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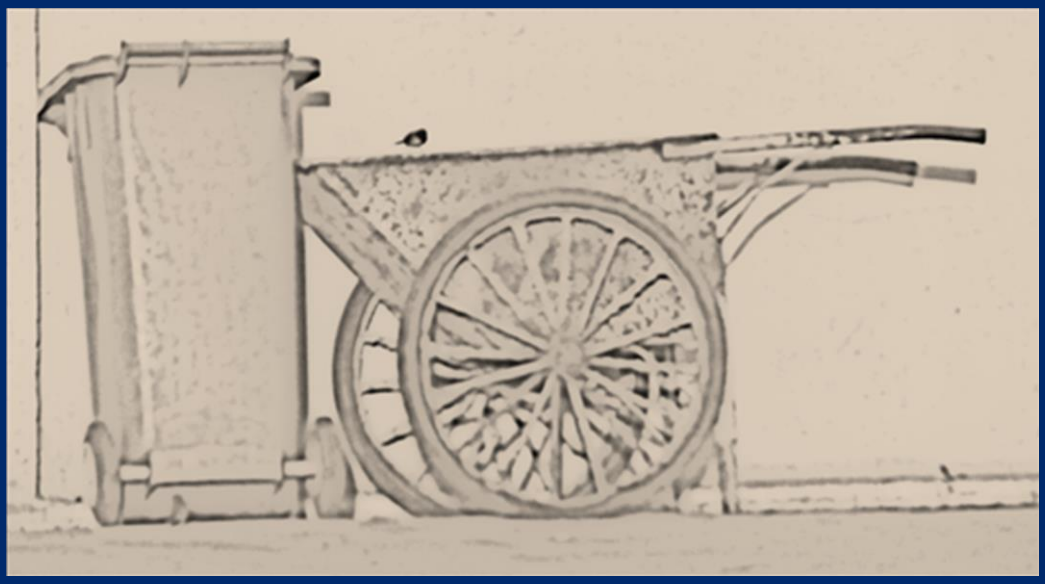
TA-8566 REG: Mainstreaming Integrated Solid Waste Management in Asia - Solid Waste Management Team (46248-001)

Integrated Solid Waste Management Plan

Mandalay



November 2016

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Contents

Executive Summary

The Integrated SWM (ISWM) Plan is a document that causes MCDC staff and advisors to consider waste management from cradle to grave and review current activities, as well as look into the future for alternatives and opportunities to improve the system overall. Success of the Plan depends upon understanding the development context and implementation priorities and responsibilities. Guidance is provided in the initial Plan chapters on how this should be done in a structured manner. This includes guidance on issues such as formation of appropriate SWM committees and Boards as required.

The nexus between the various stakeholders including the political arm of the City, their technical staff, and private sector organizations involved in any facet of Waste Management and civil society is addressed in the Plan. This even extends to the issue of information, education and communication plans to maximize Plan effectiveness not only for the initial implementation but during the entire life cycle of the Plan.

Initial sections of the Plan provide an overview of SWM at present within the municipality. This section of the Plan describes the current status and relationship between the various stakeholders in the municipality, relating to all stages of Waste Management from generation through to disposal. The Plan provides data on the physical assets such as the waste haulage trucks as the haulage responsibilities remain with the municipality rather than being outsourced at present. Similarly a description is provided on the current waste disposal facilities and how they can be upgraded to provide a better standard of operation and much extended operational life.

Understanding the legislative environment is critical to preparing a future Plan for Waste Management. This is typically divided into three levels of government, namely national or central, provincial or regional and finally municipal. Locally, the most relevant legislation is a combination of national and municipal. The city has developed five by-laws as well as some regulations relating to SWM. These could be expanded however to improve SWM controls overall.

It is important to understand the historical context for the city or municipality. This background is provided in the municipal profile chapters. Geophysical information is also provided relating to the geographical location and boundaries, overview of population, land area and topography as well as climatological data.

All aspects of ISWM Plans are predicated on a sound knowledge of the waste components and quantity that needs to be managed. These waste data are essential not only for the sizing and design of the infrastructure requirements, but also allow the social elements be better understood in terms of assistance required to increase recycling activities and other recovery operations. It was initially expected that site specific waste audits would need to be conducted. However, recent waste audits have been conducted within the city that were of a sufficient standard to ensure that the SWM Plan would still be based on appropriate data sets.

Waste Minimisation is a key component of overall SWM interventions. The Plan provides background information and a number of options including various legislative opportunities as well as noting the relevance of information and ongoing education campaigns. Some of the recommended interventions particularly relate to plastic bags and plastic beverage containers. This section also mentions household hazardous waste which based on the audit results to date that indicated HHW is not a major problem but still requires ongoing monitoring.

The existing recycling facilities have been reviewed, including the local recycling centres and smaller junk shops. This review is primarily to determine the causative

factors limiting recycling quantities at present. An outcome of this section is to list the issues currently limiting recycling and provide a program for improving recycling where appropriate. Overall the present recycling activities are successful in recovering most high-value recoverables prior to disposal.

The ISWM Plan notes that composting can occur at three different levels, namely household, community or centrally. Many examples are provided both in the text of the Plan and also in the appendices on the advantages and disadvantages of composting organics at these three levels. The default position is that household based composting (or diversion to animal feed) should be supported and that greenwaste wherever possible should be segregated for chipping and mulching or giving back to the community for gardening mulch. The city has interest in considering a number of pilot composting plants in the future.

Estimates have been made for both the future population and waste generation rates for a 30-year period. (The MCDC has indicated that it is interested in privatising collection in one township Chan Aye Thar Zan as a pilot, so the population projections have been based just on the township not the city in total.) It is recognised that significant error bands must be placed around these projections however it does provide a guide to ensuring that any new waste facilities, especially landfill sites, are suitably sized to avoid having to find new sites on a frequent basis. The adopted growth rate is low as the township is fully developed so population increases will only be due to densification.

The current waste collection services are generally substandard. A significant quantity of waste is left on the streetscape as well as being dumped or washed into the local drains and water bodies. The collection fleet is a mix of modern compactor vehicles but is dominated by old tipper style vehicles which provide no compaction. There are also some hooklift bins servicing hard to reach areas and commercial and institutional waste generators.

MCDC indicated it would like to establish a private collection service in one of the six townships within the city and that that and the privatized system should satisfy some key performance requirements. These include the maximum possible use of compactor vehicles to increase the collection efficiency and use of skip bins to be emptied mechanically into compaction vehicles (rather than ongoing use of Hook-lift bins which cannot be collected by compactor vehicles). The overall plan is to avoid waste being placed on the footpath at the informal primary dumping locations.

Guidance is provided in the Plan on the management of specific waste types such as difficult wastes, sometimes acceptable waste and prohibited wastes. This includes wastes such as hospital or medical waste, liquid waste and specifics such as asbestos.

All successful integrated SWM Plans involve a component related to information and education, particularly if sustainability is a key city focus. A number of typical IEC components are presented together with a possible approach including community training elements. The importance of the correct communications strategy is also addressed together with options and opportunities for the implementation of such a program. This includes aspects such as radio, television or community outreach through contracted NGOs, and through to mainstreaming through a school's curriculum program. The city currently has some IEC activities through various media outlets and will remain a key focus for the city.

Climate change issues are addressed and the review notes potential climate change impacts on SWM as well as climate change adaptation and mitigation steps to be considered.

There is no benefit in providing large capital interventions unless these are operated efficiently and effectively. Therefore guidance is provided on appropriate evaluation

and diagnostic tools to ensure that the municipality is maximizing returns on their capital interventions, be it financial or human capital.

City Summary and Project

The CATZ township has a population of about 150,000 persons.

There is evidence of recycling and also limited but ongoing IEC campaigns.

The collection fleet is inadequate and will be privatised in one township CATZ as a pilot for ultimate full privatisation of the city collection activities. The privatised fleet will be mainly compactors accepting waste door to door or from skip bins. It will be fully mechanised and efficient.

The private operator will be contracted to either supply the equipment as well as the staff and technology required. This option will be more fully assessed during the Pre-Feasibility study to follow.

The operation of both the northern and southern landfills is very substandard. The landfills accept waste from nearest townships within the city.

The landfills are essentially operated as uncontrolled dumps and the staff running the facility appeared unaware of the significant operational changes that are essential to improving the operation to more closely mimic a controlled landfill status. For example both sites have extensive areas of uncovered waste and is placed at very flat slopes and therefore will maximize leachate generation and associated hazards. Leachate was observed flowing off the southern dumpsite onto neighbouring properties. By operating the sites appropriately and applying sensible slope limits, then the sites have 3 to 5 year's life without extending the footprints at all. This gives enough time to develop an extension area or a new site for a controlled landfill.

The city would also like to minimize the quantity of residuals going to landfill. However the city is distant from modern kilns that could accept any Refuse Derived Fuel and therefore there is little chance of RDF being sustainable at this time. The two landfills are presently receiving the bare minimum tonnage to attract Waste to Energy providers at present, but this option should be reviewed in the medium term once the waste quantities have increased and become more attractive to international WtE contractors. The intervening period will also the government to demonstrate to the investor community an ability to let major PPP contracts.

1. Introduction

1.1. What is an ISWM Plan

An Integrated Solid Waste Management (ISWM) Plan is a document that causes Municipal staff and advisors to consider waste management from cradle to grave, review current activities as well as looking into the future for alternatives and opportunities to improve the system overall.

In summary, the ISWM planning process aims to:

a) Ensure the protection of public health and the environment;

b) Utilise environmentally-sound methods that maximise the utilisation of valuable resources and encourage resources conservation and recovery;

c) Set guidelines and targets for solid waste avoidance and volume reduction through source reduction and waste minimisation measures, before collection, treatment and disposal in appropriate and environmentally-sound solid waste management facilities in accordance with ecologically sustainable development principles;

d) Ensure the proper options are considered for segregation, collection, transport, storage, treatment and disposal of solid waste through the formulation and adoption of the best environmental practices in ecological waste management;

e) Consider greater private sector participation in solid waste management;

f) Retain primary enforcement and responsibility of solid waste management with local government units while establishing a cooperative effort among the national government, other local government units, non-government organisations, and the private sector;

g) Encourage cooperation and self-regulation among waste generators through the application of market-based instruments;

h) Institutionalise public participation in the development and implementation of national and local integrated, comprehensive and ecological waste management programs; and

i) Strengthen the integration of ecological solid waste management and resource conservation and recovery topics into the academic curricula and formal and non-formal education in order to promote environmental awareness and action among the citizenry.

In summary, developing the ISWM Plan provides an opportunity to jointly consolidate a new focus on ISWM within the Municipal environment, and use this as a base to incorporate that recent paradigm shift into all future ISWM decisions and operations.

1.2. Development Context for an ISWM Plan

This document provides the details for and structure of a solid Waste Management plan. However the plan cannot be developed and implemented in isolation of political support and civil society engagement.

The following section provides guidance on how the solid Waste Management plan should be developed and implemented in a structured manner.

