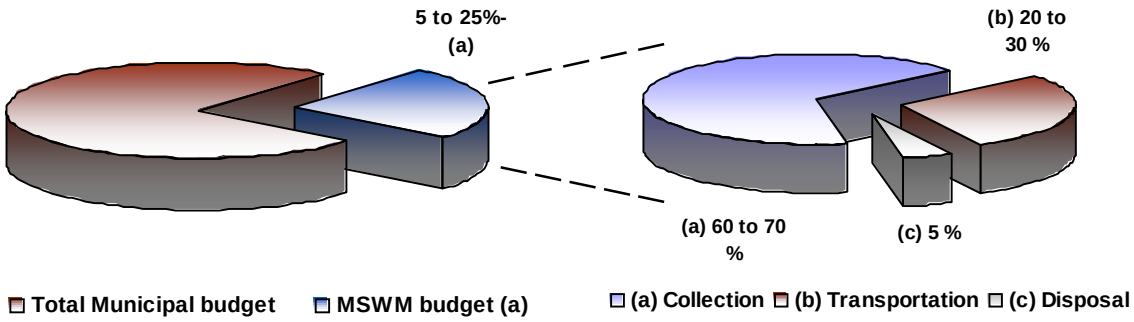


Figure 2.37 Total budget allocations for MSWM in India

Sri Lanka

Financial provisions for SWM in Sri Lanka generally fall under the health section of the annual budget of LA, except for the CMC, which has its separate budget. The main source of revenue for LAs is through property rates and taxes, supplemented by Central Government grants (through Western Provincial Council) for reimbursing expenditures on salaries, wages and allowances incurred by LAs. There is no specification in the budget allotment for the various tasks involved in SWM, but it has been estimated that the LAs spend around 3 - 15% of their total budget (Figure 2.38). All LAs spend more than 80% of the allotted budget in collection and transportation of refuse of which a significant amount goes to salaries, allowances, wages, maintenance and fuel costs. Most LAs, with the exception of MCs and UCs spend hardly any for disposal since the wastes are hastily dumped without spreading and compaction. The disposal cost only covers the mechanical cost for waste spreading. For instance, CMC is currently paying around Rs. 230 (US $ 2.37) per ton for spreading the waste at the Bloemendal dumpsite.

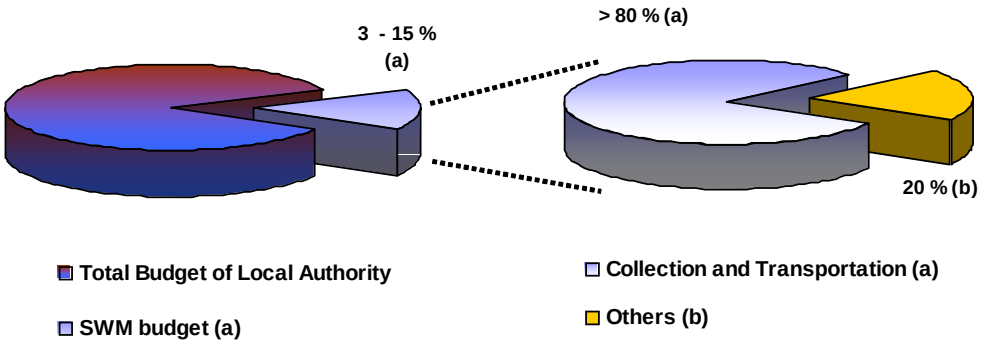


Figure 2.38 Total budget allocations for MSWM in Sri Lanka

Box 2.20 MSW tipping charge in Sri Lanka

The tipping fee paid by the CMC is Rs 550/ton (US$ 5.67) and in comparison two of the LAs out of the three pay Rs 150/ton (US$ 1.55) for the services provided by the University of Peradeniya pilot compost plant. Gagawata Korela PS, Kalutara UC and Dabulla PS are not willing to pay for disposing the wastes. Gagawata Korela PS serving a population of over 125,000 habitants prefers to dump the wastes along the embankment of Mahaweli River rather than pay Rs 150/ton.

Source: NRI Sri Lanka, 2003

Thailand

The budget for MSW management in Thailand comes from the national expenditure and servicing fees collected. The former part of the budget is basically spent on the construction of SWM facilities and the latter portion provides for the running cost.

The concern and the initiation of the government towards the environmental issues are clearly reflected from the increment in the budget allocation for the environment development sector in its fiscal year 2001 (Figure 2.39). The budget allocation for the development of the environment sector has increased by 3.5% from what was allotted in 2000. About 10% of the total budget goes to the MSW and hazardous waste management. Some additional budget comes through research and development. The levied fees are always lesser than the actual operating cost. For instance in Bangkok, the collection fee per household is THB 40 per month (US $ 1.0) compared to THB 150 (US $ 3.75) of the actual cost incurred by BMA. Similarly, the tipping fee to the incineration plant in Phuket is about THB 200/ ton (US $ 5.0) compared to the operating cost of approximately THB 600 - 2000/ton (US $ 15 - 50). NEB has the authority to designate an area as Pollution Control Area under which the area would have a priority to receive a grant from the Environmental Fund (Box 2.21)

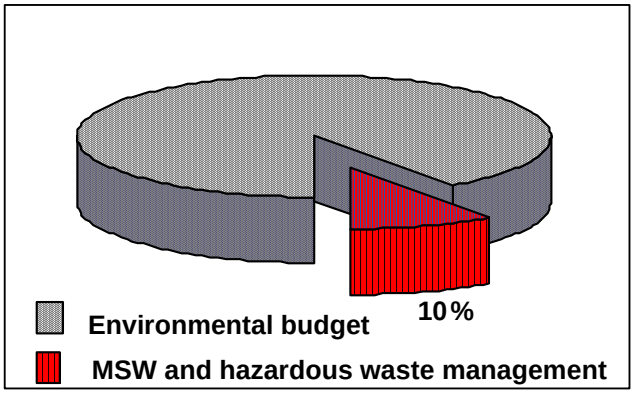


Figure 2.39 Total budget allocations for MSWM in Thailand

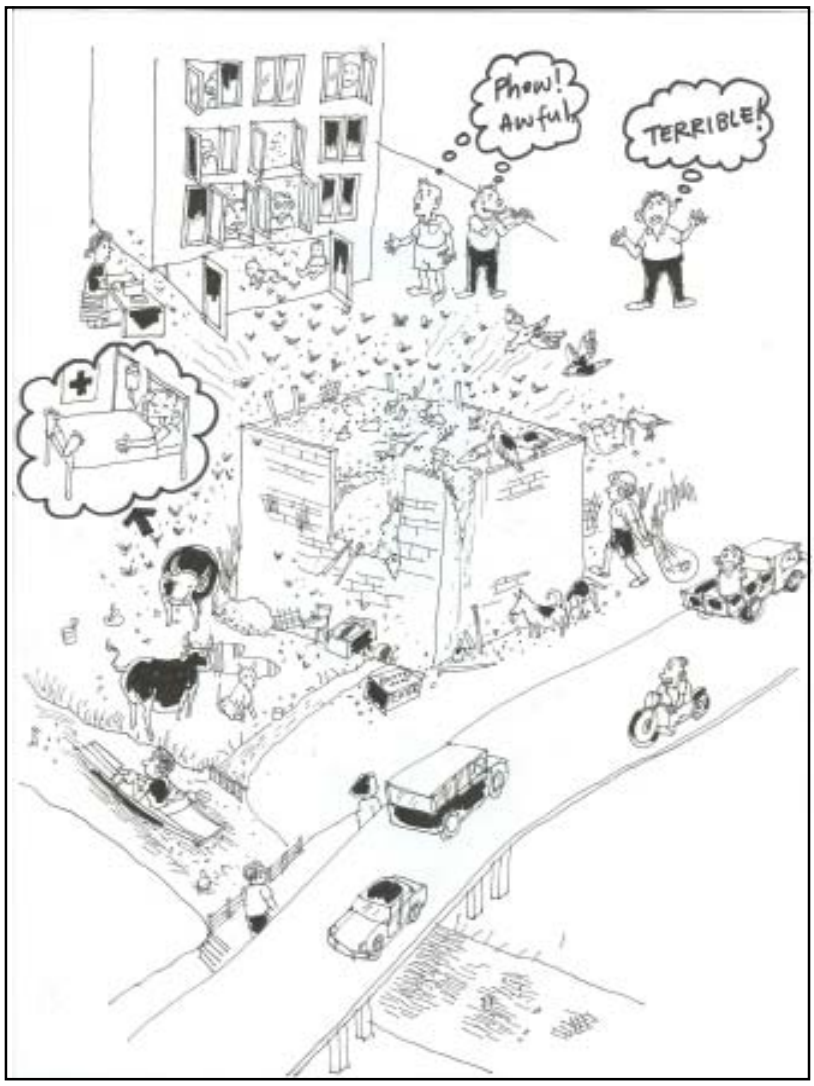
Box 2.21 Environmental Fund in Thailand

The Environmental Fund was established by the Ministry of Finance with an initial capital endowment of 500 million Baht (US $ 12.5 million) and has been boosted to 5 billion Baht (US $ 125 million). One of the main targets of the Fund is to construct and operate wastewater treatment plants or waste disposal facilities in designated areas - the Pollution Control Areas. The Fund provides grants to governmental agencies and low-interest loans to the private sectors that are engaged in the activities related to the improvement of the environment. Most of the Fund is disbursed in the form of credit facilities through financial institutions. The Fund is managed by a special inter-ministerial committee named Environmental Fund Committee (EFC), chaired by the Permanent Secretary of the MONRE with high-level representatives from various agencies. The EFC is responsible for allocating the Fund to appropriate environmental improvement activities. Final decision for the Fund allocation would be made with the permission of the NEB.

Source: NRI Thailand, 2003

2.4 Health Aspects

The accumulations of solid wastes in any locality become health and safety issues. They also arise due to improper handling of MSW during transportation, disposal and scavenging. Insects, rodents and other vectors are attracted to the waste and can spread communicable diseases like cholera and dengue. Furthermore use of water polluted by solid waste for bathing, cooking and irrigation or for drinking could expose individuals to diseases, pathogens and other contaminants. Various diseases are spread via the fecal-oral route facilitated by unsafe water supplies and inadequate sanitary conditions. The lack of understanding on the causes of diseases related to garbage and the existing bureaucratic approach to MSWM often fails to judge the significance of health impacts and the potential threat to the workers in the waste stream. Due to these reasons health aspects are often neglected by the government and the concerned authorities.



China

Over 200 cities in the whole country are faced with the problems of MSW accumulation and lack of proper management. It has become a serious threat to the health of the people as the municipal waste is contaminated with various kinds of pathogens, parasites, hazardous waste fractions and other harmful substances owing to the lack of proper segregation of the components. The uncollected and disposed MSW has been causing soil, air and water pollution as well as environmental sanitation risks that threaten public health to a large extent in China.

India

Human excreta is one of the important components of urban solid waste, possibly caused by the lack of adequate sanitation facilities for individuals and communities. The concerned authorities are not responsive of the lacunae in sanitation while the public is ignorant of the risks associated with inadequate sanitation leading to the practice of open defecation. Moreover the practice of unscientific disposal system leaves the waste unattended attracting rodents, scavengers (humans and animals) and insects creating unhygienic conditions and aesthetic nuisance (Figure 2.40). Surat city in Gujarat experienced the outbreak of plague in 1994 due to the negligence of the MSWM and had a high human casualty. Plastics collected by rag pickers and scavengers are recycled mostly in factories, which do not have the adequate technologies to mitigate the toxic fumes and other by-products, thus exposing the workers (UNEP, 2001b).

Figure 2.40 Women scavenging a dump, a health risk (India)

Apart from that, indiscriminate landfilling has led to the deterioration of water quality in the neighborhood of the sites due to leachate infiltration causing adverse health impacts to the people in the vicinity and methane accumulation and emission poses a constant threat of explosions and associated risks to the environment. An estimated 7 million tons of methane was released into the atmosphere in 1997 (TERI Times, 2001).

Sri Lanka

In the Sri Lankan scenario, the decision-makers, town planners and environmentalists have now begun to foresee the potential hazards caused by the current practice of disposing clinical waste in open dumps and the potential occupational health risks for the scavenging community and their family. Yet the authorities fail to remedy the issue appearing as silent observers. Waste workers are not cautioned to take specific precautions (wearing protective gear) and hence are exposed to health hazards. Most often protective measures are not available from the management primarily due to the lack of resources and awareness and also negligence on the part of the management and the workers as well. The scavengers at disposal sites are exposed to high health risks during sorting of the recyclable materials from the waste pool comprising clinical wastes, fecal matter and hazardous wastes.

Thailand

Open burning of MSW was widely practiced at the disposal sites in Thailand to reduce the volume of wastes so that the service period of dumping sites could be extended. These uncontrolled open burnings resulted in malodor, air pollution and immediate hazards to the nearby community, especially the scavengers. Recently open burning of MSW has been prohibited by the Public Health Act B.E.2535. As per the national statistics of the country in 1998 (Table 2.9), some households were officially reported as victims of improper MSWM.

Table 2.9 Solid waste pollution impacts reported as percentage of households in 1998	
Locations	**Households impacted by solid waste pollution, %**
Bangkok Metropolis	5.1
Central Region (excluding Bangkok)	3.4
Northern Region	1.8
Northeastern Region	2.9
Southern Region	5.1

Note: Percentage impacted by pollution was calculated from households in the same region and area.
Source: Ministry of Public Health (NRI Thailand, 2003)

2.5 Legal aspects

The programs for effective management of waste and environmental protection often require a clear definition of roles, legal responsibilities, rights and jurisdictions of the concerned governmental bodies and organizations. The absence of clear jurisdiction may lead to controversies and ineffectiveness of MSWM systems. The potential for establishing efficient institutional arrangements depends largely on the existing systems of urban planning and administration. As the basis for performance-oriented management, a comprehensive strategic plan for the sector is required. This plan should provide relevant quantitative and qualitative information on waste generation and specify targets for waste reduction, reuse, recycling and coverage of related services. It should describe the organization of waste collection, transfer and disposal in the medium and long-term perspectives. Table 2.10 shows the coverage of some important aspects in MSWM in the study countries.

Table 2.10 Current status of overall waste management			
Country	**Legislation**	**Institutions**	**Manpower capabilities**
China	B	B	B
India	B	B	B
Sri Lanka	B	B	B
Thailand	A	B	B

Legends: A - Extensive coverage; B - Moderate coverage; C - Minimal coverage
Source: UN, 2000

China

The Chinese State Council has issued the sanitation regulation in 1992 called the 101 Order Management Rule of Environmental Sanitation of the Urban Appearance as its first measure for a strong legal basis for urban appearance management. The Plan for National Economic and Social Development, a state policy, gradually promotes or implements a series of policies to protect the environment laying a firm foundation for the sustainable development. In the following years, the Ministry of Construction has made a series of management methods for urban waste, lavatories, special vehicles, roads, public places and garbage in urban infrastructure.

The National People's Congress manages the urban appearance and environmental sanitation of the cities according to the Law of the Solid Waste Prevention and Cure enacted in 1996. Recent investigations show that about 85% of the cities have made regulations on environmental sanitation reflecting the steady legalization of urban environmental sanitation. Table 2.11 lists the main laws and regulations pertaining to proper MSWM.

Table 2.11 Laws, regulations and guidelines for MSWM enforced in China

Laws, regulations and guidelines	Enactment date	Effective date
Law of People's Republic of China (PRC) on the Prevention and Control of Environmental Pollution by Solid Waste	30 Oct 1995	01 Apr 1996
Law of the PRC on the Promotion of Cleaner Production	29 Jun 2002	01 Jan 2003
Administrative regulation of city public toilets	31 Dec 1990	01. Jan 2001
Administrative regulation of exclusive vehicle of city environmental sanitation	07 Jul 1991	
Administrative regulation of city vehicle cleaning	07 Aug 1993	01 Sep 1995
Administrative regulation of MSW	10 Aug 1993	01 Sep 2003
Administrative regulation on cleaning of roads and public places	12 Apr 1994	12 Apr 1994
Administrative regulation of city construction and decoration wastes	26 Feb 1996	26 Feb 1996
Administrative regulation on pollution prevention of solid waste from ship and riversides of Yangtze River waterway	24 Dec 1997	01 Mar 1998
Guidelines of city environmental sanitation facilities establishment	25 Mar 1989	
Guidelines of city environmental sanitation quality	03 Feb 1997	

Source: NRI China, 2003

Based on the laws, regulations and guidelines, Chinese cities in the eastern part have adopted stricter environmental approach by enacting by-laws as compared to their western counterparts as some of the cities like Xian have no local law on the environmental sanitation.

India

India has made provisions for the protection and improvements of the environment by the 42nd Amendment of its Constitution in 1976. Article 51-(g) of the Constitution makes environmental protection and improvement as the duty of every Indian citizen. The Directive Principles of State Policy in the constitution contains a specific provision enunciating the State's commitment for protecting the environment. These constitutional provisions are implemented with environmental protection laws by the Ministry of Environment and Forests constituted in 1985 which is the apex agency at the central level for planning, promoting and coordinating the environmental programs apart from policy formulation. At the state level, the State Departments of Environment and Pollution Control Boards are the designated agencies to perform these functions. SWM services are provided by the civic bodies as per the provisions of the respective Corporation/Municipal/Panchayat Acts, many of which require amendments to adapt to the changes in the waste management scenario. The state creates municipal bodies based on its legislations of two kinds: (a) The Municipal Corporation Acts for larger cities (population of 0.3 million or more) and (b) Municipal Council Acts for smaller cities (population of less than 0.3 million). The rural areas have their own local bodies called the village Panchayats (Councils). The municipal laws based on the respective acts make SWM an obligatory function of the municipal bodies both for large and small civic units.

A national policy and legislation for MSWM, entitled the Municipal Solid Waste (Management and Handling) Rules, was notified in 2000 with an implementation schedule as given in Table 2.12 while box 2.22 gives the spectrum of functions of civic bodies.

Table 2.12 Implementation schedule as per MSW rules in India

Compliance Criteria	Implementation schedule
Setting up of processing and disposal facilities	By 31 December 2003 or earlier
Monitoring the performance of waste processing and disposal facilities	Once in six months
Improvement of the existing landfill sites as provisions of these rules	By 31 December 2001 or earlier
Identification of landfill sites for future use and making site(s) ready for operation	By 31 December 2002 or earlier

Source: Ministry of Environment and Forests, New Delhi, Notification S.O. 908(E) – dated 25 September, 2000

Box 2.22 Major functions of the civic bodies in India

The civic bodies are required to enforce Municipal Solid Waste (Management and Handling) Rules and undertake to:

1. Prohibit street littering;
2. Organize house to house waste collection;
3. Conduct awareness programs and disseminate information to the public;
4. Provide adequate community storage facilities;
5. Use color coded bins and promote waste segregation;
6. Transport wastes in covered vehicles;
7. Process the wastes by an appropriate combination of composting, anaerobic digestion, etc.; and
8. Upgrade the existing dumpsites and dispose only inert wastes in sanitary landfills.

Source: NRI India, 2003

Besides establishing these laws, the government should also oversee to their implementation and practical compliance, which is rather ineffectual. Most of the civic bodies are yet to take initiatives to comply with the rules citing financial constraints though the deadlines for the compliance already passed on 31 Dcember 2003.

Sri Lanka

In the Sri Lanka setting, policies, strategies and legal provisions for solid and hazardous waste management that provides the necessary basis for effective and sustainable improvements in MSWM are:

1. National Environmental Act of 1980 enabling the prevailing legislation for the regulation and control of SWM activities.
2. National Strategy for Solid Waste Management providing guidance for tackling the problem on various fronts.

3. National Agenda for Sustainable Development addressing broader policy and governance issues related to environmental improvement and economic development.

A number of regulations and directives set out standards and appropriate provisions for different aspects of SWM. Yet the main challenge remains in implementing the strategies and policies due to lack of developmental resources.

(a) Local Government Law

Local government acts and ordinances for Municipal/Urban Councils and Pradeshiya Sabhas provide the legal framework for SWM. LAs are responsible for the collection and disposal of solid wastes in the country and the provisions are given in box 2.23.

Box 2.23 Provisions of the Local Government Law for SWM in Sri Lanka

1. All street and house refuse, night-soil, or other similar matter collected by LAs under the provisions of this part shall be the property of the Council with full power to sell or dispose of all such matter.

2. Every MC, UC and PS shall have to provide places for the proper disposal of all street refuse, house refuse, night-soil, and similar matter according to 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 removed in accordance with the provisions of the law is disposed of in such a way as to cause a nuisance.

Source: NRI Sri Lanka, 2003

(b) National Environment Act, 1980.

NEA enacted in 1980 and subsequently amended in 1988 provides for the establishment of the Central Environmental Authority (CEA) with defined powers, functions and duties and relate to the provisions for:

1. Protection, management and enhancement of the environment;

2. Regulation, maintenance and control of the quality of the environment; and

3. Prevention, abatement and control of pollution and related matters.

NEA initiated the establishment of Environmental Council (EC) comprising 20 representatives from various government ministries, the Director General of the CEA, seven members representing the voluntary environmental agencies and two persons with adequate expertise or experience in environmental protection and management. The functions of the EC are to advise the LAs on matters relating to its MSWM responsibility, powers, duties, functions and other issues referred to it by the CEA.

(c) Environment Impact Assessment (EIA)

EIA regulations under the NEA require a landfill site to undergo environmental impact assessment if its capacity exceeds 100 ton/day.

(d) National Strategy for Solid Waste Management (NSSWM)

NSSWM was launched by the Government in May 2000 in recognition of the need to manage solid waste from generation source to final disposal. It also defines the identification of the component strategies for waste avoidance, reduction, re-use, recycling and appropriate final disposal.

Thailand

The Environmental Act was revised and enacted in September 1992. Unlike the former Act of 1979, the new Act provides for the first time, a comprehensive set of instruments and facilities to effectively manage the environmental issues. Under it, the National Environment Board entrusts the departments indicated in box 2.24 with their respective duties and responsibilities.

Box 2.24 Duties and responsibilities of environmental bodies in Thailand

1. Office of Environmental Policy and Planning (OEPP): The OEPP is responsible for planning and supporting facilities including the Environmental Fund (EF). The OEPP has regional offices for EF to support feasibility studies, engineering design, construction and operation of disposal sites.

2. Pollution Control Department (PCD): PCD has been mandated for regulatory powers to control pollution by implementing national regulations and providing guidelines for MSWM.

3. Department of Environmental Quality Promotion (DEQP): The DEQP is responsible for promotional activities and environmental education such as the establishment of the Environmental Research and Training Center (ERTC) in Rangsit (north Bangkok) with financial and technical assistance from Japan International Cooperation Agency (JICA). In addition, the establishment of Pollution Control Committee (PCC) is one of the major components in the revised Environmental Act. It focuses on a new administrative unit to monitor and control problems of wastes (wastewater and solid waste), air and noise pollution, and recommend various measures concerning pollution control to NEB.

Source: NRI Thailand,2003

According to the new Public Health Act of 1992, it is the duty of local public organizations to administer suitable living conditions in their jurisdictions with full power to penalize the offenders. Table 2.13 lists the rules and regulations related to SWM in Thailand.

Table 2.13 Additional acts and regulations related to SWM in Thailand		
Acts and Regulations	**Objectives**	**Statements concerning solid waste**
The Public Cleansing and Orderliness Act. B.E. 2535, (Royal Government Gazette, Vol.109, Part 15 of 28 February 2535)	The cleanliness and orderliness of the country.	Nobody shall be allowed to litter saliva, catarrh, sputum, excreta and discharge anything on road or public car/ship, or places where is not provided. Nobody shall be allowed to discharge solid waste or excreta from a building or vehicle on the road or into waterway or public places.
The Royal Thai Irrigation Act. B.E. 2485 (Royal Government Gazette, Vol. 92 Part 33, of 13 February 2518)	The promotion and protection of the Royal Thai Irrigation System	Nobody shall be allowed to dump solid waste and night soil in any irrigation water system that will cause danger to plants or consumers.
The Maintenance of Canals Act. B.E. 2446 (Royal Government Gazette, of 14 October 2446)	The protection and maintenance of canals	Nobody shall be allowed to dump cobweb, dust or dirt in the canal and it is forbidden to do so.
The Royal Highway Act. B.E. 2535	Control, maintenance, enlargement and reservation of highway	It is forbidden to dump solid waste, excreta, soil, sand, stone or other things on highways.
The National Park Act. B.E. 2504 (Royal Government Gazette. Vol. 78 Part 80 of 3 October 2504)	The protection and maintenance of the national parks	In the area of the national park, nobody shall be allowed to dump solid waste or other things in any place, which is not provided.

Source: NRI Thailand, 2003

CHAPTER 3

RECOMMENDATIONS FOR NEW DIRECTIONS AND STRATEGIES

3.0 Introduction

The present status of MSWM in the study countries makes it evident that the local authorities lack coherence in adoption of measures to effectively cope with the growing solid waste menace, while the citizenry appears to be ignorant under their supervision. The characteristics of the municipal waste indicate that food wastes account for more than 50%. This could be diverted from the dumpsites and landfills, effectively reducing the bulk of MSW for disposal and the space required for the purpose causing a reduction in the municipal expenses. The diverted organic waste could be utilized by adopting appropriate technologies for processing it into bio-fertilizers or as a source of green energy. While promoting sustainability of local bodies with revenue generation, it would help prevent the degradation of the urban environment.

Waste generation could be reduced if the local and national stakeholders (environmental and civic bodies) follow the concept of product stewardship (box 3.1). This concept would encourage manufacturers to gear up towards environmental concepts of resource utilization with focus on economic cost and benefit of product development, consumption, disposal and resource recycle. Product stewardship follows the cleaner production approach whereby waste generation at the upstream is targeted for reduction rather than abating downstream. Since all parties responsible during the life cycle of a product are involved, they have a role to play in managing the waste generated. The MSWM framework cannot achieve the adoption of this concept alone but has to coordinate it closely with the waste generators, from manufacturers and the product middlemen until the consumer's end.

Box 3.1 Product stewardship

The concept can be defined as a product life cycle where all parties responsible for the design, production, sale and use of a product assume responsibility for its environmental impacts throughout its life cycle. The concept of product stewardship incorporates the following principles:

1. All parties who have a role in designing, producing, selling or using a product or product components should assume responsibility for:
   - Reducing or eliminating toxic and/or hazardous constituents in products and/or its components;
   - Reducing the toxicity and amount of waste that results from manufacture, use and disposal of the products; and
   - Developing products that use materials, energy and water efficiently at every stage of a product's life cycle, including manufacture, distribution, sale, use and recovery.
2. The greater the ability of a party to influence life-cycle impacts of the product, the greater the degree of responsibility the party should have to minimize them.
3. Those responsible for the design, production, sale or use of a product should have flexibility to determine how to reduce toxic and/or hazardous constituents in it and how to keep materials from becoming waste.
4. The costs of recovering resources and managing products at the end of their useful life should be internalized into the costs of producing and selling them.
5. Government should provide leadership in the area of product stewardship in all its activities, including, but not limited to, promoting it when it purchases products, making capital investments in green buildings and infrastructure, procuring services, and managing them at the end of their useful life.

Source: EPA, 2003 (http://www.epa.gov/epr/index.htm)

By integrating the principles of sustainability and resource efficiency into our consumer culture, we can begin a transition away from the end-of-the-pipe practice of waste disposal, such as containment, remediation and pollution control to a process that maximizes recovery of resources, eliminates toxic materials, prevents pollution, and minimizes the economic liabilities associated with environmental degradation and clean-up activities. Waste management investments can then be shifted to resource recovery and development strategies that could relieve the local governments of the heavy burden of financing and managing the waste disposal systems.

The SWM system must be modified to reflect a comprehensive system. Solid waste issues should be linked to environmental, economic and community issues. This chapter details country wise recommendations for various aspects based on the present status of the MSWM in the study countries.

3.1 China

3.1.1 Technical aspects

This aspect incorporates the technicalities associated with MSWM that could pave way for an efficient system in China. It would require the setting up of the integrated waste treatment system that could effectively reduce the volume of the waste to be landfilled. In the process, recycling of the different kinds of waste using specialized technologies, and recovery of the conversion products and energy would be a sustainable option. The organic portion of the MSW would require chemical and biological processes for transformation into useful products/resources – biogas and compost. However, a single system would not be applicable for all regions and would have to be adapted to suit the waste characteristics and development of science and technology. Some of the important recommendations are as follows:

1. Improvement in resource utilization and technical expertise;
2. Implementation of a classified collection, transportation and disposal systems, regulating of the existing buy-back system and encouraging second hand markets;
3. Enhancement of the existing MSW disposal facilities along with its technicalities which if imported should be adapted and made suitable for the local scenario;
4. Provision of liqufied petroleum gas in the northern cities to reduce the clinker and coal ash component in the MSW;
5. Reinforcing the management of municipal facilities with stricter adherence to the laws;
6. Increasing pilot projects in different parts of the countries to promote waste segregation, classified collection, efficient transportation, disposal and recycling systems;
7. Due to the high moisture content waste incineration technology should be restricted to those developed cities with relatively high calorific value wastes;
8. Development of aerobic and anaerobic composting systems for the organics with efficient air pollution control systems, larger capacities and reduced capital costs; and
9. Provide sanitary landfilling as the primary disposal technique and rehabilitate the existing dumpsites into sanitary landfills.

Figure 3.1 Marketable animal feed from food waste in China

3.1.2 Institutional aspects and capacity building

Any organization to function efficiently would require a strong institution or organization to handle its varied functions with a capacity to tackle technical, managerial and legal problems that arise during the implementation of the institutional programs and policies. The following gives the outline of the institutional aspects and capacity building for China.

1. The environmental protection and sanitation departments along with the professional corporations should play the roles of supervisor, manager and service provider.
2. The existing department for MSWM requires to be reformed either by introducing privatization or by grouping the relevant departments into public sectors with clear-cut role designations and separation of the management and operational sector.
3. A separate department for MSW disposal under the reformed structure is required with specific authority to manage and coordinate national MSW activities.
4. A separate department should be set up under the Environmental Protection Office to manage and maintain records of resource recovery, treatment and other aspects of MSW with regular updates.
5. The departments responsible for MSW should be made independent functionaries (except the government departments) or as an enterprise which can adopt multiple investment means - stock investment and joint ventures - and can establish MSW disposal corporations.
6. The government should have sufficient manpower resources and mechanical units for:
   - Collection, monitoring and analysis of MSW data;
   - Research and Development (R&D) of MSW disposal and operation of the facilities; and
   - Management of MSW disposal industry.
7. Special on-the-job trainings/educational workshops should be given to the municipal staff for technical and managerial compatibility.
8. The government, NGOs and environmental units should initiate and promote educational workshops and environmental awareness campaigns for the local citizens.
9. The government should reform the curriculum in schools, colleges and universities by including environmental related activities and introducing relevant courses.