1. Convene an ISWM Working Group of Cleaning and Greening or equivalent Departmental staff involved in ISWM, and any technical advisors as required such as provincial or national advisors or hired consultants, and other municipal staff involved in ISWM. The group is responsible for the actual Plan development and implementation.
2. Convene the ISWM Committee of elected representatives, MAB nominees, national or provincial government specialists, external stakeholders, technical advisors as required, and finally municipal staff from other departments such as finance, involving the Mayor or nominee and gaining general support. The ISWMC sets the priorities and policies to then be implemented by the Working Group
3. Prepare background data summary and status such as current and future serviced areas, population growth forecasts, technical assessment of existing haulage fleet, bins as well as the disposal site. This work is strictly a technical process with the political support to come at the next stage
4. Advise ISWM Committee and gain endorsement and agreement on background status. Some political input is essential at this stage to confirm current and future serviced areas etc.
5. Undertake the waste audit to determine the current waste constituents as well as the current waste density and mass leading to a better understanding of the current waste problem
6. Develop the integrated ISWM Plan including community engagement and education aspects. The details of the plan are established below involved looking in a holistic way from cradle to grave of Waste Management issues. .
7. Present the Plan to the committee for endorsement. Following this endorsement, identify clusters of similar or related activities which can be converted to projects.
8. The Solid Waste Management committee would then agree criteria to prioritize projects for implementation, and the funding required. Personnel required duration of implementation, project impact on other operations and the municipality generally and deep that is a patient of external stakeholders. Overall the consensus of the Solid Waste Management committee members is required to agree the priorities and content going forward
9. As soon as the projects are prioritised, the appropriate committee member will then formulate the detailed concept including setting the objective, coverage implementation activities, funding requirements personal responsible, resource requirements and relevant timeframes
10. Depending upon the project type, the committee may need to conduct community consultation to present the project concept, obtain feedback and improve the project concept by incorporating external recommendations

11. The final project concept would then be presented to the Mayor or equivalent, in the presence of the Solid Waste Management committee and the possible presence of representatives of the beneficiary community
12. Following obtaining the Mayor's support, the assigned department will then ensure that the required personnel and logistics are prepared and/or made available as planned. Some of the projects may not require additional budget but merely a change in the way that the activities are implemented or the closer integration with the private sector or civil society. It is expected that training activities will be required for various roles and responsibilities. Some media launching activities may be appropriate to signal the start of the project. Progress reports and budget status will be reported to the committee and then to the Mayor as appropriate during project implementation.
13. The project management team appointed by the solid Waste Management committee will then conduct regular monitoring and inspection activities during project implementation. This will be achieved by the committee agreeing appropriate metrics and indicators and the development of simple monitoring sheets. For example, for the environmental monitoring of the solid waste disposal facility, and environmental management plan will be provided that has to be simply localized for the specific facility. In terms of general operations at the waste disposal facility, the landfill Operations Manual could be used to provide and generate a simple checklist for the inspection team to monitor the quality of landfill operations.
14. At the end of the specific project, the project management team would review project implementation success based on these objectives set. Any lessons learned from this particular implementation would then be fed back into the Integrated Solid Waste Management Plan to enhance any future similar project activities.

These activities may be summarized as shown in the table below, together with guidance on the lead actor as well as the desired output:

Table 1-1 Summary of ISWM Plan Activities

Nº.	Activity	Actor	Output
1	Convene a Working Group and establish the Solid Waste Management Committee (SWMC). These can be part of existing committees or groups.	SWMC and advisors	Problem analysis
2	Ensure the Mayor is involved with the process and gain support for preparing the ISWM Plan	SWMC	Political engagement
3	Prepare city background data summary and present waste management status	Working Group members and advisors	Current status documented
4	Advise Solid Waste Management Committee (SWMC) and gain endorsement and agreement on background and status	Working Group members and advisors	Agreement on current status and shortcomings
5	Undertake the waste audit	Working Group members and advisors	Quantified waste composition and waste mass data
6	Develop the integrated ISWM Plan including community engagement and education aspects.	Working Group members and advisors	Structured plan for solid Waste Management
7	Present the ISWM Plan to the ISWMC	Working Group members and advisors	Adopted ISWMP
8	Agree criteria and prioritize projects for implementation	SWMC	Prioritised activities for Plan Implementation
9	Formulate the detailed concept	Working Group members and advisors	Activity definition and costings
10	Conduct community consultation	Working Group members and advisors/SWMC	Engaged, educated and supportive community
11	Final project concept would then be presented to the Mayor and ISWMC	SWMC	Political support for specific project implementation
12	Organize logistics for implementing project and implement	Working Group members and advisors	Basis for project implementation
13	Conduct regular monitoring and inspection during project implementation	Working Group members and advisors	Project implementation understanding
14	Modify future projects based on lessons learned from this implementation	Working Group members and advisors/SWMC	Improved future projects

1.3. Implementation Arrangements for the ISWM Plan

The Municipality is primarily responsible for developing and implementing the ISWM Plan. The main entity for the ongoing implementation of the ISWM Plan is the Municipal ISWM Committee (SWMC) guiding the implementing ISWM Working Group (SWMWG).

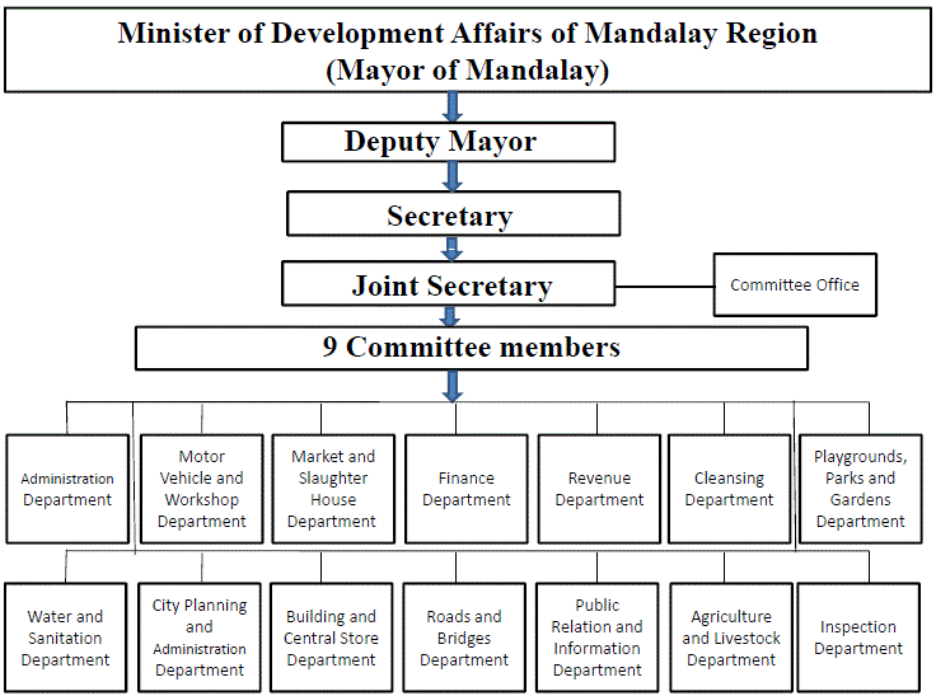


Figure 1-1 Organization of MCDC

Source: MCDC

It is noteworthy that the organization of MCDC cannot be changed easily. Any major change (such as merging or splitting departments) requires approval by the MCDC but also by the Region government and the Executive level (President of the Union of Myanmar). The institutional autonomy of MCDC remains therefore, and to this regard, limited.

Further to the general elections of November 2015, a new Mayor has been appointed by the (new) Chief Minister.

As mentioned below, it is noteworthy that an official tariff structure of the SWM service defines level of fees applicable to the customers for the SWM service.

No PMO exists at the Cleansing Department and only one PMO exists in the whole MCDC and that PMO is responsible only for the Mandalay Urban Services Improvement Project.

2. ISWM Plan Background

2.1. Overview of Solid Waste Management Locally

Waste developed in the six townships making up Mandalay is collected by the MCDC staff, and not private contractors.

The collection service is notionally door to door, however large areas are serviced by community bins and informal primary dumping areas located throughout the city. These bins are also used by commercial and institutional waste generators.

The collection fleet is a mixture and of waste compactor vehicles, tipping vehicles, hook lift bins with both covered and uncovered containers, small tricycle collection vehicles and push carts. Overall the collection service is barely adequate and improvements are required to bring Mandalay into line with the more progressive cities in the region.

Waste is taken to one of two dumping sites located to the north and the south of the City respectively. Both dump sites are operated essentially as uncontrolled open dumps but with some attempts to provide limited compaction and cover.

The available footprint area has been almost fully utilized at both sides. However the depth of waste at both sites is less than 10 metres indicating that by operating the sites with the usual compaction and batter slopes, then between 3 to 5 years of additional life is available without extending the footprint area.

A number of information and education campaigns have been undertaken and materials are available for the ongoing campaigns subject to available funding.

Significant recycling occurs at all stages of the waste cycle, starting with households sales of high value recyclables to private sector operators going door to door, recovery from the primary dumping locations and from scavenging activities at the final dumping sites.

Other studies are investigating upgrades to the disposal facilities so it was agreed with MCDC that the focus of this RETA would be privatisation of collection in one township.

2.2. Employment (labour force) involved in collection activities

MCDC staff are recognized as having the same status as government staff, although there is no definite clause or provision in the MCDC law or Regional Government notifications to that effect. There are many similarities between MCDC staff body and government departments.

- Although MCDC operates on its own financial/revenue resources, its budget is allocated according to Annual Budget Bill passed by the Regional Government.
- MCDC's books of accounts and other financial documents are subject to inspection and review by the Regional Budget Department
- Planning and Implementation status of MCDC needs to be reported regularly to the Chief Minister of Regional Government.
- MCDC staff are also entitled to salary, travel and daily allowances, pension, gratuity, compensation, holidays, and other benefits which are allowed to government employees.

- Like government staff, MCDC staff are governed by the Civil Service Rules and Regulations published by Union Public Service Board, which is a ministry under the Union Government

2.2.1. Delegation of Authority

All activities planned and implemented by MCDC staff need to be submitted to the Committee for information, review and approval. Heads of Departments have the authority to submit their suggestions to the Committee but have no authority to make decisions.

MCDC staff are employed by the Committee. Staff starting from the Heads of Departments down are not entitled to be elected to membership on the committee, because they are staff who are appointed to the positions provided in the organization chart.

2.2.2. Recruitment of MCDC Staff

Recruitment of MCDC staff follows a standard procedure prescribed by the Committee.

As mentioned above, internal selection boards are organized for the purpose. The recruitment procedures may involve written examinations, personal interviews and other assessment methods. The list of candidates is submitted to the Committee headed by the Mayor and final approval is given by the Committee.

2.2.3. Staff Rules and Regulations

Like government staff, MCDC staffs are governed by the Civil Staff Rules promulgated by the Union Public Service Board for all civil servants throughout the country.

MCDC is a development-oriented organization and it is not an administrative body and therefore it has no administrative power like for example, General Administrative Department. However, its staff management is the same as those exercised in government departments.

2.2.4. Categories of Staff

The following categories apply:

- **Permanent Staff** – They are appointed to work at the positions created in the organizational set-up.
- **Daily Waged staff** – Their payments are calculated on working days basis.
- **Piece rate Staff** – They are employed to meet the workload required for a certain period of time.
- **Flat pay Staff** – They are usually employed for their specialize skills needed by MCDC.

2.2.5. Staff Summaries

The number of employed labour increased rapidly between the years 2005 and 2013 from 911 up to 1942 workers, and this workforce is mainly involved in primary collection. Based on field surveys and employee feedback it has been assumed that approximately 25% of employed workforce are working as drivers of heavy vehicles, 20% in secondary collection and 55% in primary collection.

Current total population within 6 townships is 1,215,970 with a current employment figure of 1942, which results in 626 inhabitants/employee. An average mechanization rate and a non-optimised administrative to operative staff ratio allows

collection/treatment (need verification) rate of 650 tons/employee per year whereas a highly mechanized system with an optimized employee ration allow a collection/treatment rate of up to 1600 tons/employee per year.

In Chan Aye Thar Zan Township, MCDC is providing door to door collection services in twenty wards, of which seventeen wards have the door to door collection for all the streets. In the remaining three wards, MCDC provide the community collection service on the main roads. The ward administrators manage the collection services in the small streets and cleansing department with their collection trucks collect the waste from the main streets. In that case, MCDC provide fuel, collection vehicles and the salary of collection labour directly to the ward administrator.