3.1.3 Legal aspects

The legal system governing the MSWM sector needs to be modified/amended to make it executable. At the same time, besides strengthening the mechanism of executing these laws, the government should also:

1. Research issues of legislation and enforcement of environmental laws in China and provide policy recommendations to relevant organizations for improving legislation and enforcement processes;
2. Train practitioners of law for enforcing environmental legislations and to increase their institutional and professional capacities;
3. Cooperate and coordinate with media for public awareness of environmental laws with handouts, posters, public meetings and electronic media campaigns;
4. Organize more international and national seminars/workshops on environmental legislation and enforcement to promote international and domestic academic exchanges;
5. Levy user charges to each family and enterprise for collection and disposal through the state legislation that can enhance investment and construction of MSW facilities; and
6. Encourage local governments to legislate based on the market economy.

3.1.4 Economics and finance

The government should establish a feasible scientific MSWM user charge criterion based on Polluter Pays Principle (PPP) as an alternative, only after examining the costs for MSW disposal, which could be set in consultation with the central and local governments, relevant individuals and organizations. The economical and financial aspects comprise investment and operation.

Investment mechanism

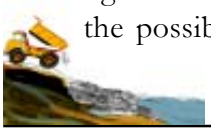
The government should reinforce the management aspects of MSW disposal by encouraging and promoting private sector participation either as individual units or as joint ventures for investment in waste recycling, marketing and utilization of MSW for environmental friendly projects. However, the management of such enterprises must be under the supervision of the government for monitoring their effectiveness. The government should practically accentuate on the investments on environmental sanitary facilities and allocate a separate budget on the MSW disposal to be used either by its own agencies or jointly with the private sector. At the same time it should emphasize more on ensuring adherence to the laws and regulations that could enable the collection of pollution charges or taxes from polluters and offenders.

Operational mechanism

Waste collection, transportation, treatment and disposal should be operated to suit the market economy with the government as the service buyer. In addition to its legislative roles, the government should be able to provide technical expertise, consultancy and contractual services with supervision for systematic operation.

3.2 India

The present status of MSWM in the country indicates that most local bodies suffer due to the non-availability of adequate expertise and experience for the implementation of the recommendations given by the Supreme Court Committee for MSWM, which is summarized in figure 3.2. It indicates a wide scope for improvement in the SWM systems. The major issues and the possible solutions could be classified into (i) Technological, (ii) Institutional, (iii) Legal,



(iv) Financial, and (v) Social aspects. These have lead to the following:

1. Inadequate municipal services due to limited resources;
2. Absence of hygienic and scientific disposal systems;
3. Lack of public awareness for waste management resulting in high levels of non-segregated waste generation and littering;
4. Existence of an extensive informal network mainly driven by market forces functioning partly on subsistence levels;
5. Absence of sufficient waste processing capacity, particularly the organic wastes; and
6. Existence of a relatively small market for recycled waste products.

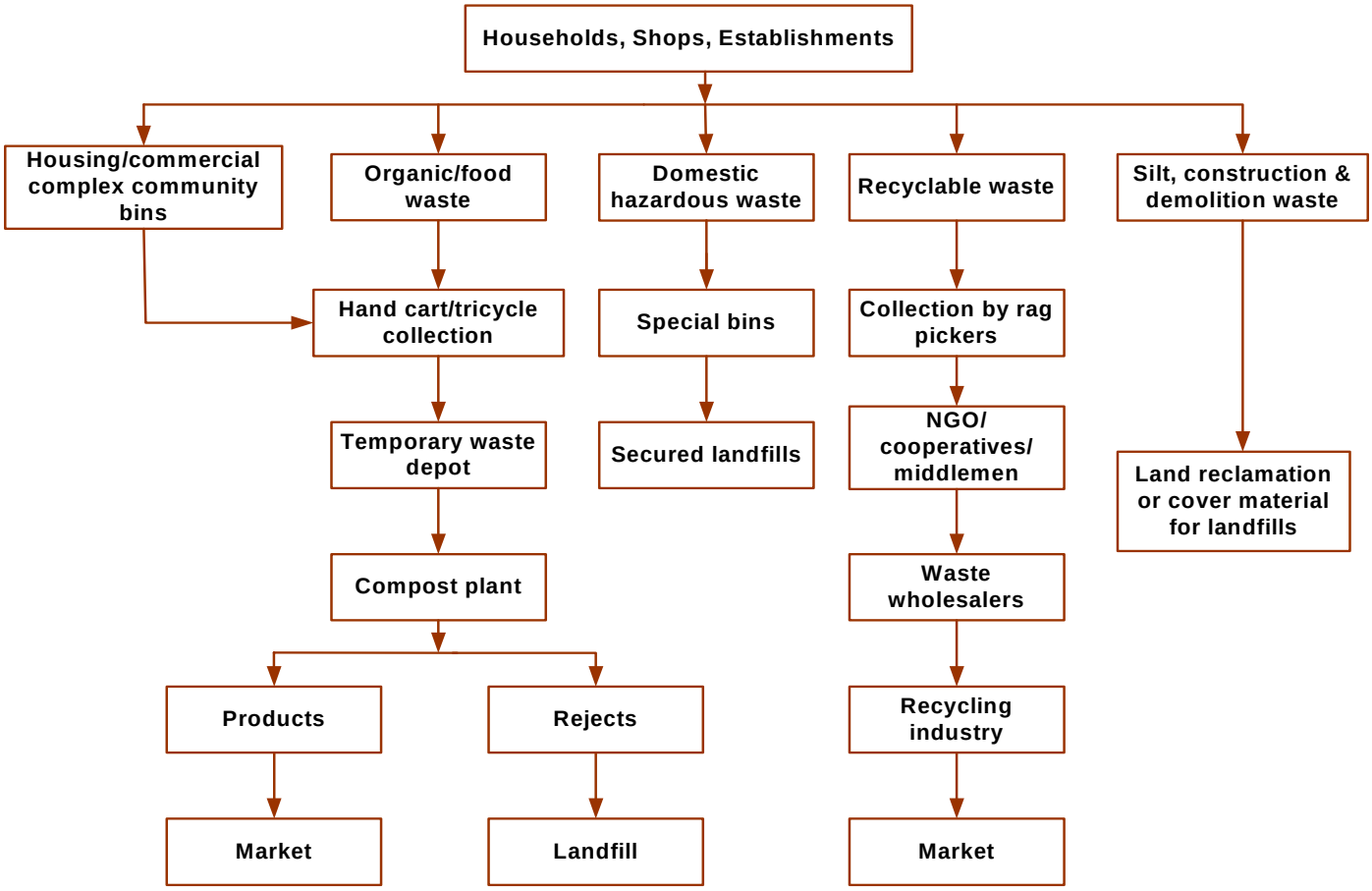


Figure 3.2 Recommended waste management strategy in India

3.2.1 Technical aspects

India has witnessed a rapid urbanization with the population shift from the rural areas. Changes in living standards and habits have increased the per capita waste generation. As a result the major technological concerns in MSWM in the country are:

1. Changing quantity and quality of solid wastes;
2. Lack of planning for SWM with inadequate technologies for collection and processing;
3. Disposal by uncontrolled and illegal dumping on land;
4. Low efficiency due to unplanned/unscientific approach with the use of general-purpose equipments and lack of preventive maintenance.

In order to improve the scenario, the possible options for improvement would be master plan based urbanization that includes MSWM. Other technical options are:

1. Development of database on waste generation and characteristics;
2. Encouraging source separation and door to door collections;
3. Scientific design of collection routes;
4. Use of appropriate equipments for collection, transport and processing, and their preventive maintenance;
5. Development and use of appropriate waste processing methods - composting, community vermicomposting, biomethanation etc;
6. Rehabilitation of the open dumps to sustainable landfills; and
7. Formalization of the informal sector and assisting their efforts.

3.2.2 Institutional aspects and capacity building

Efficient services would demand adequate infrastructure with institutional capacity to effectively manage the MSW. The related institutional issues are:

- Low priority for MSWM which itself is fragmented;
- Lack of trained manpower and absence of norms of work; and
- Unhealthy conditions of waste workers resulting in lack of social involvement.

The possible solutions to the institutional issues could include:

1. Awareness of the issues to the stakeholders;
2. Coordination/operation by a single agency based on the master plan;
3. Human resource development;
4. Community participation and privatization; and
5. Provision of improved amenities and service conditions for formal and informal sector workers.

In terms of capacity building for SWM in the Indian urban areas, the responsible department should have the following:

1. Sufficient staff with adequate financial and administrative powers and single line of control and supervision.
2. SWM Department should shoulder the entire responsibility of collection of all the municipal and construction wastes, debris etc. and have a workshop for necessary repair and maintenance of the transport units and other equipments.
3. The work force and the supervisory staff should be motivated and exposed to modern methods of waste management through training, seminars and field visits.
4. Unqualified supervisors and other workers should receive relevant trainings.

The center and states must make a concerted effort towards capacity building of urban local bodies for improved accounting systems, commercial orientation in service delivery and private sector participation. It could be carried out through training programs, providing hands on experience in projects, exposure visits and experience sharing with peer groups. It may be beneficial to provide career growth opportunities based on such learning. States must also move towards benchmarking service delivery between various cities.

3.2.3 Legal aspects

The government should emphasize more on the enforcement and implementation of the existing laws and regulations. The possible reasons for poor implementation could be a combination of social, technical, institutional and financial issues. Public awareness, political will and public participation are essential for the successful implementation of the legal provisions. The following points may be addressed to improve the present scenario:

1. Identification of an apex body (Ministry/Commission) to tackle urban SWM problems, set implementation deadlines for various activities and monitor their adherence;
2. Constituting of an inter-sectoral task force under the apex body to carry out sector assessment supported by SWM expertise to prepare a national policy and strategy;
3. Formulation of a national action plan based on community participation, institutional and human resource development, technology transfer, financial support, cost recovery, promotion of privatization and legislative support to discipline the people; and
4. Establishment of a waste management institute at the national level which acts as a R&D center for appropriate technologies that can be applied at the field level in tackling urban MSW problems. The institute can also act as a medium of technology transfer, a center for institutional and capacity building and a center of readily available expertise.

3.2.4 Economics and finance

The major issues related to the financial aspects of MSWM arise solely due to inadequate resources and absence of national level policy and guidelines for allocation of resources for SWM. In addition, community participation can aid the financial constraints which is lacking while the private sector is not motivated for participation. The possible solutions for solving financial constraints may include:

1. Development of a national policy on SWM and resource allocation specifically for it;
2. Implementation of by-laws/acts effectively with strict penalties for defaulters;
3. Fixation of rational tariff and its efficient collection; and
4. SWM tax should be imposed to meet city cleaning costs. Entire cost recovery should be introduced in all specialized services - collection of waste from the hotels, restaurants, malls, hospitals and nursing homes and other doorstep collection services.

In addition to improving general revenues, local bodies must increase and implement collection of operating revenues by user charges, tipping fees/disposal siting fees and landfill taxes.

3.2.5 Health issues

All the necessary efforts should be made to ensure the cleanliness of the cities. Special attention should be paid to the slums and other traditionally unclean areas. Open defecation should be stopped by providing adequate sanitary facilities for individuals and groups. In the rural areas, cattle sheds and pigs are common and the owner should also dispose the waste on a daily basis at the community storage sites or by using individual composting systems to keep the surroundings clean.

The contamination of MSW by excreta, clinical, hazardous and animal wastes is a serious health risk which must be avoided making necessary arrangements for their exclusion from the waste stream. Formal MSWM workers and the informal sector (scavengers and rag pickers) are ignorant of the risks associated with their work. Provision of protective gears, their mandatory use and awareness of health risks should be initiated along with a comprehensive health insurance schemes for these workers.

3.2.6 Social aspects and public awareness

Public awareness on SWM should be conducted through the media as well as mass personal contacts with the help from NGOs/CBOs, etc. This would further motivate the people through group meetings, formation of neighborhood committees, and youth and children awareness campaigns.

Further, the community must be sensitized of the MSW issues and the contribution of the field level workers (socially downtrodden) with public awareness, organizational protection and recognition of their roles as an integral part of SWM. The inadequacy of segregation system for hazardous, organic, inorganic and recyclable wastes at household level and during disposal must be remedied.

3.3 Sri Lanka

3.3.1 Technical aspects

1. Training or educational workshops should be conducted for MSW stakeholders for selection, construction and operation of the required number of sanitary/semi-engineered landfill sites. Furthermore, the concept of operating a common landfill site as an integrated approach should be emphasized among small LAs.
2. Landfills should be the core technology supported by different options to reduce the quantity of waste.
3. Aerobic systems of pre-treatment prior to landfilling should be promoted, as composting systems are relatively simple and appropriate for processing the agricultural wastes.
4. R&D efforts should be made to develop better energy recovery from MSW (Box 3.2)

Box 3.2 Lost opportunities in Colombo, Sri Lanka

The Colombo Metropolis with a total urban population of 1.3 million (inclusive of about 500,000 floating population) generates an estimated 1200 tons/day of solid waste; its collection rate is just about 50% (600 – 650 tons/day). The per capita generation ranges from 0.5 – 1.0 kg/day comprising more than 80% organic waste. The collected MSW is mostly dumped at Bloomandale Road dumpsite - a 12 acre plot in the heart of the city. The cost of SWM for the Municipal Council is about Rs. 400 million (US$ 4.12 million). The only processing of waste is home composting (about 600 households) and recycling activities (segregation in 1000 households), limited to a minute fraction. At large, most of the solid waste is simply dumped ignoring the environmental impacts. These can be observed in the urban water supply contamination (causing water borne diseases) and as air pollution (dust, odor and toxic fumes from open burning). The other impacts are loss of wetland habitats and change in ecological balance (loss of flora and fauna), breeding of pests and vermin, aesthetics, decreased property values, flooding risks, and health and safety issues. The uncollected waste or its illegal dumping adds to the deterioration of the environment.

The corporation has not been able to fulfill its mandate of MSWM efficiently citing financial constraints while it ignorantly wastes valuable resources that could be efficiently utilized to generate energy and hence be a source of revenue for the city. The dumped waste could generate 8 – 10 MW of electricity from a biogas power plant. One such unit of 8 MW would produce 63,360,000 KWh of power annually (in 330 working days) amounting to Rs. 354.82 million (US$ 3.66 million) at an average electricity price of Rs. 5.6/KWh. This opportunity of extracting green energy from wasted resources could easily cover more than 88% of the municipal expenses. With 100% collection and processing of the MSW, the power generation would significantly increase which in the long run could make the council self sufficient financially. That would drastically reduce its dependence on loans, grants or aid from the government or funding agencies. However, this opportunity is lost and the resourceful waste continues to be wasted unless the political will is tuned to harness the readily available source of energy. Till such times positive actions are taken in this direction, Colombo's lost opportunities would also add to the deterioration of environment by emissions of greenhouse gases.

5. Transfer stations for MSW should be constructed wherever necessary for the proper transportation with data maintenance.
6. The government should introduce monitoring and control systems for sustained management of MSW.
7. Private sector participation and NGOs and CBOs should be given the required technical expertise and consultancy facilities to enable them to function efficiently.

3.3.2 Institutional aspects and capacity building

The institutional aspects would involve the following recommendations:

1. The government should introduce and improve the concept of source separation in the country.
2. It should strive to provide a balanced waste management service by considering all the elements and activities related to the service (technology, man power and material), level of service provided, financial allocations, cost recovery concepts and stakeholder participations.
3. The concept of polluter pays should be encouraged and NIMBY (Not In My Back Yard) syndrome needs to be cured promptly.