A total of 51 different collection points (open collection points and TC tanks) are located in the whole township.

2.3. Legislative Environment

2.3.1. National

By the provisions stated in the Constitution of the Republic of the Union of Myanmar 2008, City Development Committees are constituted by City Development Committee Law in three cities (Yangon, Mandalay and Nay Pyi Taw). The law in each city is drafted by individual city development committees and passed by the Regional or State Hluttaw (or parliament) with the recommendations of Regional or State Attorney General. Townships within the municipality areas of each city are governed by the law. (Note: previously, city development committee laws were passed by the national legislation bodies)

Finally, Department of Rural Development (under the Ministry of Rural Development) is responsible for the development of rural areas outside of municipal boundaries of township development committees.

Laws that relate to solid waste management in Myanmar are:

- **Table 2-1 Solid Waste Management Legislations in Myanmar**

	Legislation	Description
1.	The Yangon Water-works Act, 1885	Prohibitions on the pollution of water works in the city of Yangon
2.	The City of Yangon Municipal Act, 1922 (The Law Amending the City of Yangon Municipal Act, 1991)	Provisions relating to environmental sanitation, pollution of air and water, and public health
3.	The Water Power Act, 1927	Prohibitions on the pollution of public water; and provisions for the use of water in the pursuit of energy production and mining in a manner which does not harm land, watersheds or "localities" [meaning unclear]
4.	The Underground Water Act, 1930	Prohibitions on accessing and using underground water without a license
5.	The Factories Act, 1951	Provisions for the proper disposal of waste and effluents in factories; treatment of waste water; regulations for health and cleanliness in factories, and the prevention of hazards
6.	The City of Yangon Development Law, 1990 (Amended in 1995 and 1996)	Provisions relating to environmental sanitation, pollution of air and water, and public health
7.	The Development Committees Law, 1993	Provisions relating to environmental sanitation, pollution of air and water, and public health
8.	The Mandalay City Development Law, 1992	Provisions relating to environmental sanitation, pollution of air and water, and public health
9.	The City of Mandalay Development Law (2002)	Provisions relating to environmental sanitation, pollution of air and water, and public health
10.	The Nay Pyi Taw Development Law (2009)	Provisions relating to environmental sanitation, pollution of air and water, and public health
11.	The Union of Myanmar Public Health Law, 1972	Provisions for protection of people's health by controlling the quality and cleanliness of food, drugs, environmental sanitation, epidemic diseases and regulation of private clinics.
12.	Prevention and Control of communicable Diseases Law (1995) (Revised in 2011)	Provisions to prevent the outbreak of communicable diseases; regulate environmental sanitation; and measures in the event of a disease epidemic
13.	Mandalay City Development Committee Law 2015	Provisions relating to environmental sanitation, pollution of air and water, and public health
14.	Pollution Control and Cleansing Rule	
15.	The Protection of Environment Directive	

2.3.2. Provincial

Provisions under Schedule II of The Constitution 2008 delegate power for administration of development sector to regional or state governments. Accordingly, regions and states have their own development committee laws governing urban development sector. For example, Mon State and Kayin State has promulgated their own State Development Committee Laws. In the absence of Bye-laws, State or Region Development Committees issue Orders, Notifications, Instructions, etc. which are enforceable by concerned authorities.

2.3.3. Municipal

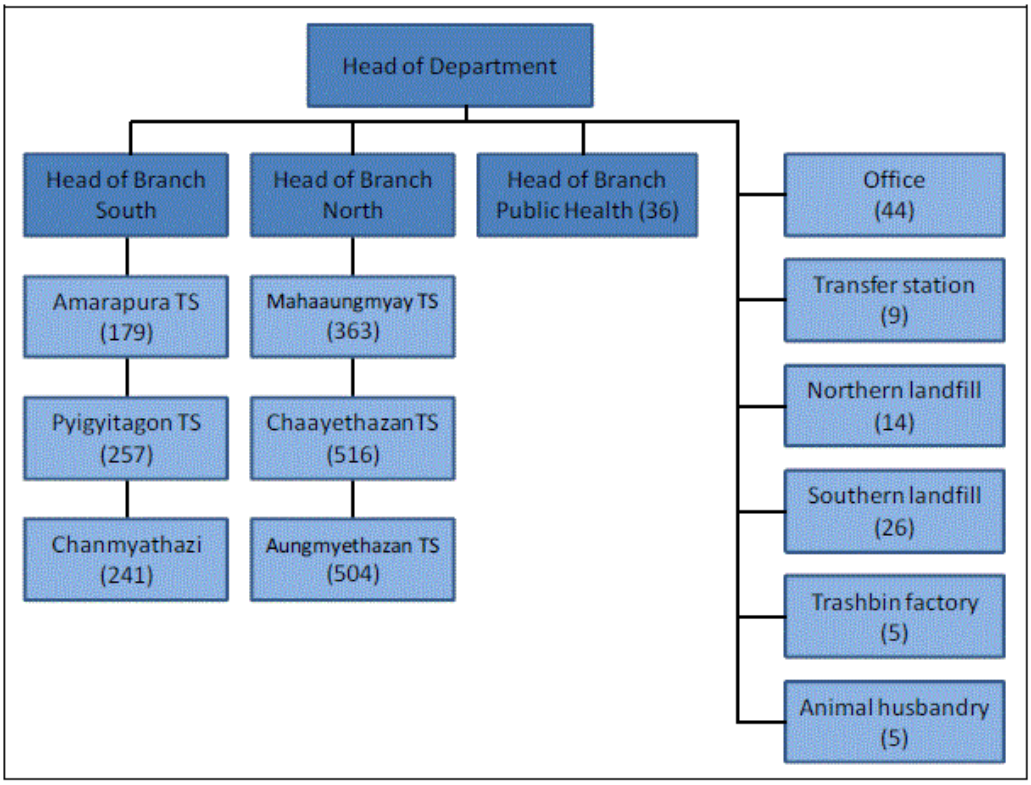
Five bylaws serve as a framework to the activities performed by the Cleansing Department:

- The Environmental Conservation and Cleansing Regulations;
- The bylaw on “Animal Husbandry”;
- The bylaw on “Guesthouses, boarding houses and room rental”;
- The bylaw on “Health”;
- The bylaw on “Supervision” (relates to business licensing).

In terms of Solid Waste Management, the Environmental Conservation and Cleansing Regulations, issued on 30th December 2013, provides:

- A description of MCDC’s responsibilities in terms of cleansing and provision of the solid waste collection service;
- A description of the obligations of citizens’, businesses, health facilities, etc. with regard to the wastes disposal;
- Provisions related to the payment of the service;
- Other provisions related to environmental conservation and management of dead bodies.

2.4. Institutional Environment



Source: GRET

- **Figure 2-1 Organization chart of the Cleansing Department (October 2015)**

The SWM service is mainly the responsibility of the Cleansing Department even if other departments of the MCDC also play a role in the SWM service:

- The Market & Slaughter Department is responsible to clean the markets and to gather the wastes so as to facilitate their collection by the trucks of the CD;
- The Motor Vehicle & Workshop Department is responsible to manage the purchase and the maintenance of all MCDC vehicles, including the waste collection trucks;
- The Revenue Department and the Administration Department play a role to prepare the collection of the Garbage collection fee included in the "Municipal Tax" (see above).

Beside the SWM service, the Cleansing Department is responsible for:

- The cleansing of roads and drainage channels;
- The cremation of bodies, management of burial, etc.;
- The provision of license to all commercial facilities (hotels, restaurant, shops, etc.);
- The management of a trash bin factory and of a kennel.

Lastly, the CD is also involved in the final inspection of works related to the construction of hotels and in the inspection of food production businesses (along with the Food and Drugs Administration).

The organizational chart above has been drawn from a previous organizational chart and from a list of staffs dated 31st of May 2016 provided by the CD. From that

document, it appears that there are a total 2,197 staff currently working for the CD, which include:

- 8 staff officers;
- 1 head of office;
- 4 branch clerks;
- 6 upper level clerks;
- 10 lower level clerks;
- 26 skilled labours of various level;
- 5 health officers;
- 43 supervisors;
- 1,494 sweepers and waste collectors (93 permanent and 1,401 temporary);
- 220 drainage workers (2 permanent and 218 temporary);
- 375 night-time waste collectors (only temporary);
- 20 staff from other departments.

Only about 200 staff of the CD are permanent while others are temporary workers. The PPTA study mentions that monthly salary per capita for the permanent staff was on average $100 and the salary of a CD worker was approximately Ks 3,500 per day in 2014.

Apart from the executive managers (Committee Member in charge of the sector, Head of Department and of Branch, plus some engineers), other staffs managing and operating the SWM service did not receive any specific training.

The Market and Slaughter House department is responsible for the collection of solid waste at the Market place. But that department provide the collection service only for the markets which are paying for the tax for market. So the Cleansing Department provide the collection service for the small markets in the wards (mainly on the street) which have tax exception.

The Parks and Playground Department have green waste in their gardening and decoration of the parks and in that case the Cleansing Department has to provide for the collection of green waste and there are no charges need to be paid by that department. The parks and Playground department has their own trucks but the trucks are used only for the moving of their plants to the garden and parks.

The Motor Transport & Workshop Department is managing vehicles, drivers, the cost for fuel and the maintenance of the fuel for the waste collection trucks. But the supervisors from Cleansing Departments manage/supervise the operation of collection trucks in the township.

The current process to develop a solid waste project is as following:

1. Study conducted by the Mandalay City Cleansing Department (MCCD) to prepare a project document, approved by MCDC
2. The project document is transferred to the Mandalay Regional Government (MRG), namely the Cabinet. The Cabinet then requires the various regional-level ministries to comment the project (such as the Land Administration Department in the case of a landfill project).

3. Usually, and before the formal submission of the project to the MRG, the MCDC starts exchanges with the concerned departments of the MRG in order to facilitate the approval process.
4. For large project, the project document is transferred to the Union's Cabinet for approval. Comments are provided by various central administrations, in particular the Myanmar Investment Commission, the Ministry of Natural Resources and Environment Conservation (MoNREC) and the Attorney General's Office.
5. The project is considered by the Environment Conservation Department to check that environmental protection measures are planned
6. Small projects require the approval of MRG but no approval at the Union's level.

The data are then forwarded to MCDC. At MCDC level there is the Planning Committee to make plans for the city areas covering all residential wards. Members of the MCDC Planning Committee include Mayor, Committee Members and Heads of all departments. MCDC based their plan preparation on the policy guidelines of Regional Government. The final plan with budget is submitted to Mandalay Region Government. At regional government level, there is a Vetting Committee (chaired by Regional Chief Minister) to review and approve the plans and budgets.

Then Chief Minister presents the plan and budget in the Hluttaw which will pass the plan and budget with a draft bill. The bills from all state and regional Hluttaw are then submitted to Finance Commission (created by the Constitution) at the Union Government level. All the State and Regional Government Chief Ministers are members on the Finance Commission. With the recommendation of FC, the annual plan and budget will be passed to National Hluttaw and promulgated as Budget Law.

2.5. Previous Studies and Investigations

Several studies and projects are ongoing or under preparation in Mandalay's SWM sector, including the following:

- A project under implementation within the framework of the ASEAN ESC Model Cities program;
- An ongoing project, funded by UNEP and implemented by the Japanese Institute of Global
- Environmental Strategies (IGES), entitled "Development of the Solid Waste Management (SWM) Strategies at National and City Level in Myanmar, Cambodia and Nepal" and hereafter referred as "IGES Project";
- An ongoing project funded by the KOICA called "*Capacity Development Program on Solid Waste Management*" and hereafter referred as "KOICA Project";
- A Technical Assistance project funded by the ADB and implemented by the American consulting firm AECOM (under preparation), hereafter referred as "ADB TA Project";
- The MUSIP project whose content will be defined based on the FASEP study (funded by the French Government) and the PPTA study (funded by the ADB and the AFD) carried out by the consulting firm Suez Consulting (ex Safège) in 2014/2015.

2.5.1. ASEAN E.S.C. model cities program

This project is funded through the regional ASEAN ESC Model Cities program and implemented by the MCDC. It started in 2013 and stems from MCDC's observation

that there is a lack of cooperation and awareness of the population on solid waste disposal. The project therefore aims at upgrading the people awareness and public participation in the SWM sector. Capacity building and awareness activities firstly target students, teachers and NGOs. To do so, MCDC prepared an awareness program on waste segregation based on short movies and essay competitions for the students and teachers to motivate ideas and activities.

For the current year (Year 3 of the program), activities include the sharing experience with Monywa city through a workshop on “Promotion of Environmental Education”, the organization of a national workshop on “Reliable data collection in the SWM system” as well as the continuing of awareness-raising activities.

2.5.2. IGES project

As described in the Project Cooperation Agreement (PCA) between UNEP and IGES, the overall project’s objective is to comprehensively support the set-up of a national legislative framework through awareness-raising, capacity building (through knowledge generation and dissemination), development of city and national level strategies and action plans, and pilot demonstrations. More specifically, IGES will undertake under this PCA the following activities:

- Development of national and city level waste management strategies in Myanmar, Cambodia and Nepal;
- Development of National and City-level Waste Management Strategies with the Action Plan;
- Finalization of Strategies and Action Plan and identification of Pilot / Demonstration Project;
- Launch of Strategies and Action Plan and identification of Pilot / Demonstration Project.

2.5.3. KOICA project

Only little information has been collected about this project from KOICA website. It seems that the project is a 3-year program mainly consisting in 2-weeks training sessions in Korea provided by the Korea Environment Corporation. The objective of the last training session (2015) was to:

- Understand various activities and policies on Solid Waste Management;
- Learn practical waste management methods: from generation to disposal;
- Find how to write proposals to seek funding for an environment project successfully.

MCDC Committee member in charge of the SWM mentioned that further to this training, a request has been submitted to the KOICA to replace the incinerator located at the Southern landfill. According to the same person, the request has been approved and studies should be launched soon for an implementation in 2017.

2.5.4. MUSIP project

The general objective of Mandalay Urban Services Improvement Project (MUSIP) is to assist MCDC in its strategy to turn Mandalay into a Green City, with a particular focus on improved environmental performance, equity in service provision and improved finances. The project, which results from a feasibility study co-financed by the Asian Development Bank (ADB) and the Agence Française de Développement (AFD), will be divided into three components:

- Water supply management;
- Wastewater and drainage management;
- Solid waste management.

No funding has been committed yet for the “Solid Waste” component and there is therefore no clear view on its implementation timeframe. As defined in the project document, the program proposes to adopt a stepwise approach in order to cope with urgent needs while anticipating the future development of the city. Details about the content of the program and its phasing are provided in the FASEP report (see document ST2) and a map locating the main investments is proposed below. The expected objectives of the “Solid Waste” component of MUSIP project are:

- A collection rate of 95% by 2020 and 100% 2025 (it is currently estimated at 85%) by the renewal of the fleet of vehicles by compactor trucks and the development of waste reception facilities (by 2015), the replacement of primary collection system with secondary collection mechanism (by 2020) and, lastly, by the implementation of a dual collection system for recyclable and non-recyclable wastes (by 2025);
- Sorting of recyclable waste up to 11% by 2020 and 27% by 2030;
- Segregation of hazardous waste up to 25% by 2020 and 75% by 2025;
- The mitigation of the risks caused by the current landfills on environment and human health by the immediate creation of a disposal facility compliant with international standards and the rehabilitation of the existing incinerator for medical waste;
- The reduction of waste sent to the landfill by the implementation of sorting facilities for organic and recyclable material by 2020 and Refuse-Derived Fuel (RDF) sorting and treatment by 2025.

2.6. Proposed Guiding Framework

The current project will build upon the previous work and take it to a level which has community, civil society, commercial and government support for a sustainable project and appurtenant activities.

Whilst the terms of reference provide clear direction for this activity, an umbrella framework is proposed as set out below which brings together the various elements of an eclectic integrated Solid Waste Management plan.

This approach is built upon the UNDP/UNCHS (Habitat)/World Bank/SDC Collaborative Programme on Municipal Solid Waste Management in Low-Income Countries Conceptual Framework, SKAT Working Paper No. 9. This document provides an effective guideline for the goals and overall aim of such a project, taking account of the key political, institutional, social, financial, economic and technical components. The programmatic approach below has been prepared to include a number of key elements and activities which directly reflect the needs of the current project.

Table 2-2 Goals, Aims and Objectives of ISWM Plan

Goals			
To promote the health well-being of the Entire urban population	**To protect the quality and sustainability of the urban environment**	**To promote the efficiency and productivity of the urban economy**	**To generate employment and and income**

Overall Aim
To establish sustainable MSWM systems which meet the needs of all citizens, including the poor

Strategic Objectives					
Political	**Institutional**	**Social**	**Financial**	**Economic**	**Technical**
Determine MSWM goals and priorities Define clear roles and jurisdiction for MSWM Establish an effective legal and regulatory frame-work	Devolve responsibility and authority for MSWM to local governments Establish effective municipal institutions for MSWM Introduce appropriate management methods, procedures and service targets Build municipal capacity for MSWM Increase efficiency and through private sector involvement Extend lower cost MSWM service through community participation	Orient MSWM to the real needs of people, including the poor, women & children Encourage proper waste handling patterns by the population Raise people's awareness of MSWM problems and priorities Mobilise community participation in local waste management Protect health and socio-economic security of waste workers	Establish practical and transparent cost accounting and budgeting systems Mobilise adequate capital investment resources Raise sufficient revenues for recurring expenses -ensure adequate O&M Improve the efficiency and reduce costs of MSWM service	Promote economic productivity & development through adequate MSWM service Environmentally sound waste collection, recovery and disposal Ensure long-term economic effective-ness of MSWM systems Promote waste minimisation and material efficiency Generate employment and incomes in waste management	Achieve low life-cycle cost of waste management facilities and equipment Technology that facilitates user and private sector collaboration Ensure that technical systems effectively limit environmental pollution

Strategic Issues					
Relative priority of collection services in relation to safe waste disposal Priority attributed to waste minimization -reduction and recovery Meeting the service needs of irregular and illegal settlements Mix of instruments for waste management: regulations, incentives and/or motivations Contribution of ESAs to MSWM policy formulation	Optimal distribution of functions and responsibilities? Devolution of MSWM responsibility in spite of limited local government capacity Involving local governments in system planning and development Responsiveness of waste management to real needs and demands Raising the professional standing of waste managers	Adaptation of waste management services to the needs of poor households and women Effectiveness of awareness building or direct community involvement Equity of MSWM service access to the poor Collaboration with and support of informal waste workers	Failing incentive of local institutions to use available cost accounting methods Use of collected revenues for the intended MSWM purposes Incorporating incentives for cost reduction and efficiency	Trade-off between low-cost waste service and environmental protection Control of industrial and hazardous waste in spite of small, scattered sources Trade-off between efficiency of waste service and employment creation	Coherence of technical systems in spite of differing requirements and decision makers Estimation of life-cycle costs of technical alternatives Appropriate standards forsanitary landfill design and operations

3. City/Municipal Profile

3.1. Historical Background

Mandalay is the second city and capital of the central dry region and is considered by many to be the capital of Myanmar culture and the Buddhist religion. It is the second largest city in Myanmar with a population of approximately 1.25 million and is on the crossroads of routes linking Laos, Cambodia, Thailand and Vietnam to India and is also on the link between China and the Andaman Sea. Growth is very fast in Mandalay at just under 3 percent per annum since 1998.

Unlike the main city of Myanmar, Yangon, Mandalay is not an ancient city. The layout was planned by King Mindon in 1857 as a new capital city for the kingdom of Ava. The original site was determined by religious considerations: it was to be 66 km2 in area, consisting of a 144-square block grid, with a 16 square block royal palace compound at the centre close to Mandalay Hill.

Mandalay District is a district of the Mandalay Division in central Myanmar. Though the district used to consist of two cities, Mandalay and Amarapura, today, with the urban sprawl of Mandalay capturing Amarapura and Patheingyi, the district and the city of Mandalay have become effectively one and the same. However, according to MCDC documents they are currently responsible for providing urban services in 6 of the 7 townships excluding Patheingyi.

3.2. Geographical Location and Boundaries

Mandalay city sits in the middle of a large plain, bordered by the Irrawaddy (Ayeyarwaddy) River on its western side, the hilly plateau of the Shan State in the east. The city is generally flat and lies at an elevation of around 75 meters above sea level. The only but noticeable topographical feature of the city is the Mandalay Hill, located at northernmost part of the city and culminating at 240 metres above sea level.

The total area of the City is now 315 km² (or 121.5 miles²) and consists of 6 townships, further divided into 96 wards, 42 village tracts and 170 villages. The 4 townships (Aungmyethazan, Chanayethazan, Chanmyathazi and Mahaaungmye) of the original city of Mandalay were joined in 1993 by Pyigyidagun and in 2011 by Amarapura. Main features of the townships are as follows:

- Aungmyethazan Township is the northernmost one and includes Mandalay Palace and Mandalay Hill;
- Chanayethazan Township includes Mandalay railway station and is the oldest and the second densest township of the city;
- Mahaaungmye Township is the densest township of the city, located in the middle of the urban area;
- Chanmyathazi Township is quite a dense township as well which includes Kantawgyi Lake;
- Pyigyidagun Township is developing fast since the early 2000s and includes the main industrial zone of Mandalay city;
- Amarapura Township is the bigger township in terms of size and still mostly rural except for its northern part.

3.3. Population

Mandalay is the second largest city of Myanmar after Yangon. According to the national Census 2014, Mandalay city's population is 1,463,164 inhabitants with 1,306,370 inhabitants living in urban area (89%) and 156,794 inhabitants living in rural area (11%). However, data from the General Administration Department (GAD) which are likely to be more accurate, mentions a total population of 1,134,577 inhabitants (945,191 in urban area and 189,386 in rural area) as of May2016. According to the same source, the total number of households is 233,062, i.e. 4.87 inhabitants per household.

- **Table 3-1 Population Distribution of Myanmar**

Township	Urban area				Rural area					Total		
	Wards	House	Household	Population	Village tract	Village	House	Household	Population	House	Household	Population
AungMyeThaZan	19	29,798	35,154	182,155	-	-	-	-	-	29,798	35,154	182,155
ChanAyeThaZan	20	22,001	33,077	146,481	-	-	-	-	-	22,001	33,077	146,481
MahaAungMyay	18	32,522	39,197	190,341	-	-	-	-	-	32,522	39,197	190,341
ChanMyaThaZi	14	35,891	39,424	212,540	-	-	-	-	-	35,891	39,424	212,540
PyiGyiTagon	16	28,465	30,606	151,614	-	-	-	-	-	28,465	30,606	151,614
Amarapura	9	10,551	13,423	62,060	42	170	34,661	42,181	189,386	45,212	55,604	251,446
TOTAL	**96**	**159,228**	**190,881**	**945,191**	**42**	**170**	**34,661**	**42,181**	**189,386**	**193,889**	**233,062**	**1,134,577**

Source : GAD

As shown on the below table and map, the number of inhabitants of each Township is quite even but their density varies from 1,212 inhabitants per square-kilometer in Amarapura to 12,844 inhabitants per square-kilometre in Mahaaungmyay. The densest areas are located in the northwestern and central parts of the city with a density higher than 20,000 inhabitants per square kilometer in some wards.