For achieving these goals, the government should increase public awareness by media campaigns, posters, board advertisements, initiating workshops and trainings, school level campaigns and student's awareness, increasing of public-private partnerships and encouraging active contribution of stakeholders in MSWM.

For a successful waste recycling program, first the government should formalize the informal recycling activities and make efforts to reduce the current lacunae in communication by inter-agency and intra-agency, various government agencies and NGOs involved in the MSWM. The government must also consider the significance of developing a harmonious link between the formal waste management units and the informal waste-recycling sector.

3.3.3 Legal aspects

National Strategy on Solid Waste Management should also cover the directives for mining and safe closure of dumpsites. The NSSWM lacks adequate provisions and methods for promoting the use of compost in agriculture. The government should consider environment impact assessment (EIA) as a prerequisite for solid waste disposal sites that includes risk assessment and economic feasibility of the project.

It is necessary to plan strategies in the NSSWM for the following activities:

- closure and mining of dumpsites;
- production and sale of compost;
- glass, paper and plastic recycling; and
- textile and rubber reclamation or recycling

The government should also impose stringent regulations to prevent and discourage indiscriminate littering of waste by individuals, government and non-government organizations as well as penalize illegal dumping.

3.3.4 Economics and finance

Resource constraints are the primary problems for effective MSWM. Measures to deal with the concern can be taken as below:

1. Charging of minimum tipping fee based on the size of LA should be worked out for using BOO/BOOT (built own operate/built own operate transfer) basis of recycling plants and landfill schemes with the private sector in the lead role.
2. Total costs for collection, transportation, recycling and final disposal should be taken into account when working out an economic feasibility of managing MSW so that resource allocations can be made accordingly.

3.3.5 Health issues

1. The government should provide or make appropriate arrangements for the local authorities to provide the waste workers with health protective gear and other necessary inventories to perform their duties efficiently.
2. The government should discourage women and children from waste picking at the dumpsites by inclusion of a clause in the NSSWM that prevents unauthorized trespassing. Formal resource recovery should be carried only with the use of adequate protective gear in the dumpsites and transfer stations.
3. The government should ban open burning of MSW at dumpsites and provide adequate storage facilities to prevent constant malodor and other air pollutants from the collection points, transfer stations, dumpsites and open body waste collection vehicles.
4. Studies should be undertaken to assess the existing conditions of old and new dumpsites and measures should be taken to reduce/prevent the contamination of ground water from leachate infiltration.

3.4 Thailand

The scenario in Thailand arises mainly from technical aspects though other concerns too have their influence to a large extent for effective MSWM.

3.4.1 Technical aspects

1. The storage, transport, and disposal of solid waste and night soil should be at the provincial level in conformity with environmental quality management plans.
2. Private sectors should be encouraged to provide services in solid waste and night soil management on contract basis or as joint ventures.
3. Each province should identify/locate a suitable land for the long-term disposal of solid waste and night soil with a preliminary EIA of the site.
4. Other measures by the government are:
   - Introduction of a system (like product stewardship) for producers to buy back used packaging materials from consumers for recycling or disposal. It should also specify product and packaging types that producers must reclaim in order to reduce the quantity of solid waste while establishing an information coordination center for recycling of solid waste;
   - Investigation, assessment and monitoring of management problems arising from solid waste and night soil from community and other sources on a continuous basis with the development of waste management information system to ensure standardization and have it periodically updated;

- Improvement of waste collection system based on the PCD criterion for each community which is allotment of collection bins of 1150 liters for 350 residents and a 10 m^3 collection truck for every 5000 residents;
- Rehabilitation of the existing disposal sites;
- Establishment of a common waste disposal center for adjacent communities and adoption of the integrated MSW management approach;
- Encourage waste separation and recycling program at the generation sources by employing segregation strategy recommended for the appropriate and effective waste collection and disposal systems; and
- Target non-residential sources for reduction of the MSW at the source with the adoption of the cleaner production concepts in manufacturing.

3.4.2 Institutional aspects and capacity building

These aspects involve the specification of organizations and their roles for efficient solid waste and night soil control, monitoring and management. Parallel to it, the organizational capability requires to be enhanced within the framework of the local government in technical, managerial and legal matters of MSWM by trainings and workshops for the workers as well as the management. Provisions should be made for the installation of sufficient equipments for separating commingled MSW while discouraging its collection.

3.4.3 Legal aspects

The national legislation has provisions for environmental protection in general and amendment of the laws, regulations and ordinances relating to solid waste and night soil management is required that includes levying fees. Certain standards for pollution control should be established for solid waste disposal sites. The government has to designate solid waste and night soil disposal facilities as pollution sources with methods of emission and effluent controls based on established standards. Other aspects are follows:

1. Establishment of regulatory framework and standards for returning used products and packaging for recycling and reduction of solid waste;
2. Establish regulations relating to wastes from construction sites, transport stations, trains, buses, ferries and rafts; and
3. Establish monitoring systems to record the MSW pollution episodes from different sources, inspect the private sector activities and provide a role for public participation in monitoring.

3.4.4 Economics and finance

The government should apply the PPP for both the private and public sector organizations that generate solid waste and night soil. The private investors or NGOs interested in waste marketing and MSWM should be given technical assistance, soft loans, grants or tax waiver to encourage their participation. At the same time, it should be able to adjust the selling prices of commodities in accordance with the environmental cost-benefit analysis and restructure associated taxes on products containing toxic materials.

3.4.5 Health issues

Health issues arise mainly from the improper SWM which have immediate and long term affects. Short term concerns can be mitigated with effective collection, transport and disposal while the long term problems require a proper disposal method by sanitary or engineered landfills and locating the facility in an out-of-bound area with adequate precautions for monitoring and remediation of the landfill gas emissions and leachate treatment.

On the workers' side, health protection systems should be established and even the informal sector involvement should be protected from the risks involving their work in MSW, which must be made free from community generated hazardous wastes.

3.4.6 Public awareness

The public play an important role in effective MSWM for which awareness is required in relation to waste reduction, recycling and separation. This should be promoted either by media campaigning or by educational means with the government support for funding the initiatives. Other methods would be to:

1. Promote public education programs and reinforce social values in keeping public cleanliness and proper MSW management for all children and citizens in the society;
2. Initiate educational and training programs to foster technical and administrative capabilities to local government and private enterprises in the field of MSWM; and
3. Promote the concept of waste processing as an intermediate step after the waste collection and before its final disposal.

One of the methods adopted in Thailand has been successful in motivating citizen's responsibility using The Magic Eyes for public awareness (Box 3.3).

Box 3.3 The Magic Eyes

"*Ah! Ah! Don't litter! The Magic Eyes see you.*" The Thai Environmental and Community Development Association (TECDA), or better known to the citizens as the Magi Eyes worked wonders in reducing littering in Bangkok in the 1980s and helped take care of the environment. TECDA works with governmental agencies, private organizations, NGOs and CBOs to build up environmental awareness. The Magic Eyes logo is widely recognized as the eyes watching the environmental behavior of the people. Now the Magic Eyes has expanded its scope to environmental and energy conservation, Chao Phraya River conservation, solid waste reduction and recycling. Its programs also offer practicable green alternatives to the citizens.

Source: The World Bank 2003 (Thailand Environment Monitor, 2003)

Source: http://www.magiceyes.or.th/main.asp

CHAPTER 4

SUSTAINABLE MUNICIPAL SOLID WASTE MANAGEMENT

4.0 Introduction

The overview of the MSWM in the four countries shows a striking degree of similarity with respect to financial aspects, technical aspects and human resource development that are an essential part of sustainable integrated solid waste management (ISWM). ISWM is defined as the selection and application of appropriate techniques, technologies and management programmes to achieve specific waste management objectives and goals (UNEP, 2001b). ISWM depicted in figure 4.1 takes into account technical, legislative, economic, socio-cultural, institutional and environmental aspects involved in the process along with community participation. It illustrates the link between the stakeholders and MSWM aspects to derive an integrated approach. It provides a comprehensive inter-disciplinary framework for addressing the problems of managing urban solid waste, particularly in the resource constrained developing countries where quality SWM services are poor and costs are high often with no effective means of recovering them.

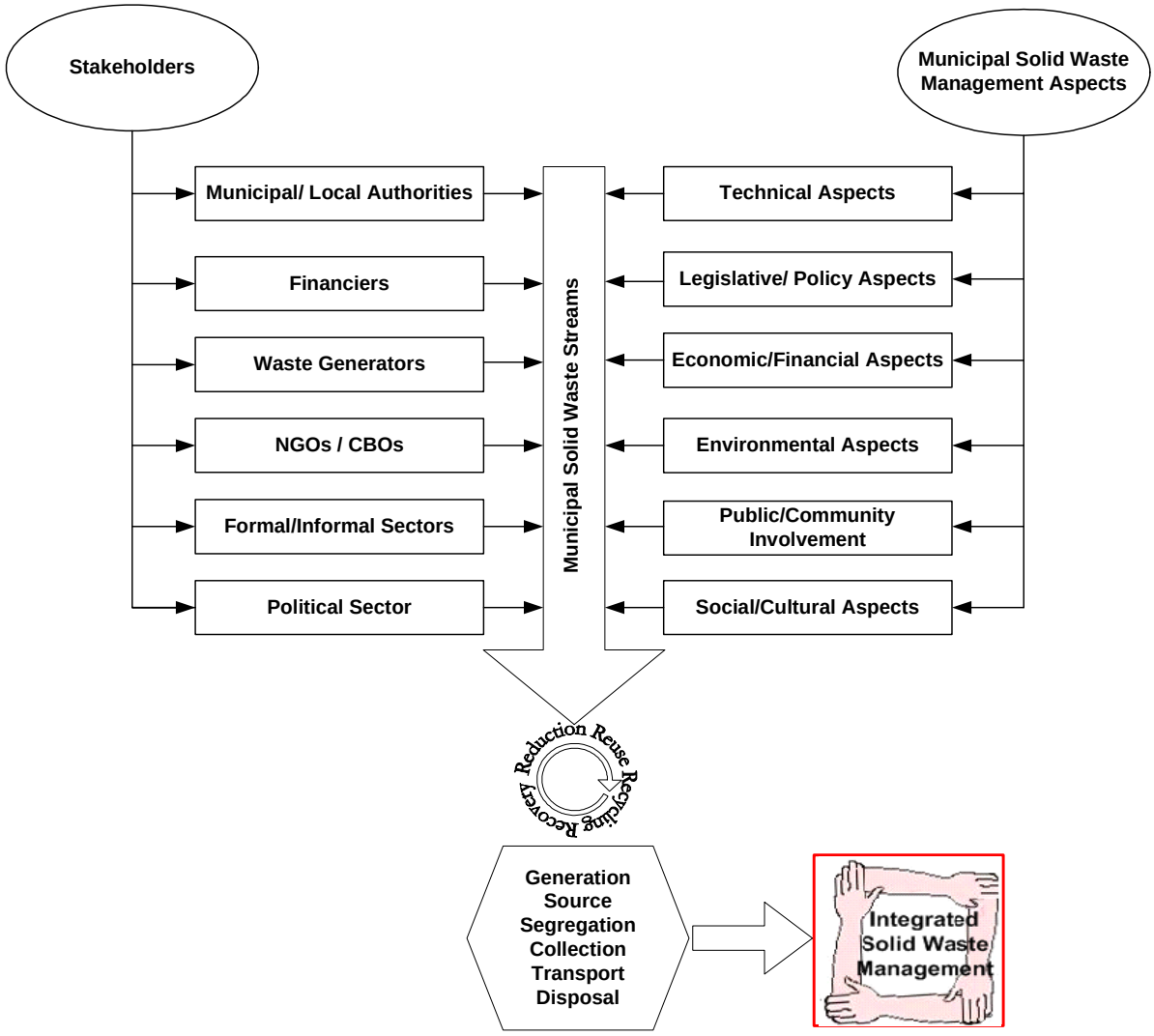


Figure 4.1 Elements of Integrated Waste Management

The approach would consider following elements of MSWM in which problem identification is required:

- waste generation;
- source segregation;
- collection and transport of waste;
- recycling of the valuables;
- resource recovery from mixed waste;
- existing disposal systems and their upgradation; and
- people's participation

The actual integration can take place at various levels (Beukering *et. al*, 1999) that enables the achievement of sustainability such as:

1. Using a range of different collection and treatment options which include prevention, recycling, energy recovery and environmentally sound landfilling of solid waste;
2. Involvement and participation of all the stakeholders - waste processors (formal and informal recyclers), waste generators (households, industries and agriculture), financing agencies, non-governmental bodies (NGOs and CBOs) and government institutions (waste managers and urban planners); and
3. The interactions between the waste system and other relevant systems relating to the product design at the industry which can have a significant impact on the recyclability of the product after its consumption.

This framework has been very successful in various industrialized countries. However, urban governments in developing countries are constrained by limited finances and inadequate services, lack of skilled manpower capable of ensuring sound management practices which prevents them from tackling the problem effectively. In addition, their SWM planning is hampered by inadequate data while information at all levels, if available is generally unreliable, scattered and disorganized. Time has come to enhance the hierarchy of waste management systems, incorporate the principle of 4 Rs (reduce, reuse, recycle and recover) with the encouraging of waste separation at all levels while considering the solid waste as a resource rather than just a localized urban problem.

It is not an easy task to plan and execute a successful ISWM framework since factors such as population growth, income, educational background and local awareness, which would have a direct effect on the waste generation, are constantly changing in the study countries However, an effort should be made from all levels of society to manage or minimize this solid waste menace in an environmentally sound manner. The communication gaps, duplication of municipal functions, lack of specific information and poor record keeping that weakens the task of apposite MSWM are mostly due to the prevailing bureaucratic system. Further more, lack of financial resources, technical facilities, skilled manpower, ignorance of the local people and lack of stringent laws and regulations deteriorate the system in one way or the other. To achieve an ISWM, the policy makers, municipal managers and the stakeholders of these countries must focus on making the existing system sustainable. The following section deals with the approaches to sustainable municipal solid waste management which would be in line with the integrated system.

4.1 Approaches to Sustainable Municipal Solid Waste Management

As observed from the status of MSWM in the study countries, a strategic approach is required in all the elements of the waste system. The approach takes into consideration the technical, managerial, legal, economic and financial aspects which are equally important and mutually dependent. Each factor must be considered while implementing the approach by identifying the major concerns in each area. A system should be developed for handling the problem as depicted by figure 4.2, which is based on the problem identification on a priority basis for MSWM.

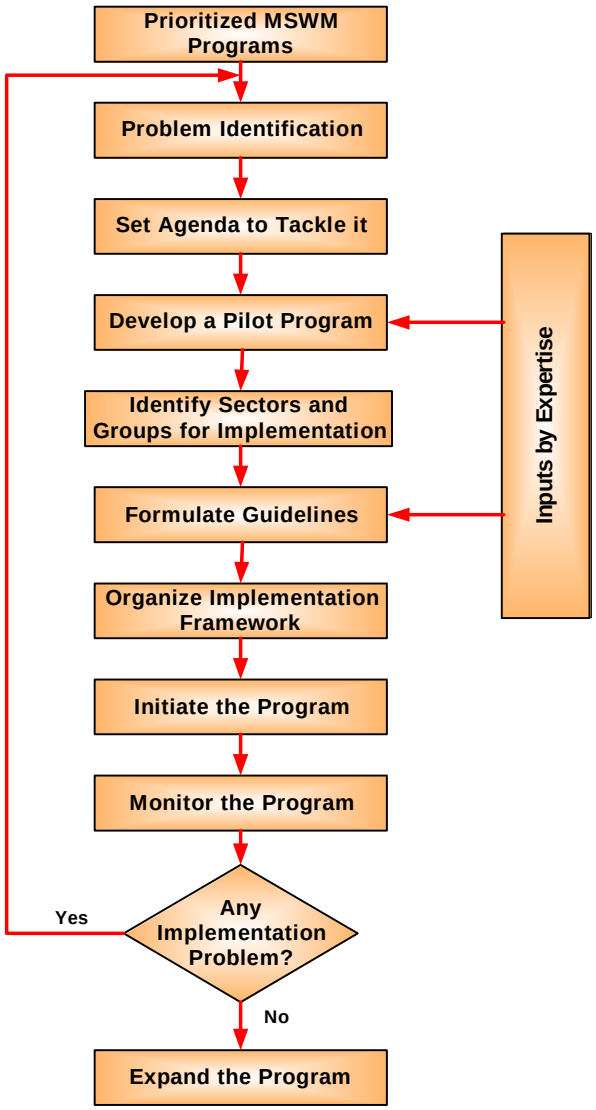


Figure 4.2 Tackling of a MSWM problem

The primary environmental concern due to MSW are accumulation of uncollected wastes and improper disposal caused by the following (Kruger Consult, 1996):

- increasing household and commercial solid waste;
- lack of or minimal separation of waste at source;
- insufficient collection and transport units for waste collection and disposal; and
- inadequate disposal capacity and inappropriate disposal methods.

Most of the urban areas of the study countries and other developing regions of Asia face this problem which requires remedial measures to ensure sustainability. The practice of disposing mixed waste without treatment has a price to pay in terms of collection, transport and disposal costs, loss of valuables (recyclables, reusables and repairables) and the impact on the environment due to air, water and soil pollutions, and associated health risks that ultimately impact the economy. This economic impact creates lack of resources for MSWM and hence a vicious cycle (Figure 4.3) is generated unless remedial measures are taken to break the circuit, the cycle continues and expands leading to further environmental degradation.

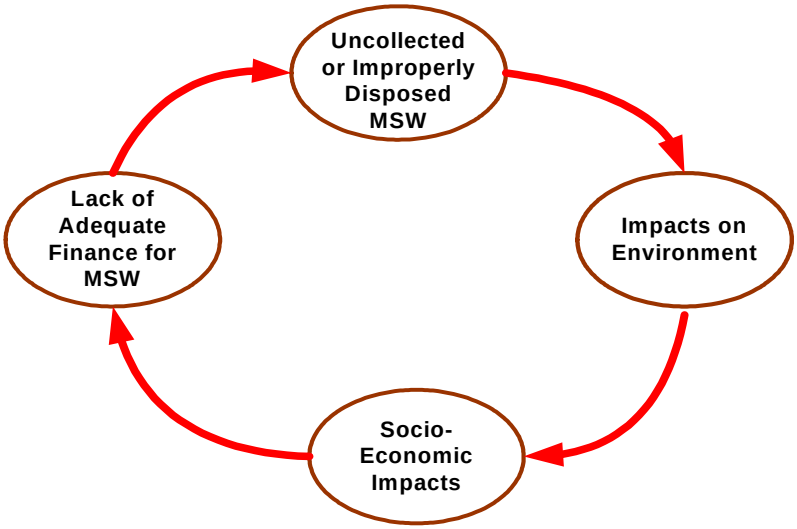


Figure 4.3 Vicious cycle of MSW

The critical item for the success of the ISWM will be problem identification in various aspects. This analysis should include both the technical and performance aspects as well as all of the other aspcts: social, institutional, economic, environmental and legislative or political. Ideally it should cover all the waste system elements as well. Some of the critical issues related to the aspects that are helpful for problem identification and analysis are given hereunder (Klundert *et al.*, 2001 at www.waste.nl).

The technical and performance aspects include the functioning of the management and its components; collection aspects (rates, area coverage, facilities, frequency and capacity of the collection units); transport (types of units and capacity, frequency and trips, routes and distances to transfer stations, performance efficiency); and processing systems (performance efficiency and capacities).

The environmental aspects include the collection and disposal rates of MSW from a locality; separation of hazardous wastes from the stream; waste related diseases prevalent in the community and the frequencies of occurrence; guidelines for waste reduction, reuse and recycle; and environmental awareness among the waste generators.

While looking at the financial and economic aspects, the sources of funds (municipal budget, taxes, levies, user fees and basis for each); adequacy in the components of the budget for the entire waste stream; recovery of costs from levy and processing activities; and the overall efficiency in financial utilization require to be considered.

The socio-cultural aspects would take into account the interest of the stakeholders in MSWM, their activities in coordination with civic bodies; the structure for involvement in various activities which encompasses the grassroots level; and the contribution of the women and social organizations.

The institutional and organizational aspects would call for role designate and sharing of responsibilities within the management framework. The management should encompass the entire waste stream inclusive of the involvement of the private sector, NGOs, CBOs and informal sector such that any problem related to their performance could be sorted out and solved. Monitoring of the waste stream and related aspects with sufficient technical expertise and enabling of the working environment for the waste workers by providing the required amenities and health insurance factors would play a vital role for an effectual system.

The legislative frame work for waste management would pose a problem if the municipal bodies do not have sufficient executive powers for planning, budgeting and operating the system. At the same time enforcement of a rule should be coordinated to enable attainment of the objectives. Any concern arising out of the policy issues and legal performance should be tackled at the level of the local body or by the immediate responsible authority.

Having identified the critical issues, two basic approaches can be taken into consideration on the entire municipal waste stream to enable an effectual management leading to the sustainability of the operations. These approaches target the upstream and downstream leading to the tackling of the problem from cradle to the grave for the MSW.

4.1.1 Upstream approach

This approach would take into account the application of the cleaner production (CP) concepts, which incorporate the basic principle of reduction of refuse generation, source segregation, promotion of organic waste composting and expansion of recycling techniques. The basic approach would be to consider the municipality as a large industry with its population as the consumers. CP principles would direct the industry to produce and supply goods and services with environment friendly norms such that the waste gets minimized at the producer's end rather than at the point of consumption with a stepwise follow-up downstream. The strategy should take into account the following issues:

(i) Factors that influence waste generation – population and income level of the citizens which determine the consumption pattern that directly illustrates the composition of waste in the garbage bins.

(ii) Waste generating sectors – residential and non-residential generators and their influence in the MSW stream.

CP concepts would be more effective in controlling the source which is basically the non-residential sector comprising the manufacturing and service industries which have been found to contribute significant amount of the municipal wastes. Waste minimization can be achieved with the use of legal and economic instruments, voluntary participation and awareness among the polluters and application of appropriate technologies. Ambiguity arises on the technological issues as CP principles would demand source reduction, which would direct the use of appropriate technology for the manufacture of goods. Conservation of raw materials and energy inputs should go hand in hand with the use of accessories for packaging of the consumables that should be minimum and can be recyclable or reusable. The target for implementing waste minimization should begin with the large-scale generators and slowly encompass the medium-scale to small-scale generators. Many

developed countries and some selected industries (heavy machinery, electronic and beverages to cite a few) in the developing region have a buy-back system for recyclables which can effectively reduce the volume of waste generated at the consumer's end. Germany has implemented the green dot system which makes it mandatory for the recycling industries to process the collected recyclables (Box 4.1).

Box 4.1 Case study: Green dot system in Germany

Germany placed an ordinance on packaging in 1991 in an attempt to minimize the quantity of solid waste. The manufacturers are required to take back the packaging of their goods and reuse or recycle it. The green dot system facilitated the industries' compliance with German regulations concerning waste management and its goals were set for gathering waste and separating it. These two goals aimed to recycle 72 percent of glass, tinplate and aluminum packaging waste, and 64 percent of paper, plastic and composite packaging while the U.S. reported recycle rate of only 22 percent of glass and tinplate packaging in 1990. The regulations to achieve this ambitious goal would create incentives for the industries to minimize waste during manufacture and packaging.

The green dot system concentrates on three types of packaging, which are:

1. transport packaging such as pallets and crates;
2. secondary packaging in containers like boxes for commodities; and
3. primary packaging - actual casing of a good.

Companies were not able to meet the recycling quotas on their own and the Dual System was created for them with a membership. Members the system then put the green dot trademark on their packaging that guaranteed recycling by a company for their packaging if collected. Drop off and curbside collection for all packaging with the green dot trademark is also available. These recycling receptacles make it more convenient and more likely for households to recycle which leads to a greater chance of companies meeting the required recycling quotas. As of September 1993, 12,000 companies had signed for the green dot program including 1900 firms based outside Germany.

In addition to the membership fee, companies had to pay based on each package's volume. The highest fee was $0.12 for package volume greater than 30 liters. Most of the German packages fell into an intermediate category in which the fee consisted of $0.012 per 200 ml to 3 liters volume packaging.

In October of 1993, a new fee schedule was announced and went into effect and the industries would now have to pay fees based on the package materials and weight. For example, glass presorted by households had the lowest fee of $0.04/lb while plastics had $0.82/lb., which still need to be sorted at the recycling plant. This new fee schedule would hopefully alleviate any of the dual system's financial problems as compliance and payment of fees increase. The burden is clearly placed on the manufacturers initially which the consumers share as prices of consumer goods increase due to the increase in production costs. The green dot system has proven to reduce waste. In 1992-1993, the consumption of packaging decreased by about 4 percent. Containers have been reused more and the quantity of secondary packaging has dropped by 80 percent. The green dot system was responsible for the collection of 4.6 million tons of recyclables in 1993. There are some concerns with the green dot system such as the oversupply of recyclable waste. As more markets for products made of recyclable waste will need to be created. In order for this program to be completely successful, the collected waste will need to be reused or recycled fully.

Source: http://www.colby.edu/personal/t/thtieten/swm-germ.html

Source segregation of the wastes into organic, recyclables and reusables, and inerts would definitely pave way for a cleaner waste stream whereby the separated components could follow the respective line of processing downstream discussed in the following sections. In order to apply the cleaner production concepts, the approach of tackling the MSW problem as given in figure 4.4 would be necessary.

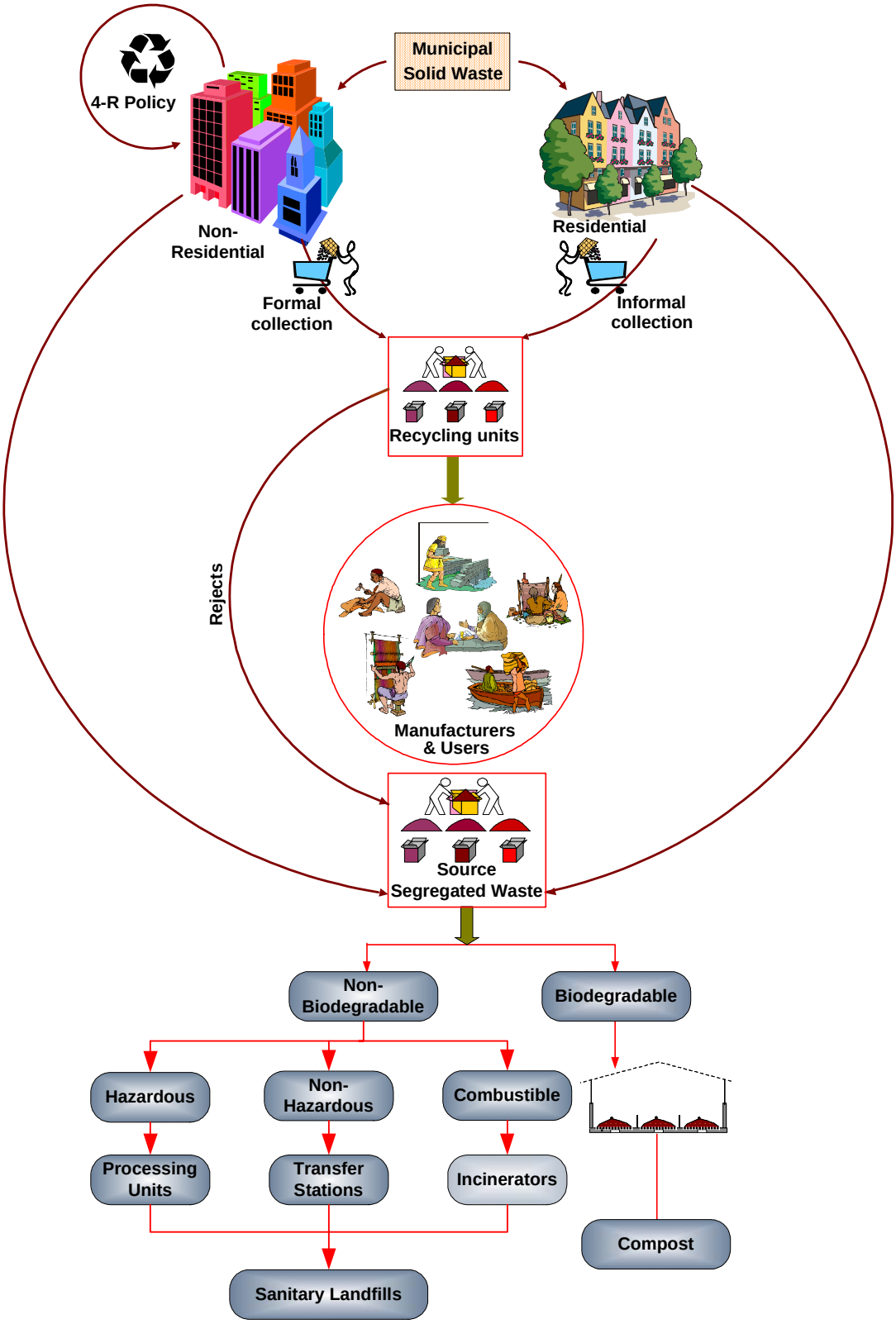


Figure 4.4 Integrated municipal solid waste management plan for municipalities.

4.1.2 Downstream approach

This approach is appropriate for the existing scenario of MSW in the study countries requiring upgradation in the system. Here CP concepts would call for segregation of the mixed waste instead of collecting, transporting and dumping it *en masse* without any consideration to its compositions and the effect it would have on the environment. To break the vicious circle of MSW, processing of the waste stream is required that would significantly reduce the quantity of refuse for final disposal. Not only the system can reduce its operating costs and land requirement for disposal but recovery of valuables would pave way for resource conservation and utilization.

In the present study, the most common problem identified are the uncollected wastes and disposal in the open dumps leading to immediate environmental health hazards and prolonged environmental degradation by emission of landfill gases and exudation of leachate from the dumps which contaminate surface and ground water. Leaving aside aesthetic, odor and dust problems, landfill gases and leachate control measures require prioritized action. The measures to provide 100% collection of wastes would be taken care of by building adequate technical infrastructure and revamping the managerial capability with legal and financial inputs. However, the problems arising out of the nature of the mixed waste composed of more than 50% organic fraction with high moisture content can only be solved by technically competent methods which have proven so either through research or by practical application in the developed countries which can be adapted to suit the Asian context. The preliminary step that can be taken is treatment of the solid waste prior to disposal. An example of the effective use of organic wastes for obtaining useful compost for agricultural and horticultural purposes is being practiced in Austria (Box 4.2).