The urban population of Mandalay is expected to continue to grow rapidly due to its strategic role as part of the bi-polar development of Myanmar. The DUHD Concept Plan Vision 2040 examined a range of population projections and concluded that the main city area could grow to between 1.7million and 2.5 million in the next 30 years, assuming an average annual growth rate of between 1.01% and 2.1% from 2011.

However, MCDC itself is projecting a much higher population of around 4.0 million by 2040 using a revised and expanded city boundary which includes 3 new townships. Given the uncertainties in existing population and growth rates, the PPTA study has made an assessment of land suitability and future availability to determine likely population carrying capacities of areas.

A key feature of this revised plan is the limiting of development of the city into the agricultural area to the east of the main city with development of two areas to the south and north of the existing city area. The project takes a conservative line by assuming that 90% of the population in Development Area 1 (Amarapura) and 60% of Development Area 2 (Patheingyi) will be in place by 2040. This would result in a population of 2.34 million persons by 2040.

There is no precise information on the floating population coming and leaving Mandalay city. However, interviews with local stakeholders showed that there is a significant, yet difficult to assess, number of workers coming from Patheingyi Township on a daily basis to work in Mandalay as skilled laborers (carpenters especially). It is also likely that some workers come to Mandalay for longer periods according to working opportunities.

As one of the main tourist destination in Myanmar, the tourist population of Mandalay should also be taken into account in demographic projections. The FASEP study (see document ST2) compares the projections of the Tourism Strategy 2013-2020

developed by the Ministry of Tourism and a projection rate based on a steady annual tourist growth rate of 6% (in line with the anticipated economic growth rate of the city).

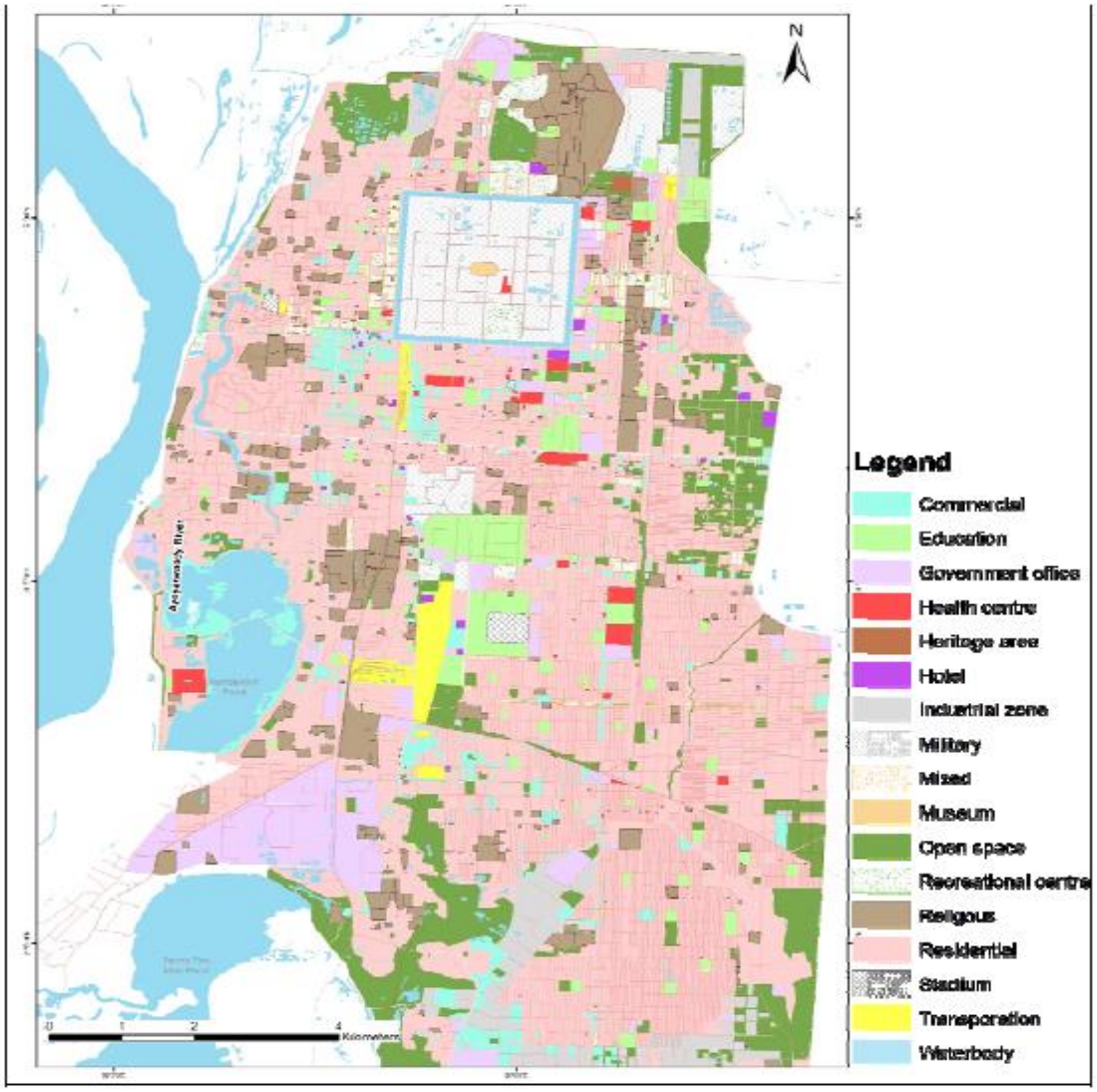
Results are very different with the second assumption looking much more realistic. Indeed, while the projections of the Ministry of Tourism conclude that the number of tourists visiting Mandalay will be 2,089,844 per year in 2020, the second estimation concludes that they would be only around 420,843 (against 183,363 in 2011).

- **Table 3-2 Population of Chan Aye TharZan Township**

Chan Aye TharZan Township						
No.	**Ward**	**Area (sq. mile)**	**Population**	**Household**	**House**	**Remarks**
1	KanKauk	0.997	12037	2443	2156	The biggest ward in the township. The ward administrator manages the waste collection in the small streets.
2	PyiGyiMyat Shin	0.591	8279	1575	1318	The ward administrator manages the waste collection in the small streets.
3	PyiGyiMyatMhan	0.325	5183	862	902	The ward administrator manages the waste collection in the small streets.
4	Pat KonePyawBwe	0.303	4594	947	722	Waste collection by the Cleansing department.
5	Pat Kone Wunn Kyin	0.155	4101	858	720	
6	Yan Myo Lone	0.192	6091	1109	1084	
7	Maw Yagi War	0.208	9778	1876	1686	
8	SateTaYaMahi	0.175	6242	1072	748	
9	KissaNaMahi	0.28	9387	1910	1425	
10	Hay Mar Zala	0.211	7105	1485	639	
11	Chan Aye TharZan (East)	0.112	6675	1103	895	
12	Chan Aye TharZan (Middle)	0.111	4638	939	586	
13	Chan Aye TharZan (West)	0.089	1317	282	179	
14	AungNannYeikThar (East)	0.275	9394	1757	1462	
15	AungNannYeikThar (West)	0.161	7732	1492	1115	
16	PyiGyiPyawbwe (East)	0.109	4979	1038	950	
17	PyiGyiPyawbwe (West)	0.23	15050	3502	2416	
18	Thiri Hay Mar (East)	0.15	3916	827	655	
19	Thiri Hay Mar (West)	0.176	7384	1557	172	
20	Day Wunn (West)	0.997	9687	2048	1313	
	Total	5.847	143569	28682	21143	

3.4. Land Area and Topography

As mentioned below, several development plans have been (and are still being) prepared for Mandalay city and region. The following map illustrates the land use within the urban area of the MCDC as of 2014.



Source :Kyaw Zeya Htun

- **Figure 3-1 Land Use Map of Mandalay**

The main documents collected with regard to urban development planning are the following:

- The “Development study for Mandalay and the region” developed by the Chiyoda Corporation in 1995. It is the most ancient document which has been collected on this topic and it is likely that it served as the basis of all subsequent urban plans;
- The “30 years town plan” (see document UB3) developed by the MCDC along with DUHD and the GAD in 2012;
- The “Mandalay City Development Concept Plan Vision 2040” prepared by the DUHD in 2012 based on the 30 years town plan previously developed by MCDC;

- The final report of ADB-funded “Capacity Building Support for Project Identification” which aimed at preparing a scoping study for a Strategic Development Plan for Green Mandalay.

Since these plans have not been prepared at the same time and by the same entities (DUHD, MCDC, consultant, etc.), it is quite difficult to assess whether they are all consistent with each other. The PPTA study, dated from June 2015, is one of the most recent documents which has the particular interest of proposing an analysis of the aforementioned documents and of identifying potential development opportunities on this basis, as illustrated on the below figure.

3.5. Climate

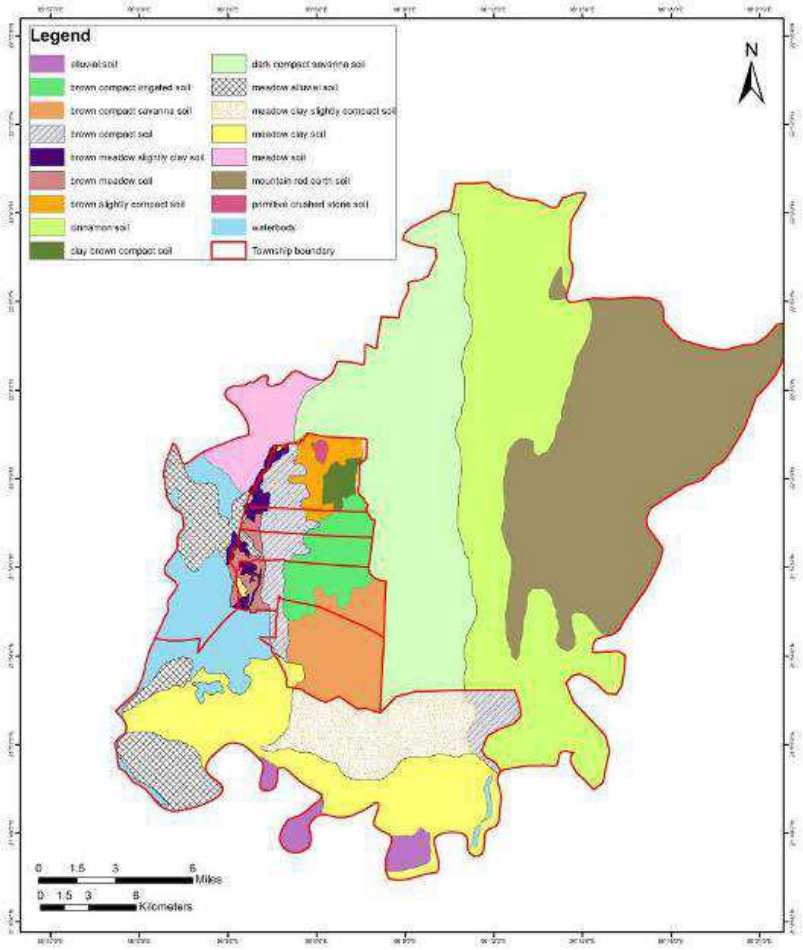
Mandalay lies in the centre of the "Dry Zone" area of Myanmar. The Dry Zone stretches across the southern part of Sagaing Division, the western and middle part of Mandalay Division and most parts of Magway Division. It is one of the most climate sensitive regions in Myanmar. The region is characterized by low annual rainfall with an average of 847 mm over the period from 1949 to 2013, ranging from as low as 409 mm (in 1949) to a maximum of 1,542 mm (in 2006). The monsoon rain is bimodal, ranging from May to October with a dry period during July when dry desiccating winds blow from the south. October is generally the wettest month of the year.