Box 4.2 Decentralized composting - successful cooperation models with farmers in Austria

Austria has practiced source separation of organic waste with the support of environmentally sound legislation (Compost Ordinances). The system of collection is separate for kitchen waste and garden/park wastes which is done from door to door to obtain purity of waste as well as high recycling rates. Curbside collection is found to have more impurities. The public is encouraged regularly for home composting with leaflets, seminars and media information on the value of source separation. Logistics are provided as a support to the collection system. The collected waste is treated with controlled moisture and temperature, odor management, leachate and rainwater collection. The resultant compost is supplied in markets as differentiated products with information to the customer groups for private gardens, landscaping, land reclamation, agriculture and horticulture

.

The process of composting required to be integrated with the agriculture sector, the potential user of the product. As a result of the integration, 350 professional schooled farmers take about 45 % (271,000 tons) of the collected organic waste. It has been estimated that more than 35% of the entire compost produced in Austria is used in agriculture. The outstanding benefits of the scheme are:

- high grade compost product and savings for the farmers in the use of chemical fertilizers;
- consciousness for soil fertility problems and ecologically sound soil management with humus; and
- diversion of the organic wastes from the landfills.

For detailed information, the source is http://www.biowaste.at/newsletter/nl200201.html

Processing of MSW in the downstream has been found to be effective in reducing the MSW volume by more than 40%. In a pilot scale study on MSW pretreatment by active aerobic composting, Norbu *et al* (2003) found that volume reduction of waste was 33% in one week and as much as 52% in two weeks which clearly indicated that a pretreatment of waste would decrease the volume landfilled. The study concluded that 7 to 10 days of composting would facilitate sufficient pretreatment before disposal.

The general unsorted waste with a larger fraction of biodegradable could be subjected to degradation prior to landfill. It has been found from the settlement pattern in landfill lysimeter studies that highest degradation occurred during the rainy season and lowest in the dry season due to the lack of moisture. This would call for the provision of moisture which is possible only by collecting leachate generated from the landfill during the rainy season and storing it for recirculation during the dry season. The present practice of open dumps would have to be upgraded to semi-engineered landfills with leachate collection facilities and hence make them sustainable (Kuruparan *et al*, 2003). Therfore, pretreatment before disposal would significantly decrease the landfill volume (Figure 4.5).

Figure 4.5 Pretreatment of biowaste in San Sebastian, Brazil

The most prominent method which can be adopted to enable resource recovery in the form of valuables, bio-fertilizers and energy with minimized landfill volume is the Mechanical-Biological Treatment (MBP) of Waste. This method is defined as the processing or conversion of waste from human settlements which includes biologically degradable components, by a combination of mechanical and biological processes. Initially the technique was applied to pretreatment and hence its acronym is MBP (Ludwig *et al.,* 2003).

The characteristics of the solid waste in Asia as found from this cross country comparative study is suitable for MBP system. The benefits of MBP can be enumerated as follows:

1. rapid improvement of SWM;
2. resource recovery in the form recyclables, compost and refuse derived fuel;
3. decreased landfill gas and leachate production;
4. less settlement of the landfill; and
5. benefits to human health by decreased emission of pollutants.

The only disadvantage is the risk of climatic effects. Figure 4.6 represents the approach to MBP process for MSW.

During the process of mechanical separation, waste is crushed, screened and sorted into its components as shown. The functions of this process are:

- homogenizing of size or a range of sizes;
- separation and recovery of recyclable metals, plastic and glass for recycling;
- removal of components that hinder biological processes which may be recyclable or inerts that can be landfilled; and
- recovery of high calorific value waste for refuse derived fuel (RDF).

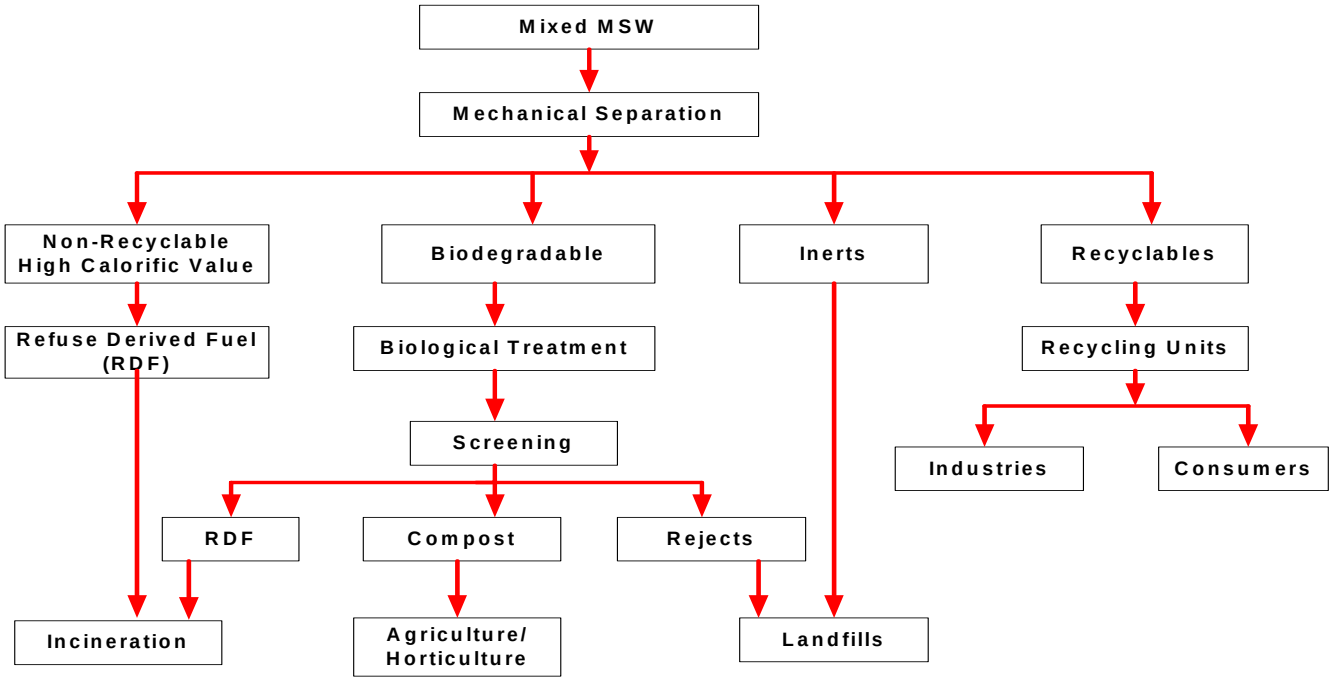


Figure 4.6 Approach for Mechanical-Biological Treatment Process

The biodegradable portion is subjected to biological treatment that comprises aerobic composting or anaerobic digestion. The former process is carried out in the open while the latter is a closed process which is expensive but enables energy recovery in the form of biogas. Often the waste can be subjected to anaerobic digestion to obtain biogas after which the digestate is subjected to aerobic composting and post-processing (screening to remove foreign materials) whereupon the compost is utilized for agriculture or horticulture. The compost rejects and the inerts from the sorting is landfilled. Larger fraction can be used as RDF after further drying if incineration facilities are present. During the mechanical separation, high calorific value waste comprising of non-recyclable plastic, paper and other non-biodegradable waste is separated for incineration (energy recovery) and the residue is landfilled. There are several pilot projects for mechanical-biological waste treatment with a view to expand the system to a larger arena of waste management (Box 4.3).

This method would find application in the Asian context for sustainable solid waste management practices provided the concerned authorities are ready to initiate the process with a strong political will.

Box 4.3 Cases of Promotion of Mechanical-Biological Waste Treatment (MBWT)

The emerging problem of uncontrolled dumping of waste is fostering the introduction of controlled forms of waste management. Such a system requires to be cost-effective and environmentally appropriate form of disposal. Mechanical-biological waste treatment is considered a simple and an inexpensive way of pretreating waste prior to disposal which would save the environmental burden of controlled disposal and its costs. The primary objective of MBWT is to find an economically viable solution to the organic wastes in the municipal waste stream. It is aimed at investigating its possible applications for the technology such that the emerging and threshold countries can benefit from it with collaborations and experiences of Central Europe.

GTZ and German enterprises have implemented various pilot projects in their project countries to evaluate the appropriateness and application of MBWT. Three of the projects are:

1. Pilot project in São Sebastião, Brazil by FABER-AMBRA® process
2. Pilot project in Phitsanulok, Thailand by FABER-AMBRA® process
3. Scale-model MBWT trial in Al-Salamieh, Syria by GORE®

Various other projects have been supported for field-testing of the system that are in:

1. City of Atlacomulco, Mexico for composting; sorting of recyclables and management of a micro-enterprise; and treatment of waste inputs according to the MBWT process using the informal sector.
2. Armenia, Columbia with a view to compile the experience gained and make it available to interested parties across South America via the internet (www.foro-z.com).

Detailed information is given in http://www.gtz.de/mba/english/pilotprojekte.html.

4.2 Approaches to the Existing MSWM Problems

The unscientific practice of disposal in open dumps is a major problem of MSWM. The associated issues are poor site design without adequate compaction and lack of cover, leachate and landfill gas monitoring systems. The dumps become a haven for waste pickers. In order to abandon the practice of open dumping and plan for engineered landfills, the municipalities have two options:

(i) Abandon the existing dumpsites after taking measures to cordon the area from rag-pickers and scavengers (humans and animals) and other necessary precautions if an upgraded landfill is available; or

(ii) convert the existing dumpsites to upgraded landfills.

The approach to sustainability would be a departure from the existing practice in most developing countries and regions towards sanitary landfills that can provide effective disposal of a city's MSW in accordance with appropriate local health and environmental standards.

A properly designed landfill would have provisions for leachate management and collection of landfill gas for energy recovery. The adoption of conventional landfill would facilitate the stabilization of waste over a period of time which could take 30 - 100 years. This long period could be decreased drastically by developing the landfill into a bioreactor which would enhance the degradation of the waste. The Landfill Bioreactor would use enhanced biological processes to transform and decompose the organic waste within 5 -10 years. During the process of degradation in a bioreactor, generation of landfill gas would be enhanced by recirculation of leachate as discussed earlier that would induce enhanced degradation. One aspect of landfill reuse after closure requires the attention of all planners and civic authorities. There have been several successful ventures of landfill reuse in the USA, which are briefly cited in box 4.4

Box 4.4 Cases of Successful Landfill Reuse in USA

There are several developments regarding use of abandoned land including former landfills in the USA. The USEPA estimated in 1995 that US had over 3500 solid waste landfills to be closed and covered in almost every community. These closed landfills can be reclaimed with special monitoring and design such that its reuse does not pose any threat to public health and safety. Some instances of successful landfill reuse are either passive open space or active redevelopment for commercial and institutional uses. A few examples in the US are:

- a nature center in Florida;
- a ski and sledding slope in New Hampshire and Virginia;
- a sculpture garden in New York;
- botanical gardens and an amphitheater in California;
- active sports fields in Massachusetts and North Carolina; and
- driving ranges and golf courses nationwide.

There is ample opportunity for the development of a closed landfill. Though closure operation is expensive, but if a community or private entity owns a landfill, its reuse will enable a tangible benefit financially as well as environmentally. However, public participation for the implementation of the program is required for addressing public issues and concerns while they are informed of the opportunities and limitations.

The most important feature that needs to be addressed is ensuring public health and safety. The people must be convinced of safety of the site for which a risk assessment to address user safety and site security is necessary.

The master plan for development of a closed landfill site would have to consider the economic viability of the project. It should balance site development with the protection of surrounding natural and diverse aquatic, terrestrial and wetland habitats, as well as minimize impact on the surrounding neighborhood and community. It should foster public-private partnerships for funding project development, sustainable use and long-term maintenance.

While planning and designing reclamation and reuse of a landfill, the project must create a clear vision, take public health and safety into consideration, involve the public and create awareness, integrate closure and reuse aspects, identify costs and funding and use an experienced consultant or an agency.

Source: http://www.nyfederation.org/PDF/7_SuccessfulLandFillReuse.pdf

The status of default disposal practices of MSW disposal in the developing countries could be improved using the techniques cited for upgradation from open dumps to sustainable landfills or by a shift to engineered landfills.

4.3 Recommendations for Sustainability of MSWM

The study on MSWM for the four countries has been successful in deriving recommendations for implementation of sustainable municipal solid waste management which involve technical, management, financial, legislative and supportive aspects which are provided in the following sections.

4.3.1 Technical aspects

The adoption and transfer of the technologies from the developed countries without adapting them to the local or regional perspective would be fallacious on the part of the developing countries. Therefore, the technical aspects for a sustainable SWM would have to take into account the following points for planning and implementation of strategies.

1. Provision of facilities for primary collection of waste from curbside/community bins (with or without community participation) would require construction of enclosures for storing communal waste and provision of color coded bins for different waste streams to facilitate easier collection and transportation. Adequate storage facilities in the urban areas should be based on the population density like providing collection bins at the rate of 150 liters for every 350 residents and a 10 m^3 collection truck for every 5000 residents, which would be sufficient to meet the needs as is practiced by the Bangkok Metropolitan Administration.
2. Transportation of waste from the community storage facilities at regular intervals before the containers start overflowing could be facilitated with compactor trucks to augment the collection fleet. Outmoded vehicles should be withdrawn and people should be encouraged to deposit domestic, trade and institutional wastes in the collection units provided by the local bodies.
3. The collection has to take place as per a fixed schedule known to the public who should place their wastes at the collection points not earlier than one hour before the collection.
4. Transfer stations (at optimal distances from residential areas) should be constructed wherever necessary with provision for weighbridges at processing and disposal sites for cities with a population 500,000 and above.
5. Centralized waste treatment and disposal facilities may be initiated for adjacent communities enabling them to share common facilities by adopting the integrated waste management approach.
6. Research and development activities should be initiated on a continuous basis to cope up with the changes in solid waste scenario.
7. The existing dumpsites require to be upgraded to sanitary landfills based on the availability of land and the finance. If upgradation is not economically viable, the unsanitary sites should be closed to prevent scavenger invasion and open burning (Figure 4.7). Construction of sanitary landfills with leachate treatment and landfill gas control facilities for the disposal of non-compostable wastes and refractory substances in an environmentally acceptable manner should go along with rehabilitation/upgradation.
8. There must be a separate SWM system for hospitals, health care establishments and industries to prevent the infectious and hazardous wastes from entering the municipal waste stream.
9. Public participation could be initiated with awareness campaigns through IEC (information, education and communication) especially in densely populated areas.

Figure 4.7 Open burning of MSW at a dumpsite in Chennai, India with residential area in the background

4.3.2 Management aspects

Sustainable SWM would call for the strengthening of the management sector which has to go hand in hand with technical planning. In most developing countries, overstaffed management due to politically motivated appointments result in absenteeism and hence the working efficiency decreases while at the same time there is a squeeze in resource allocation for technical aspects that get neglected. The effectiveness can only be achieved by a strong management that takes into consideration the following aspects.

1. An executable master plan and implementation plans for MSWM at the provincial level or the state level in accordance with the strategy for national environmental quality would help the management;
2. Application of Polluter Pays Principle to all waste generators, especially in urban areas including governmental and non-governmental agencies, private sectors and commercial enterprises;
3. Application of the concepts of product stewardship, cleaner production and specification in the selection of packaging materials to the manufacturers for their mandatory recovery reduce the generated wastes both during manufacture and at the consumers' end while managing conservation of resources;
4. Continuous monitoring and record keeping of MSW aspects with the development of a systematic information system that can be comparable, utilizable and updated;
5. Identification of a suitable site within each province/state for the final disposal of the solid waste as a long-term plan for waste management;
6. Appointment of responsible governmental agencies that can regulate and supervise MSWM activities of both local government and private operators so as to reduce the environmental impacts; and
7. Providing of organizational support for encouraging the involvement of private sector operators, NGOs and CBOs.

4.3.3 Financial aspects

Technical and managerial aspects of sustainable waste management depend on the resources that can be mobilized and budgeted to encompass all aspects of waste management. As observed form the figures from the study countries, allocation of adequate budget for the final disposal of the collected MSW is a priority sector. Often there is adequate budget for the municipality but overstaffing cuts on the finances meant for waste processing and the most neglected sector is the waste disposal which is hidden from the view of the legislative authorities and the general public. There should be transparency and coordination amongst the staff regarding the operation and maintenance costs at each level of waste handling so that the expenses are rational.

The levying of waste collection and disposal fees should be based on waste generation rates and according to the economic standard of the area, whilst considering the nature of the waste wherever necessary. However, these fees should not be levied solely to meet the financial lacunae for management and the equipment demand. The larger generators should be charged on excessive waste generation which could be prevented with cleaner production principles.

Promotion of private investment for waste management and recycling should also take into consideration the establishment of a waste recycling information center. This could encourage investment by the private enterprises on resource recovery as well as on sanitary disposal facilities and waste processing units. Granting of soft loans and subsidizing or exempting taxes for machineries,

equipments and spare parts which need to be imported would encourage the private sector.

Box 4.5 provides an insight on using a pricing system used in USA and how such programs have helped in recycling.

Box 4.5 Case study: Effect of solid waste pricing programs

There are several methods of framing the cost structure of waste disposal using drop-off sites and curbside recycling which decrease the cost of recycling for households. Mandatory recycling and quantity based pricing increase the cost of disposal. Compliance of mandatory recycling depends on making recycling easy for households. When the cost structure of recycling is changed to increase the cost of disposal and decrease the cost of recycling, the probability of recycling is greater.

Quantity based pricing programs increase the marginal cost of disposal thus creating economic incentives to recycle. Some problems associated with quantity based pricing are illegal waste disposal (dumping and burning), which occurs when charge per container of waste is too high. Such illegal methods of waste disposal are difficult to determine making enforcement difficult. Predicting of revenue is hard but necessary for the funding of the solid waste or recycling programs. Quantity based pricing is not feasible with common receptacles in an apartment or office building as it would be hard to determine the trash owner and individuals that do not live where there is a common receptacle may chose to dump their refuse in the common dumpsters. This issue is different from pure dumping of refuse because the waste is being collected properly, but the individuals are not paying for the collection.

A study was conducted in Tompson County of New York, which has various combinations of waste disposal programs. The three predominant combinations of policies are curbside pick up only, mandatory recycling only, and mandatory recycling along with trash tags. The tags cost $0.70 each and are not applicable for those individuals using common receptacles. The study was by a survey for waste management programs based on randomly sampled individuals in this primarily rural setting. The findings show that married households report a greater likelihood of recycling as well as more educated individuals. Individuals are also more likely to recycle if they have knowledge of the availability of a drop-off center or are concerned about environmental issues and waste management.

From the results, it was found that the most effective policy combination included both mandatory recycling and curbside pickup with the probability of recycling newspaper and glass by 22 - 37%. These various programs in which the cost structure of waste disposal is changed have proven to provide incentives in order to increase recycling. Pricing systems are found to increase the likelihood of recycling. Quantity based pricing causes individuals to experience the marginal costs of trash disposal. Marginal cost pricing is much more effective than flat fee pricing because it creates incentives for individuals to recycle. However, individuals are also more likely to recycle when the costs of recycling are reduced by providing curbside recycling. The combination of such programs has the greatest probability of decreasing the quantity of solid waste.

Source: http://www.colby.edu/personal/t/thtieten/swm-ny.html

4.3.4 Legislative aspects

Legislation and its effective enforcement is a key to sustainability for which the framework requires to be established. The related aspects are given hereunder:

1. Set up of appropriate pollution discharge standards for solid waste disposal facilities such as effluent and emission standards either based on World Health Organization (WHO) norms or related to the national standards for pollution control;
2. Declare all solid waste disposal facilities as pollution sources, which if done should be strictly enforced such that discharges should be regulated in pursuant to the established standards;
3. Develop regulations and related laws to set up mechanisms for recovered materials, waste recycling and source reduction;

4. Review related laws on tariff for MSWM in accordance with the current situation and impose higher tariff on commodities with excessive packaging or that generate higher volume of refuse;
5. Regulate an appropriate SWM system for the mass-transportation terminals;
6. Though setting up of appropriate waste management regulations as an implementing guideline for waste collection, transportation and disposal has been done, enforcement is lacking. (This should regulate health care, hazardous industrial, construction and demolition wastes in the MSW stream such that they could be stored within the premises or outside separately to eliminate the practice of co-mingling.);
7. Declare a no-development buffer zone within 500 meters from the boundary of all processing and disposal sites.

Box 4.6 highlights the success use of legislation in Ireland to reduce plastic bags by 95% from the MSW stream and substitute with 'bags-for-life'.

Box 4.6 Success story: Plastic bag levy, Ireland

Litter problem in Ireland has been a primary environmental concern as the rapid economic growth of the 1990's was marked by a significant increase in the amount of per capita solid waste. Inadequate landfill sites resulted in escalating waste disposal costs leading to frequent illegal dumping and littering. This problem affected severely Ireland's green image and one of its largest industries (tourism). The food industry with a healthy and wholesome reputation also suffered due to increased litter and pollution. The most visible element of litter was plastic bags which the government set about to reduce. Each year, 19,000 supermarkets and other retail outlets in the country provided to Irish consumers 1.26 billion plastic bags (roughly 14,000 tons) free of charge that translates 325 bags per consumer per annum. About 99.5% of this plastic was sent to landfill sites or became litter on roadsides, in parks and along the coastline.

In March 2002, the government introduced the Plastic Bag Environmental Levy on all plastic shopping bags, with a few exceptions on bags used for dairy products, fruits and vegetables, confectionary items, meat and fish (for health and safety reasons). Retailers paid a fee of 15c per plastic bag, which they passed on to the consumers. This levy was designed to alter consumer behavior and create financial incentives for more environmentally friendly alternatives, such as 'bags-for-life' or heavy duty paper bags available in all supermarkets at an average cost of •1.27.

The Revenue Commissioners and the Department of the Environment and Local Government collect the payments from the retailers based on the records of plastic bags they purchase and sell to customers. Quarterly payments are made electronically from the retailer's bank account. The retailers are able to make savings, as they no longer provide free disposable bags to customers while they earn profit on the sale of 'bags-for-life' whose sales have increased by 600 - 700% since the introduction of the levy.

It was anticipated that this levy would bring about a 50% reduction in plastic bags, but is currently estimated at 95%. The consumption of plastic bags reduced from 1.26 billion to 120,000 per annum while raising approximately •10 million for the Irish Revenue Commissioner, which was placed in the Environmental Fund to finance future environmental initiatives (recycling, waste management and anti-litter campaigns).

This levy has been viewed as a major success by the government and environmental groups alike. It has also been enthusiastically embraced by Irish consumers after intensive environmental awareness campaign in conjunction with the levy. The amount of plastic being sent to Irish landfills has been dramatically reduced, bringing about a clear, visual improvement in cities, on coastlines and in the countryside due to the decrease of litter. The Department of Environment has received a number of calls from a multitude of countries expressing interest in the levy, including Australia, New Zealand, and Britain. It is hoped that many other countries will adopt similar policies in the future, which will further reduce the unnecessary use of plastic bags around the world.

Source: http://www.colby.edu/personal/t/thtieten/litter.htm

4.3.5 Supportive aspects

Municipal bodies could have the required technology, financial resources, management structure and a framework of legislation for effective SWM. However, its implementation cannot be effectual unless the supportive aspects are mobilized to work hand-in-hand with the system. This can be achieved if the system can:

1. Encourage private sector involvement for waste collection, hauling and disposal as both short term and long term contractors since efficiency is found to increase with their involvement (These contractors could be provided with concessions in related activities and imports of machineries which would be used for the MSWM sector);
2. Promote public education program, trainings and workshops, revise school curriculum by introducing the concept of environment in general and SWM in particular, and reinforce social values for all children and citizens in the society;
3. Initiate education and training program in fostering technical and administrative capabilities to local government and private personnel;
4. Encourage waste separation and recycling program at sources - households, commercial centers, institutions and factories by employing segregation strategy that would fit the appropriate waste collection and disposal practices; and
5. Encourage research and development projects for suitable technology in coping with the mounting MSW management problems and enhance management efficiency through established academic and research institutes.

Instances of private sector involvement and NGO/CBO participations as success stories and case studies have already been cited from the study countries in Chapter 2. One illustration of a unique use of industrial waste and other refuse at the initiative of an individual with the cooperation of the concerned agencies is given in box 4.7.

Box 4.7 Case Study: Nek Chand's Rock Garden, Chandigarh, India

The Rock Garden at Chandigarh is a unique feature built using industrial wastes and other residential, construction and non-residential refuse. It has been aimed at retrieving beauty from the garbage bins, littered wastes and dumpsites with creativity. It expresses the fragility of the environment and how the non-renewable resources can be preserved in a different form after their useful life is over. The features displayed there encompass social, cultural and historical aspects along with the diverse ecosystem and physical features that are a part of the human environment. It is also a testament to the artistic taste and talents of the architect blended with the environmental concepts. The monument addresses the concerns and problems of a fragile environment related to waste generation. The Rock Garden and its salient features express vividly how our environment can be preserved for the posterity keeping in mind the global concern of sustainable environment.

In the words of Carl Lindquist, "The Rock Garden built by Nek Chand is of international importance which expresses this global problem through beauty, ingenuity, and imagination"; and a visit to the garden would provide a lesson from the pages of sustainable management in practice.

Source: Carl Lindquist (http://www.clt.astate.edu/elind/nc_chandig.htm)

4.3 Conclusions

The study of MSWM in China, India, Sri Lanka and Thailand culminated in the compilation of this cross-country comparison of MSWM with country specific recommendations for new directions and strategies. The evaluation of the present scenario and the developing trends show that each country has a specific role to play to reach the goal of integrated approach and that the entire environmental status with respect to the urban refuse activities needs to undergo metamorphism. This can be achieved with a stepwise approach which has been discussed with some success stories. The national research institutes from these four countries with their respective expertise coordinated by Asian Institute of Technology convened at a workshop at Chennai, India. This workshop has come up with specific recommendations on sustainable strategies as a path lighter for the desired goal of sustainable integrated solid waste management (Box 4.8).

Box 4.8 Sustainable strategies for integrated solid waste management

The principle of *'keep it simple'* and *'make it sustainable'* should be adopted not by directly transferring the available technologies from the developed countries. Improvements in MSWM may be introduced incrementally in keeping with the ability or willingness of the public to pay. These issues and others were discussed at Chennai during the workshop on Sustainable Landfill Management (3 - 5 December 2003). The workshop was organized by the Centre for Environmental Studies, Anna University, Chennai, India in association with the Asian Institute of Technology, Thailand. About 20 international experts from China, Germany, Russia, Sri Lanka, Thailand and the USA, and 150 Indian resource persons and delegates participated. During the workshop, it was also highlighted that urban garbage in India is generally dominated by stones, fine earth and ashes (15 - 50%) next only to fermentable matters (45 - 75%). The following points emerged during the deliberations that could play a major role in developing tangible and affordable strategies to tackle a large number of issues and concerns related to MSWM.

1. Policy makers should give priority to SWM schemes on the lines of drinking water supply schemes.
2. A comprehensive master plan including monitoring of activities should be developed and implemented by all municipal bodies for managing the MSW with periodic reviews.
3. Specific provisions for SWM should be made in the budget of all municipal bodies. The budget should specifically provide funds for waste processing and disposal.
4. Minimizations of waste generation through source reduction and separation, reuse, recycle and recovery should be given the highest priority in the hierarchy of waste management.
5. Segregation of wastes at household levels should be popularized by local bodies. Awareness programs on SWM should be developed and offered by concerned agencies to encourage public participation.
6. Rehabilitation of the existing dumpsites should be given top priority by upgrading them to sanitary landfills in a phased manner depending on the risk and the financial aspects of each dumpsite. The availability of the financial resources generally dictates the course of transition.
7. Attempts should be made to collect and dispose inerts separately as they may not require any further processing.
8. Confidence-building strategies should be evolved by the concerned authorities to involve multi stakeholders while setting up waste handling, processing and disposal facilities.
9. Authorities should take measures to create linkage among the stakeholders in SWM and encourage government-private entrepreneurship.
10. Reliable and scientific database should be generated with the help of academic and research institutions.
11. A comprehensive policy should be formulated regarding the creation and use of co-disposal facilities for municipal solid wastes and non hazardous industrial wastes.
12. The provisions of national legislations and policy frame work should be reviewed in line with the principles of sustainable waste management.

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Appendix A: Waste Generation and Characteristics in Urban Areas

(a) Waste generation in metro cities: China

Area (Municipality)	Municipal Population (Millions)	MSW (tons/day)	Per capita Waste generation (kg/day)
Beijing	12.9	12181	0.94
Tianjing	10.7	5690	0.53
Sijiazhuang	2.9	1644	0.57
Taiyuan	4.0	2000	0.50
Huhehaote	1.8	1307	0.73
Shenyang	7.4	3123	0.42
Dalian	4.6	2263	0.49
Changchun	4.9	2942	0.60
Haebin	6.0	3764	0.63
Shanghai	19.6	12877	0.66
Nanjing	5.2	2438	0.47
Hangzhou	3.1	2161	0.70
Hefei	2.3	800	0.35
Fuzhou	2.5	1293	0.52
Nanchang	2.9	986	0.34
Jinan	4.3	1534	0.36
Zhengzhou	3.4	2001	0.59
Wuhan	7.7	6101	0.79
Changshan	3.0	2116	0.71
Guangzhou	7.3	6074	0.83
Nanning	2.3	874	0.38
Haikou	1.1	795	0.72
Chongqing	17.2	3491	0.20
Chengdu	5.4	2533	0.47
Guiyang	3.0	1019	0.34
Kunming	3.1	1308	0.42
Lasha	0.3	449	1.50
Xian	5.7	2428	0.43
Lanzhou	3.2	1774	0.55
Xining	1.3	2118	1.63
Yingquang	1.1	623	0.57
Wurumuqi	2.8	2566	0.92
Total/Average	162.7	93273	0.62

Source: NRI China, 2003

(b) MSW Generations in Indian metro cities

Area (Municipality)	Municipal Population (Millions)	MSW (tons/day)	Per capita Waste generation (kg/day)
Ahmedabad	2.9	1,683	0.58
Bangalore	4.1	2,000	0.49
Bhopal	1.1	546	0.50
Bombay	12.3	5,355	0.44
Calcutta	10.6	3,692	0.35
Chennai	4.8	3,124	0.65
Coimbatore	0.8	350	0.44
Delhi	8.4	4,000	0.48
Hyderabad	4.1	1,566	0.38
Indore	1.1	350	0.32
Jaipur	1.5	580	0.39
Kanpur	1.9	1,200	0.63
Kochi	0.7	347	0.50
Lucknow	1.6	1,010	0.63
Ludhiana	1.0	400	0.40
Madurai	0.9	370	0.41
Nagpur	1.6	443	0.28
Patna	0.9	330	0.37
Pune	2.2	700	0.32
Surat	1.5	900	0.60
Vadodara	1.0	400	0.40
Varanasi	1.0	412	0.41
Vishakapatnam	0.8	300	0.38
Total/Average	66.9	30,058	0.45