The dry season lasts from November to April, December to March being with almost totally dry. Over a period of 40 years (1974-2013) the average annual maximum temperature in Mandalay was33.4°c and average annual minimum temperature 22.2°c. Hottest month is April (Max. temp. average38.8°c) and coldest is January (Min. temp. average 13.5°c).

3.6. Current Disposal Site Soils and Hydrogeology Details

The geological succession of the Mandalay Region is composed of a mixture of the units which are typically exposed in the Eastern Highlands Province and in the Central Myanmar Belt. In Mandalay city, soil is composed of Quaternary unconsolidated sediments of Middle Pleistocene to Holocene age: the fluvial sediments of the Ayeyarwaddy River and the piedmont colluvium deposits from the marginal highlands of the Shan Plateau.

The total thickness of the sediments reaches to 180 m near the Ayeyarwaddy River in Mandalay. Probably the former is distributed mainly in the western area and the latter is mainly in the eastern area with inter-fingering relationships. However, the boundary is still unclear due to lack of detailed geological information. Rock types in Mandalay region include both hard rocks such as limestone, dolomite, gneiss, schist, and granitic rocks, and soft rocks such as sandstone, shale, limestone and conglomerate.



Source: PPTA

- **Figure 3-2 Geological Map of Mandalay**

4. Waste Audits and Load Determination

4.1. Introduction

All aspects of this ISWM Plan are predicated on a sound knowledge of the waste components and quantity that needs to be managed.

These waste data are essential not only for the sizing and design of the infrastructure requirements, but also allow the social elements be better understood in terms of assistance required to increase recycling activities and other recovery operations.

4.2. Previous Waste Audits

A number of previous audits have been undertaken and are summarised below.

- **Table 4-1 Previous Audit Results**

Source of information	MCDC*					ASEAN ESC		FASEP	Towards GM**
Date of reference	***2012***	***2013***	***2014***			***2005***	***2014***	***2015***	
Solid waste generation [ton/day]	301.60					250	1024	932	500 to 800
Solid waste generation [kg/cap/day]	0.35							0.73	0.64
Waste density [kg/m^3]								219	
Basic composition [%]									
Organic								65.5%	
Recyclables								30.0%	
Hazardous, inert and other material								4.5%	
Detailed composition [%]									
Plastic	22.1%		14.0%					14.5%	
Vegetables, leaves, street refuse	37.4%		55.0%					65.5%	
Woods, bamboo pieces	17.7%		3.0%						
Rubber	1.3%		0.3%					-	
Clothes, textile	0.4%		3.6%					3.7%	
Paper	1.0%		5.1%					6.2%	
Metal	0.1%		5.0%					1.4%	
Glass	2.3%		5.7%					2.2%	
Clay, sand, dust (drainage sludge)	17.8%		8.3%					-	
Compound, hazardous, inert and other wastes	-		-					6.5%	

The September analysis was carried out in the wet season, while the January analysis was performed in the dry season. Results show significant differences in the weight percentage of plastics (8,09%), Wood (14,7%), vegetables (17,7%) and drainage sludge (9,5%). Since a standard procedure was not followed while conducting this analysis hence it was envisaged to carry out an additional waste analysis under clear & defined methodology and investigation area, which was based on statistically valid assessment.

The new analysis was carried out the months of September & October 2014 along with a training session in September 2014.

A qualitative waste analyses standard was developed, using statistical methods to verify significant areas in a ward / township base. A total of 89 sampling zones in 40 sampling areas were identified within the various wards

This overall grouping allows an overview of potentials in regard to organic treatment, which is above 65%. The theoretical potential of recyclables is currently almost 25%. Above 5 % are non-recyclable materials with high calorific value. The remaining 5% do not have any meaning for recovering and have to be disposed off. This does not yet include the disposal material coming from energy recovery (30% of input) and from material recovery (10% from recyclables and 21% from composting).

Economical development will allow an overall reduction of organic and related components waste from current levels of around 65% down to 53% (including wood). Paper and cardboard share will increase up to 5% (due to increased packaging), Glass up to a total of 6%. Similar increases will face metals in up to 4% and compound materials (tetra-pack) up to 3,5%. Percent share of all kind of plastics related to packaging will increase 18.7%, while other plastics share will be decreased to 2%.

Inerts and other not identified will be reduced to 0,5%. The scenario has been predicted (and interpolated) until the year 2030. An important observation form this evolution pattern can be taken that specific density decreases due to a shift from high density components (organics) to low density ones (plastics). This is an important factor and it shall form the basis for further necessary capacity requirements in terms of compaction rates, logistic / transport / transfer build up as well as in the calculation of landfill compaction rates and required and /or spent volume.

The component paper & cardboard is broadly divided into three categories which is biodegradable comprising around 25% of paper & cardboard, RDF (high calorific value) comprising 25% and the balance 50% which is counted as recoverable material (recycling).

Similarly glass is broadly divided in to two categories i.e. Residual content comprising 50% of glass and the balance 50% considered as recoverable material (recycling).

100% of organics, fines and wood lie in the category of biodegradables material.

100% of inerts, hazardous and other components are counted as residues without having any potential for material and energy recovery, however having potential for waste minimization

4.3. Waste Audit Results

It is the overall waste stream entering the landfill that will determine the equipment requirements, as well as the possibility for enhanced recycling efforts together with waste minimisation activities. Therefore because of the accepted limitations of the site specific audits described above, a more detailed end-of-pipe style audit could be undertaken to assess the mixed waste as it entered the landfill. The possible approach for future audits is presented in **Appendix B–Waste Characterisation and Density Determination Audit Protocol.**

4.4. Discussion of Key Results

4.4.1. Plastic Bags

Plastic bags are visible both throughout the city as a result of wind-blown litter and fly dumping, as well being highly visible at the final disposal location. These bags are also present in the local rivers after being carried by wind or through the city drains following rain events. Given the obvious presence of plastic bags in the community, there is often a strong emphasis by communities to recycle these bags.

To make plastic bags more attractive to recycling companies, they require cleaning which can result in significant water pollution. Most plastic bags observed during the site audit and other inspections and the primary dumping location were dirty and this would require wiping/scraping and then washing before recycling.

In some countries, such as in Quezon City in the Philippines, selected types of plastic bags are cleaned and then recycled into high value recyclable such as handbags and casual jewellery. However the amount of water pollution resulting from washing these bags is very significant and must be considered as part of the overall impacts of recycling. It is of course possible to clean the plastic bags using a wastewater recycling system that would involve sedimentation and possibly filtration, but this is not considered to be appropriate locally at the time

Further, the bags are obviously low density and expensive to transport unless they are processed through chipping or granulating. Even with these interventions, there are very few junk shops in developing countries, even in major cities, that recycle plastic bags. The profit margin is relatively low even with local buyers, and the large storage volumes required to generate any significant turnover means that the available junk shop storage areas are not being used efficiently. Therefore the operators tend to focus on other materials such as aluminium, metals or perhaps even plastic bottles.

There are some exceptions to this in Vietnam where clean plastic bags are recycled in some cities. However, these activities are in significantly larger cities than Dili. The definition of clean and dirty plastic bags needs to be defined. In countries such as Viet Nam, “dirty” plastic bags are purchased for recycling. However, the definition of dirty in this case is that there is some inorganic soil making the bag dirty rather than being exposed to or containing quantities of organic waste such as food scraps. So therefore any references to recycling dirty plastic bags refer to those bags which have some soil contamination rather than plastic bags used for disposing of food scraps. Any plastic bags contaminated with food wastes will need both scraping and then washing and drying before recyclers will accept the bags, which is clearly not commercially viable. Plastic bags are being recycled in some cities in Thailand as well.

Overall, given the fact that the great majority of the plastic bags are dirty (both from inorganic and also organic) and would require significant cleaning, and the fact that the city is a significant distance from the possible recycling market in Indonesia, recycling plastic bags would not seem viable at this time. The recycling benefits must also be offset against the expected pollution that would result from cleaning all plastic bags which would be essential. Much larger volumes are required and also a higher proportion of clean bags to make it viable.

Other options include driving oil from plastic plants, or low temperature burning in peri-urban households.

A better approach would be waste minimisation – using reusable bags and waste bins to carry waste to the primary dumping areas, rather than plastic bags.

Alternative types of plastic bags are available which are:

- “degradable” (physically break down into much smaller pieces of plastic),
- “biodegradable”(an additive in the plastic makes the bags chemically break down into basic elements over a proscribed time)or
- “compostable” (organic-sourced bags often containing starches which are compostable and do not leave smaller plastic residuals).

However all these are possibly too expensive to be considered as a viable alternative at this time.

Both recycling and waste minimisation will be continually reviewed during project implementation.

4.4.2. Organics including Food Waste

Organic waste represented some 65% of the total waste stream, based on mass. It was composed of greenwaste, mainly rice, vegetables, fruit residue and peelings, but with very little meat scraps.

There are few recycling options for food waste apart from feeding domestic animals at the household level, feeding semi-commercial scale animals such as pigs or chickens, use for fish food in commercial ponds and composting at household or commune level, or centrally.

Household composting can be by shallow burial and retrieval, simple slatted containers or commercial plastic bin systems with inversion capabilities.

Feeding domestic animals is strongly supported, but is not possible in all areas due to households having small or no yards to run chickens or goats.

In summary, household composting is strongly recommended for further investigation. Commune level composting has some guarded support and centralised composting has many hurdles to overcome for it to be sustainable economically. The issues include waste segregation efficiency, compost quality (such as seeds not being inactivated), foreign objects (glass shards or metal pieces) and most critically, developing a sustainable commercial market where users are willing to pay enough for the product to cover all the composting costs.

4.5. Detailed Comparison with other Waste Audits

While a rigorous audit protocol was followed and a large mass of waste sampled, there is still the possibility that the audit results may have been skewed by some external factors. Therefore it is important to compare the audit results with other results.

This comparison not only provides some comfort that the local detailed audits are representative, but also provides some comparisons that can be used when deciding a local 3R strategy. For example, if wealthier developing countries have a good 3R market for say glass, then that material should be monitored in the future as it may become a viable commodity for recycling/reuse as Mandalay becomes wealthier and this waste component becomes more prevalent.

More details are provided in **Appendix C– International Waste Audit Comparisons.**

- **Table 4.2 Comparison with Other Audit Results (Percent)**

Waste Type	Mandalay	Afghanistan	East Timor	Philippines	Cambodia	Vietnam	Pakistan
Food Waste	65	13 – 22	12	9 - 19	19 – 23	15 – 35	10 – 15
Green Waste		10 – 21	33	40 - 54	31– 40	15 - 38	20 – 25
Paper and Cardboard	5 - 6	1 – 8	22	4 - 8	2 – 6	3 – 8	4 – 8
Plastic	14 - 22	11 – 15	18	15 - 17	3 – 15	9 – 16	15 – 18
Textiles	4	-	2	1 - 3	1 – 4	0.1 –0.9	1 – 4
Glass	2 - 6	2 – 3	2	1 - 3	1 – 8	0.4 –5.0	1 – 3
Metal	.1 - 5	0.02 – 0.95	1	2 - 3	0.6 – 8	0.3 –1.5	1 – 5
Wood	2 - 17		0	0 - 2	-	0.5 – 3	0.5 – 2
Soil and Dirt	8 - 17	5 – 11	28	10 - 15	10 - 30	10 - 15	15 - 25
Miscellaneous	4 - 6	4 – 12	2 – 10	7 - 14	2 - 8	2 – 12	2 – 10

The results in the above table confirm that the audit results are in line with other local audits and the international data from other developing countries, especially those with similar socio-economic status and weather patterns such as the Philippines, East Timor, Cambodia and Viet Nam.

5. Waste Minimisation Approach

The approach is based on the principles listed in **Appendix D – Source Reduction Policy Options.**

Appendix E – Waste Minimisation for Special Wastes and **Appendix F – Minimisation of Plastic Bags and PET Bottles** also refer**.**

So far, there is no other mandatory waste reduction or recycling targets in National, Provincial or Municipal legislation or by-laws.

5.1. Community Mobilization in Waste Minimization

With the support of Ward Administrative Offices, MCDC has been conducting community meetings to encourage the community to participate in the waste minimization initiatives. Local NGOs and CSOs were also invited to the meetings. So far only one ward in Chan Mya Thazi township had responded well. The ward community took the initiative to readjust the disposal frequency of household waste into two days (at weekend) a week by educating households to adopt the habit of segregating household wastes into dry and wet storage bags to be ready for the garbage truck to come to collect. Community youths were mobilized to help putting the household garbage bags onto the truck.

5.2. Encourage recycling and reuse of waste

The concept of recycling and reuse of waste materials has long been transformed into profitable commercial and industrial use by a segment of business communities in Mandalay City. The extent of waste recovery by households for re-selling is indicated by the reducing percentage of plastic, paper, Penang bags, and other recyclable and usable materials in household waste. A senior officer of Cleansing Department estimated that out of total plastic waste generated daily by the households, only 10% is disposed as waste and the bigger bulk end up in recycling market. Materials such as Penang bags are rarely found in the waste as they are in high demand in the market.

Despite the fact, MCDC is consistently providing education to institutions (ward administrative officers, schools, departments, community-based organizations) in the importance of recycling and reuse of waste materials as essential components of waste minimization programme through conducting workshops and disseminating information materials.

5.3. Legislations required

MCDC believes that the topmost critical issue in waste minimization and in other urban development initiatives is whether the policy makers have the political willingness to impose strict laws to change the behaviour of people. Some elements of laws as foundation of a comprehensive legislation already exist at regional level (for example, it was reported that use of plastic bags was prohibited in Mandalay municipal areas some years ago). But the legislation needs to be made at national level and be effective in all regions and states. Required legislation should include

- Environment Conservation Laws (ECL),
- Green Economy Concept (requiring to make minimum use of environment-degrading materials such as soaps and shampoos, or selling cut and clean foodstuff ready for cooking, etc)
- Green Packaging Concept (requiring to use bio-degradable bags, etc)

- Polluters Pay Principles (requiring producers to use brands and recollect empty bottles or packages with their brands or requiring vendors to collect garbage generated from selling) and other laws and regulations that would enforce business entities to take heed of and be accountable for environment conservation.
- Waste must be packed by the waste generators to prevent nauseating visual appearance and environmental pollution, as well as the waste pickers and dogs and other animals from spreading the waste from the dumpsite.
- To segregate the dry waste and the wet waste before throwing. (To reduce the frequency of waste disposals by storing the dry waste for example, for a week.)

5.4. Integrated Resource Recovery (IRR)

There is no integrated resource recovery system in operation for now. The Cleansing Department is now planning on its own initiative to establish an IRR system under the education program. The department will cooperate with the CSOs and NGOs to establish this program in November, 2016. Two main components are included under that program to support the purpose of the department.

Integrated Resource Recovery (IRR) is the recommended approach to waste management for the Municipality. This aims to *"instil an understanding and support within the community of waste management principles".*

Fundamentally, this can only be achieved by creating the opportunity for members of the public to play an integral and valued role in the decision making process, from initial planning through to system implementation and operation. This has to cover all aspects including resource recovery systems and technology.

It should be developed in three phases, as follows;

- The Strategic Framework – rationale, opportunities, vision, goals, implementation paths, and evaluation of public sector participation
- The Strategy; Why should communities participate in waste management decisions – detailed assessments of international practices in waste management aspects, including analysis of different communication methods
- Principles of Public Participation – Develop rules for the IRR, including roles and responsibilities for the Municipality (elected representatives and staff), National agencies such as civil society, NGO's, industry, Neighbourhood representatives and other interested parties

5.5. Legislation

Currently, there is no legislation concerning with the waste minimisation at MCDC level. But the local people in Mandalay have already had a good knowledge and awareness about the recycle waste and the profit from commercial and industrial businesses associated with recycling and reusing of waste.

Waste minimisation legislation has been utilised in many parts of the world in order to control the generation of waste. Examples of such legislation follow.

5.5.1. Container Deposit Legislation (CDL)

There is no Container Deposit Legislation at MCDC level and the Cleansing Department in not interested in introducing it for the present

However many countries have CDL, including Australia and a number of EU countries and State in the USA. This legislation requires a deposit on containers for products

defined as beverages under the Act, with exemptions granted by Regulation. Refunds on containers with deposits are paid at point-of-sale or collection depots and are collected from there for reuse or reprocessing. The primary reason for the introduction of CDL was as a litter-control measure.

However a recent waste industry commission considered CDL as part of its study and found that there was no convincing case for container deposit legislation. The Commission found that deposit schemes are expensive to operate and impose high costs on both producers and consumers and are inefficient compared with other available economic instruments.

CDL operates as a disincentive for the kerb-side collection of recyclables because it lowers the value of the remaining waste stream by lowering the quantities of high-value recyclables such as glass and aluminium.

The degree of success will probably not be too high as there is already very efficient recovery of glass and bottles, first at source by users and by jumper boys in the collection vehicles and scavengers at the dumpsite.

This is addressed further in later chapters relating to PET bottles.

5.5.2. Packaging and Plastic Bag Legislation

There is no legislation governing packaging and plastic bags at the National and regional level. Nevertheless, there was no lack of national company owners who have been exposed to the international business environment and attempted to introduce the green packaging ideal in national context. One of the pioneers is the City Mart Supermarket, which promotes the use of biodegradable bags by selling them at cash counters at the convenience of customers.

Another City Mart supermarket in Yangon, in a proactive measure for introducing the use of the biodegradable bags, introduced a ruling that on every other day the shop would not provide plastic bags for customers to carry goods and instead would sell biodegradable bags for the customers who do not bring their own bag or basket for their shopping.

However, MCDC has not yet planned to establish laws for the replacement of plastic bags

In 1991 Germany introduced the "*Ordinance on the Avoidance of Packaging Waste*" (Verpakungsverordnung). This Ordinance was designed to ensure manufacturers take more responsibility for the packaging they create, by giving consumers the right to leave excess packaging behind or return it to the point-of-sale later. As a result, far greater pressure is placed on manufacturing, via retailers, to establish alternative collection schemes and ensure that their packaging is reusable and recyclable.

Two cities in North America, Minneapolis and St Paul, have also enacted ordinances which require that food packaging sold in retail outlets be reusable, recyclable or biodegradable.

Manila in the Philippines has simply banned plastic bags and paper bags or cardboard boxes are supplied instead.

Although this type of legislation is usually enacted at federal or state/provincial government level, it is appropriate that agencies lobby and support the introduction of such legislation.

Another option is the introduction of compulsory charges for all plastic bags used at supermarkets. This has been used in other developing countries such as Fiji in the Pacific. The charge is in the order of 2 US cents per large plastic grocery bag. The aim is twofold:

- Firstly, it is to encourage people to only use the actual number of bags required.
- Secondly, it encourages people to reuse the bags, either for later trips to the supermarket or to use the bags for storing garbage rather than buying special garbage bags and liners. It has also had the effect of people now bringing hessian and other reusable bags to the supermarket and not using many if any plastic bags.

A further option discussed separately below is the mandatory use of biodegradable bags, which is common in both developed and less-developed countries.

5.5.3. Prohibition of Non-Environmentally Acceptable Packaging

No prohibition of Non-Environmentally Acceptable Packaging both at the National level and Municipal level has been established so far.

The Municipality is aware of the need to establish localised guidelines pursuant to the prohibition of the use of non-environmentally acceptable packaging, in association with National initiatives.

5.6. Education

The education for waste minimisation is part of ongoing education program of the department which has started in 2014. Under the programme, flyers are disseminated with key messages encouraging food industry to reduce unnecessary packaging and educating people to reduce the food waste at domestic and commercial sources. That education program is carried out in cooperation between ASEAN ESC Model Cities and the Cleansing Department.

The flyers are targeted at students and members of women affairs federation at community level. The messages in the flyers also deal with the issues of 3Rs and provide current market price information of recyclable wastes so that people understand waste recycling activity as a source of household income.

A major key in any Government body achieving reduction of waste to disposal is the education of the community, both general society and business. Locally a National Government initiative is required to support education with respect to waste management. This effort could possibly be best directed through a combination of national campaigns, supplemented with funding for local level education through local NGO's.

The USEPA has produced booklets such as "*The Consumers Handbook for Reducing Solid Waste*", 1996. This booklet is particularly comprehensive and addresses the integrated waste management approach, or the cradle to grave approach. This addresses all phases of waste management including advice on reducing the amount of unnecessary packaging. The handbook also covers the issue of adopting practices that reduce waste toxicity, and the associated issue of household hazardous waste collection that is often overlooked in these publications. The composting section is also very basic and provides the details for constructing and operating a household or Neighbourhood level compost scheme.

Also the UNDP funded Project "*Public and Private Sectors Convergence for Solid Waste Co-governance in Urban Poor Communities*" being trialled in Calamba, Philippines would provide good educational material as input to developing a local plan and strategy. These booklets could be used as a basis for developing local educational information.

It is considered that education is the fundamental key to a successful waste reduction strategy.

5.7. Landfill Scavengers

The department employed one supervisor at each landfill site to monitor the activities of collection vehicles. People working and living at the landfill sites are informal waste pickers who collect recyclable wastes from the landfill sites. However, recyclable wastes disposed at the landfill sites are what remained of the mass after all the valuable wastes had been sorted out at source by the owner, waste pickers and municipal collection labour and it is estimated that it constitutes less than 10% of overall recyclable waste.

The Cleansing Department let the informal waste pickers stay in the landfill sites area with the understanding that they are informal settlers who make a living from by collecting recyclable waste from the landfill sites. Since the condition at landfill site is difficult to control, the department has no plan to manage the landfill sites for the recovery of recycle waste. The program is incorporated in the Year 3 of the Plan and the department is trying to continue it to 2017.

Another method of removing useable items from the waste stream is controlled scavenging at the landfills. Some countries ban scavenging from Controlled Landfills and entirely from landfills. However, such schemes can be successful even in developed countries such as the "*Revolve*" scheme in Canberra. In this type of scheme, a community group has a designated area of land set aside at the landfill for the receipt and sale of reusable items. Other cities establish “dump shops” at or near the landfill to sell recovered items. These schemes can be operated in a safe and sensible manner to avoid health risks and manage safety issues.

The alternative of a mechanised Materials Recovery Facility is really only appropriate with segregated or select waste. Waste segregation options and the locally adopted approach are discussed elsewhere.

The most common approach is to allow scavenging but introduce some rules such as no children allowed and provide some training on the health risks involved, etc.

It is proposed that controlled scavenging will be allowed at Controlled Landfills to continue to achieve good recovery of recyclables and reusables.