Source: NRI India, 2003

(c) MSW characteristics in Indian metro cities (2002)

Metro city	Characteristics (% by Wt.)							
	Paper	Textile	Leather	Plastic	Metal	Glass	Ash, others	Compostable matter
Ahmedabad	6	1	-	3	-	-	50	40
Bhopal	10	5	2	2	-	1	35	45
Coimbatore	5	9	-	1	-	-	50	35
Hyderabad	7	1.7	-	1.3	-	-	50	40
Indore	5	2	-	1	-	-	49	43
Jaipur	6	2	-	1	-	2	47	42
Kanpur	5	1	5	1.5	-	-	52.5	40
Kochi	4.9	-	-	1.1	-	-	36	58
Lucknow	4	2	-	4	1	-	49	40
Ludhiana	3	5	-	3	-	-	30	40
Madurai	5	1	-	3	-	-	46	45
Nagpur	4.50	7.00	1.90	1.25	0.35	1.20	53.40	30.40
Patna	4	5	2	6	1	2	35	45
Pune	5	-	-	5	-	10	15	55
Surat	4	5	-	3	-	3	45	40
Vadodara	4	-	-	7	-	-	49	40
Varanasi	3	4	-	10	-	-	35	48
Visakhapatnam	3	2	-	5	-	5	50	35

Source: NRI India, 2003

(d) Municipal waste generation in Sri Lanka (2002)

Area	Municipal Population (Millions)	MSW collected (tons/day)	MSW generated (tons/day)	Per capita Waste generation (kg/day)
Colombo	2.4	1171(40%)	2927	1.22
Gampaha	2.0	197(25%)	788	0.39
Kalutara	1.3	79(25%)	316	0.24
Galle	0.9	75(25%)	300	0.33
Hambantota	0.6	22(25%)	88	0.15
Matara	0.8	46(25%)	184	0.23
Kandy	1.6	162(25%)	648	0.41
Matale	0.5	16(25%)	64	0.13
Nuwaraeliya	0.5	45(25%)	180	0.36
Kegalle	0.2	39(25%)	156	0.78
Ratnapura	1.0	78(25%)	312	0.31
Kurunagala	1.5	66(25%)	264	0.18
Puttalam	0.7	23(25%)	92	0.13
Badulla	0.9	147(25%)	588	0.65
Monaragala	0.4	23(25%)	92	0.23
Anuradhapura	0.7	23(25%)	92	0.13
Polonnaruwa	0.5	10(25%)	40	0.08
Ampara	0.5	46(25%)	184	0.37
Batticaloa	0.6	125(25%)	500	0.83
Jaffna	0.9	194(25%)	776	0.86
Kilinochchi	0.2	4(25%)	16	0.08
Mullaitivu	0.2	1(25%)	4	0.02
Mannar	0.1	4(25%)	16	0.16
Vauniya	0.1	10(25%)	40	0.40
Total/ Average	19.1	2692	9015	0.49

Source: NRI Sri Lanka, 2003

(e) MSW compositions in Sri Lanka (2002)

District	Biodegradable waste (Short term)	Biodegradable waste (Long term)	Polythene and other Plastic waste	Metal waste	Wooden waste	Glass waste	Paper waste
Ampara	25.40	19.55	10.38	6.78	10.36	4.45	24.27
Anuradhapura	35.43	28.91	4.38	3.48	9.37	5.85	11.07
Badulla	51.44	22.51	6.80	2.70	3.21	7.19	9.29
Batticalo	46.79	10.61	8.26	2.90	17.12	2.20	16.45
Colombo	68.15	11.63	6.69	1.85	5.02	1.64	5.99
Galle	41.76	20.25	8.23	4.79	11.18	4.33	9.41
Gampaha	49.49	15.45	7.71	3.55	8.73	2.92	12.59
Hambantota	40.54	24.67	7.61	3.84	11.35	2.62	10.39
Jaffna	54.85	8.62	7.21	8.49	5.58	2.21	12.80
Kalutara	44.32	26.61	5.38	2.96	10.02	4.16	7.96
Kandy	54.83	17.95	4.02	4.46	6.36	5.35	11.08
Kegalle	45.89	26.09	5.55	5.67	6.92	2.53	8.08
Kilinochchi	46.67	11.67	6.67	3.33	25.00	2.00	4.67
Kurunegala	46.61	24.34	4.48	2.93	10.86	3.78	8.37
Mannar	55.00	10.00	8.50	7.00	11.25	3.00	5.25
Matale	36.20	13.08	5.93	3.00	8.11	3.53	22.46
Matara	56.81	18.60	6.90	3.07	5.78	2.07	8.50
Monaragala	38.41	27.36	4.91	1.91	9.90	1.37	16.19
Mullaitivu	37.09	13.56	8.70	0.00	20.33	0.00	20.33
Nuwara Eliya	60.53	9.73	8.46	2.12	8.92	2.90	8.72
Polonnaruwa	35.52	25.10	8.47	3.57	7.63	3.68	16.04
Puttalam	52.75	16.88	4.88	2.67	10.42	2.75	10.06
Ratnapura	46.69	21.24	6.28	1.41	4.80	1.85	11.11
Trincomalee	27.98	20.06	4.33	12.51	22.04	1.85	18.04
Vavuniya	37.44	9.89	6.56	0.78	9.22	1.22	34.89

Source: NRI, Sri Lanka, 2003

(f) Municipal waste generation in Thailand (2002)

S.No.	Area (Municipality)	Municipal Population (Millions)	MSW (tons/day)	Per capita Waste generation (kg/day)	Per capita Waste generation (re-checked) (kg/day)
1	Chiang Mai	0.17	250	1.46	1.44
2	Nakhon Ratchasima	0.17	153	1.03	0.88
3	Khon Kaen	0.13	130	1.18	1.00
4	Hat Yai	0.16	225	1.60	1.44
5	Rayong	0.05	92	1.68	1.68
6	Chonburi	0.05	43	1.18	0.94
7	Phatum Thani	0.30	479	1.62	1.62
8	Samut Prakarn	0.77	781	1.02	1.02
9	Pattaya	0.11	163	1.54	1.47
10	Phuket	0.16	247	1.66	1.56
11	Udon Thani	0.16	128	1.04	0.82
Total/ Average		2221204	2691	1.36	1.26

Source: NRI Thailand, 2003

Appendix B: Specific Provisions for MSWM in Sri Lanka and Thailand

(i) Sri Lanka

Specific powers, functions and duties of the CEA include:

1. Making recommendations to the Government on national environmental policies and criteria consistent with the Act's objectives [clause 10(b)];
2. Being able to require any local authority (within the limits of its jurisdiction) to comply and give effect to any recommendations relating to environmental protection, including the prohibition of unauthorized discharge, emission or deposition of litter, waste, garbage and sewage; and the storage, transport and disposal of any material which is hazardous to health and the environment [clause 10(i)];
3. Undertaking investigations and inspections to ensure compliance with the NEA and to investigate complaints relating to non-compliance with any of its provisions [clause 10(l)];
4. The issuing of licenses permitting the discharge, deposition, or emission of waste into the environment. These licenses are valid for a maximum period of 12 months and are renewable [clause 23];
5. Being able to ban the deposition or emission of waste into inland waters, clause 23(h), the atmosphere [clause 23(k)] and the soil [clause 23(l)] of Sri Lanka, except when they have a license to do so and in accordance with the standards/criteria prescribed in the NEA.

The standards/criteria prescribed in the NEA include:

1. Placing any solid, liquid or gaseous wastes in or on waters or in a place whereby it may gain access to any waters [clause 23 h (2)];
2. Restrictions on burning wastes other than at the times or in the manner/place prescribed elsewhere [clause 23 k(c)];
3. The establishment on any land of a refuse dump, garbage tip, soil and rock disposal site, sludge deposit site, waste injection well, or other usage of the land for the disposal of or repository for solid or liquid wastes so as to be obnoxious or unduly offensive to human beings or which will pollute or adversely affect underground water or be detrimental to any beneficial use of the soil or surface of the land [clause 23n-2b].

The summary of NSSWM:

i. Waste avoidance/reduction

Education and awareness programs are needed to reduce the quantity of waste generated. Good housekeeping practices should be inculcated by producers as well as consumers. Reduction of excessive packaging by producers and consumers, avoidance of consumer goods with excessive packaging materials, particularly so with non-biodegradable should be encouraged. Consumers should have a preference for biodegradable. The methods of packaging, handling and transport of perishables need changes to reduce losses at market centers. Most of the cleaning, sorting and grading is done in the markets leading to large quantities of perishable wastes. Although plastics offer a unique advantages in packaging of certain products and it will virtually be impossible to eliminate its use. However reduction and appropriate types, including biodegradable polythene should be promoted. An incentive regime can be developed if life cycle costs are taken into account.

Also priority should be given to long-life products and that multi-use packaging is used instead of throwaway packaging. Household composting of organic matter should be encouraged and manufactures avoiding wastes by creating life-cycle processes such as reusing of residual material in the production process.

ii. Reuse of wastes

This aspect is not dealt in depth concerning the manufactures to encourage greater responsibility in reusing the waste in the primary product. However, the consumers are encouraged the reuse the products for some other purpose when such products are not fitted into its original intended use (Primary), if it is possible to do so in an environmentally sound manner without disposing it at once.

iii. Recycling of wastes

Sustainable solid waste management systems should be established in order to make recycling economically viable.

Composting: The high biodegradable component in waste composition and high moisture contents make composting a better option for treating MSW. In lieu of high prices of chemical fertilizers and also the health problem, the farmers should be encouraged to use MSW compost as a soil conditioner. It points out that compost made from MSW may contain heavy metals originated from contaminations and type of organic matter as the feedstock. (Therefore, Sri Lanka should have heavy metal standards for MSW compost). Marketing aspects of the MSW should be undertaken through proper authorities to encourage farmers to use MSW compost.

Recycling of glass wastes: The NSSWM relies on the Ceylon Glass Company to increase the recycling capacity to 60%, since the cost of production would be less and will reduce and facilitate saving of natural resources.

Recycling of waste paper: At present technology exists in Sri Lanka in the process of paper production. Equipment is also available in the world to produce different grades of paper from recycle paper. The policies should be developed to encourage the use of waste paper in the process of paper production.

Sanitary land filling: The definitions given in the national strategy clearly state the difference between open dumping, semi-engineered and sanitary landfills. As mentioned before, at present solid waste disposal sites are located in low-lying areas or sloping lands creating tendency for surface and ground water pollution. Open dumping should be prohibited and potential sites should be identified on a countrywide basis and necessary clearances of IEE or EIA should be obtained. The controlled landfills should be based on the guidelines provided by the CEA.

Incineration: Direct incineration of high moisture with low calorific MSW found in Sri Lanka is not economically viable and environmentally suitable. However, clinical wastes should be incinerated and residues arising from incineration should be disposed in sanitary landfills.

Energy recovery: After removal of the recyclable components, there may be considerable amount of garbage left behind which could be utilized for the generation of electricity and thermal energy.

Special attention should be paid to control air pollution when incineration is used as a strategy for waste disposal. Landfill gas and Biogas are options mentioned in the national strategy.

Sorting of wastes at source: National strategy recognizes the importance of source separation making recycling economically viable and infrastructure facilities should be established to motivate sorting of wastes at source which in turn would facilitate establishment of formal and informal waste collection systems. Therefore, educational and awareness programs on source separation should be conducted.

Integrated solid waste management strategy: Integration of the above activities in an economically feasible and environmentally sound manner could be developed by combining several LAs together depending on the amount and type of waste generated. The main objective of this strategy should be to:

- prioritize waste avoidance over recycling, and recycling over the other forms of environmentally sound disposal;
- reuse non-avoidable waste as far as possible;
- maintain the content of hazardous substances in waste at the lowest possible level; and
- guarantee an environmentally sound residual waste treatment and disposal as basic prerequisites for human existence.

Incentives and law enforcement: The strategy is to provide LAs with sufficient incentives in the form of financial and technical assistance to develop and implement solid waste management strategies in a sustainable manner and law enforcement should be coupled to these incentives in order to ensure compliance.

R&D: There is recognition given for R&D activities promoting new waste management techniques; recycling methods, reusing of materials and resources and innovations on new technologies to make successful implementation of the strategy.

Private sector Participation: The national strategy encourages private sector participation in the development of infrastructure facilities involved in collection and transport of MSW, establishment of recycling plants at provincial/regional level and involved in disposal with attractive financial and technical support, including adequate protections. It is recommended that LAs should consider privatizing the collection and disposal of wastes so as to make these activities efficient, particularly so in more urbanized areas.

Community participation: There is no specific strategy in developing community participation, except through educational and awareness programs. The levels of participation, role of NGO's, methods of establishing community-based organizations are not mentioned in the national strategy.

Role of the Government: The document indicates the need for the government to take the initiative to provide infrastructure for collection and transport of wastes. The recycling industry will be able to establish economically viable processes. A user fee should be introduced along with initial investments from the Government. This investment could be reduced with the private sector gradually taking over most of the activities in a sustainable manner. National policies should be developed to implement this national strategy of solid waste management and suitable regulatory controls should be evolved to implement these policies. The aspects of legislation as mentioned above are stated in the NSSWM.

(ii) Thailand

Public Health Act

The Public Health Act provides the powers and duties of local public organizations overseeing the suitable living conditions in their jurisdictions.

The new Public Health Act was enacted on April 5, 1992. Major difference from the former version of the Act is that the new Act specifies the stronger power for the local authorities to perform their duties. Although the power of the performing authorities is increased, the structure of these agencies is still considered vulnerable.

The Act contains major codes relevant to solid waste management, which include:

- Chapter 3 of the Act defines "Solid waste" as pieces of paper, cloth, food, commodities, plastic bags, food containers, ash, animal remains including other objects collected from road, markets and other places, and "Night Soil" means human excretions including other dirty and stinking objects.

- The disposal of solid wastes and night soil in any locality shall be under the authority of that locality, but the local authority may authorize any person to carry out this work under its control.

- No person shall be permitted to carry on a business of collection, transportation and disposal of night soil or solid waste unless a permit has been obtained from the local office.

- For the purpose of cleansing and orderliness related to collection, transportation and disposal of night soil and solid wastes, the local administration shall set forth laws or regulations in order to conduct the management in accordance with this Article as follows:

    1) Nobody shall be allowed to dump solid waste in any place, which is not permitted.
    2) Solid waste and night soil containers must be provided where necessary at public or private places.
    3) Regulations for solid waste and night soil collection, transportation and disposal must be established for the building owner or processor.
    4) Collections and transportation fees must be established, not exceeding the rate issue under the Ministerial Regulation.
    5) Regulations for the solid waste or night soil collection, transportation, disposal and service fees must be established for the Licensee under Article 19 of the Act. The maximum service charge must be also provided.
    6) Other management as necessary for health conditions should be provided.

Penalty: A person who contravenes the laws or regulations under the Act is punishable by imprisonment not exceeding six months or a fine not exceeding ten thousand Baht or both.

- The Act does not only gives the responsibility for collection and disposal of solid waste and night soil collection fees according to the fees announced in the Act.

The Asian Institute of Technology (AIT) is an international graduate institution of higher learning in Bangkok, Thailand. Its mission is to develop highly qualified and committed professional who will play a leading role in the sustainable development of the region and its integration into the global economy. Its vision is to become a leading and a unique regional multicultural institution of higher learning, offering state of the art education, research and training in technology, management and societal development.

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For details regarding publications of the Sustainable Solid Waste Landfill Project, please visit: http://www.arrpet.ait.ac.th/swlf/index.htm or contact visu@ait.ac.th