5.8. Pricing

It is understood that 3% of Property tax is relocated for cleansing tax. Municipal tax is collected every four months by the Revenue Department of MCDC and it is able to collect about 96% of due tax. Assessment of Cleansing tax is based on the building rental prices and is divided into three tax brackets of 30, 60 and 90 MMK per month for one household. Cleansing Department collects Commercial Waste Tax by itself and tariff structures for commercial waste tax has been formulated for businesses, health institutions and industries. Further to these taxes are fees for on call collection service. The department provided collection trucks and labourers for commercial businesses who call for the services. The on-call collection fees are charged at 35,000 MMKs for one truck (normally for one time) and the customer is required to pay in advance for the service at the department.

Since the service provided by the department cannot cover all the area in the city (especially in the small streets) and the budget is still limited for improvement of the collection system and purchase of new equipment, it is not likely that the department would consider expansion and improvement of services and raise of collection tariff:

- For hotels: the SWM service fee is based on the number of rooms. It amounts to 20,000 MMK per room and per year. The frequency of the invoicing is not known.
- For industries: the service is provided on-demand ("on-call service") and charged at a rate of 35,000 MMK by truck (which capacity is around 1.5 tons).
- Education and religious institutions do not benefit from a different level of services than individuals but they are exempted from the SWM service fee (even when if on-call service is provided for special events). Likewise, shop owners working in markets do not pay the SWM service fee since the cost of the service is already included in the rental costs of their stall.
- For commercial and health facilities, invoicing is done on a quarterly basis by the Cleansing Department.
- Payment can be done directly to the CD office or to the dedicated staff of the department in charge of collecting the fees. It seems that SWM service fees are systematically paid, sometimes with delays, since each business has to renew its "business license" on a yearly basis (and MCDC can therefore check at that time whether the business is up-to-date with its payments).
- For businesses (shops, restaurants, etc.), the service is provided door-to-door at a frequency which depends on the quantity of wastes generated (from daily to bi-weekly collection).
- The SWM fee is based on the average weight of wastes generated, calculated by the MCDC after weighing five samples of wastes. It varies from 1,500 MMK for 0.01 to 0.214 tons/month to 100,000 MMK for over than 4.500 tons/month. It is charged on a quarterly basis;
- For health facilities: nine public and (the twenty four main) private hospitals benefit from a daily door-to-door collection service. However, while public hospitals are exempted from the SWM service fee, private facilities are charged on a weight basis like other businesses.

A major influence on the success of waste minimisation and, indeed, recycling is the pricing regime for waste disposal. In addition, charging the full cost of disposal will provide a commercial incentive for business and industry to become involved with waste minimisation and recycling.

In setting the appropriate waste disposal charges the following factors need to be considered;

- operational costs
- present and future costs of purchasing and developing disposal sites
- costs of new equipment in the future
- rehabilitation and long term site monitoring and after-care
- possible costs associated with environmental disadvantages, and
- charges set by external waste management or environmental authorities.

Worldwide experience has shown that merely providing recycling services is not sufficient to reduce waste volumes significantly. Only where there is a direct link with increased pricing of waste services do improvements in recycling rates occur.

Incentive schemes include:

- Garbage by Volume - householders are provided with a specific size waste bin, for a prescribed annual payment; the larger the bin, the higher the annual fee. In Seattle, the charges were gradually increased resulting in a dramatic drop in the number of large bins being used. However, the scheme does not encourage reductions in waste that is difficult to compact, due to the waste frequently being denser.
- Garbage by Weight - each householder's bin is identified by a bar-coding, or similar device and weighed before being collected. Householders are charged on a weight basis for the actual waste disposed of. Separated recyclable materials are not subject to this charge. This scheme promotes illegal dumping and favours the disposal of plastics and packaging which, whilst bulky, weigh relatively little.

5.8.1. "Pay as You Throw" Charging Policy

This is a method of introducing a financial incentive to dispose of less waste, by having the Municipality charging the householder/business on the basis of the amount of waste actually given over for collection and disposal. This internalises the cost of waste services, and provides a strong incentive for generators to minimise waste production. This may be in the form of waste avoidance or greater focus on reuse and recycling, such as composting for domestic situations.

In developing countries, the legislation and ordinances are usually in place but the community culture and enforcement is such that increased littering and waste dumping will usually occur. This has the result of diverting waste away from the collection service and associated correct disposal systems, to encouraging illegal dumping in vacant lots, watercourses and drains.

A further issue noticed even in developed countries is that waste generators will place their waste in other people's bins or receptacles, and not their own. This transfers the waste cost to innocent parties, and can have the effect of introducing neighbourhood tensions.

For less fortunate communities, the Municipality can issue vouchers to partially cover waste costs. This avoids inequalities in service between wealthy and less fortunate Neighbourhoods.

An example of the implications of PAYT charging is the Landfill at Kalangitan, Luzon, Philippines. During the feasibility studies and subsequent design of the site, a daily waste load of 2000 tons was predicted from the CSEZ waste generators. Upon opening the site to receive this waste, the waste load quickly dropped to 1000 tons per day. This was a result of waste generators having developed recycling and waste avoidance/minimisation schemes. The quantity going to the Landfill has now dropped to around only 100 tons per day, as most waste is now illegally disposed of in other locations or controlled dumps with much lower cost gate fees. The CSEZ locaters are legally obliged to use the Kalangitan Landfill.

Therefore until the penalty provisions are firmly and consistently applied in theregion, and a culture of responsibility for waste generated is engendered in the domestic and commercial community, then a "Pay As You Throw" system may be inappropriate. Rather it is preferable to provide a good collection service that discourages illegal dumping and back yard burning. The other options such as waste management education and better packaging are a better approach for this project.

5.9. Household Hazardous Waste Management

There is no household hazardous waste collection service in Mandalay under the management of Cleansing Department. The household hazardous waste are usually mixing with general domestic wastes and it can do harm to people, especially waste collectors going along with the collection trucks and the waste pickers at the landfill sites who have direct contact with HHW because they don't use gloves, boots and masks for protection.

The management of household hazardous waste (HHW) is one area of waste minimisation that can significantly reduce both water system and landfill pollution.

The proper management of HHW is an issue that emerged in the 1980's in the US along with the awareness of problems caused by toxic chemicals and hazardous waste. Collection of HHW at single-day events has been the standard approach adopted by local government.

In many places, collection days have become institutionalised as annual or semi-annual events. In other places, permanent drop-off sites have been established for the ongoing collection of HHW. Established recycling markets for a number of hazardous materials allow materials to be diverted from the waste stream through special collection programs. Used motor oil, one of the largest single categories of hazardous waste generated from homes, is currently collected throughout several cities and states. Scrap battery collections attracted interest in order to reduce heavy metals in landfill leachate and incinerator emissions. Household batteries are targeted for collection in many areas of the US.

In addition to the regular collections, the Municipality should provide facilities at each waste facility for the drop-off of HHW to reduce the impact of these wastes on leachate quality. This should comprise a securable impervious area with separate areas for the storage of oil, batteries, chemicals and paints. The imposition of a fee on these items is not considered appropriate as it discourages people from "doing the right thing" with these wastes.

The disadvantages of the HHW collection days are:

- Management of the individual containers on the collection vehicle. Due to the unknown nature of the wastes a common disposal tank on the vehicle is not practicable and potentially dangerous.
- Kerbside collection is not practical. Personal contact with the householder would be required to collect the HHW.

The advantages of an annual collection of HHW include:

- Remove HHW from the municipal landfills and sewage treatment plants.

  Clear households of these dangerous wastes, particularly where children are present.

5.10. Special Wastes

Special wastes require separate consideration due to the deleterious effects on landfill capacity and leachate quality and are described in Adopted Approach to Waste Minimisation

Based on the above background to waste minimisation, it is considered that efforts should initially focus on managing plastic bags which make up to 14% (IGES) of the total waste delivered to the dumpsite, and PET bottles which make up a smaller percentage.

Both represent a major litter issue and following protracted storm events, are washed out of the local unofficial dumping areas and litter areas through the local drainage canals and into local rivers.

Also they degrade very slowly meaning that these materials are present in the environment for decades impacting both aesthetics as litter and the environment.

Finally plastics are often associated with stormwater drain blockages possibly leading to flooding in municipal precincts.

Therefore management of plastic is a high priority. Plastic bags can be replaced with paper bags or a charge applied to customers for plastic bags at large shops. Alternatively various types of degradable plastic bags are available.

Various types of degradable plastic bags are easy to buy at big shopping centres. Furthermore, waste minimisation topic is already included in the curriculum of public awareness education program and the program is now focusing on the community level by cooperating with the CSOs and NGOs.

6. Approach to Recycling

6.1. Introduction

Recycling is a form of resource recovery that allows the use of recovered materials in a form similar to its original use, as in recycling paper for use again as paper or cardboard. The Solid Waste Management Plan will advocate such practices as it diverts a considerable amount of useful materials present in the waste stream from being disposed of in landfills.

Recycling issues are also addressed in other sections in this Plan, such as Container Deposit Legislation in Source Reduction Options and generally the section on Legal Environment for Source Reduction, and are not repeated in this Section.

6.2. Background

6.2.1. Evaluation of Existing Programs

No other programs existed except MCDC's own plastic bin production from plastic bags, but it is not operating very well. The locally constructed system has weakness in mechanical design. That plastic bags recycle factory is now operating only with the plastic extracted from recyclable plastic bags without mixing with virgin pellets and therefore the quality of finished products is substandard. The recycling plant is not operating every day due to the high cost of electricity consumption.

About 13 junk shops are located in the township. Waste collection labourers of the department collect recyclable waste while they are collecting the waste around the city. The collected recycling wastes are brought to the junk shops for selling. The income from these transactions is about 3000kyats/day. And about two or three collectors share the income which is added to their daily wages. The waste recycling market is not managed by MCDC and the segment of market occupied by municipal workers exists at micro enterprise level.

That recycling waste business is a lucrative one is evidenced by a remark made by an officer of the department who commented that a group of workers (he is referring to municipal workers) could make a small fortune if all city dwellers dispose all the wastes they generate into municipal trucks, without retaining recyclables or reusables for themselves. This is also a measure of how extensively city dwellers are involved in the waste recycling business.

6.2.2. Junk Shops and Pricing

The main junk shops business community in the Municipality was located in Taung Palin Win Ward in the Aung Mye Thar Zan Township. Junk shops accounted for about 95% of the residents' business in the ward.

There is no plan yet for increasing or improving of recycling business activity level both at the MCDC and private operators. But the market is a big one where all private but no municipal operators participated. Individual waste pickers and collecting intermediaries can sell their recycled waste at junk shops.

So far, waste recycling is entirely managed by the informal sector and private actors. Except for some initiatives individually taken by its employees, the MCDC therefore does not play a significant role in the current waste valorization process. However, it is believed that a significant, yet difficult to estimate, part of the wastes is collected at different levels of the waste management stream in order to be recycled:

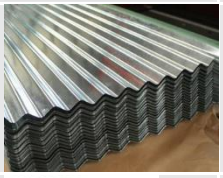
- At source, there is a real effort to minimize the quantity of wastes disposed of, especially from the private sector (construction companies, factories, etc)

When possible, manufacturing wastes and by-products are thus reused internally or sold to other factories to be used as fuel, fertilizer or animal feeding.

- Between wastes' disposal by households and dumping at the landfill, a significant amount of valuable wastes is collected by informal waste pickers;
- At the landfill's level, waste pickers collect the remaining valuable wastes
- Valuable wastes collected by waste pickers are generally sold to intermediaries or wholesalers who themselves have a direct contact with recycling factoring. A great number of such wholesalers are established in the ward of Taung Palin Win. It is said that waste recycling business is the main activity and source of revenue for 200 out of the 300 households living in this ward. Such "wholesaling companies" would sometimes be registered (and have a license from MCDC) and are generally of medium size (around 15 employees). The biggest wholesaling companies employ their own waste pickers but the majority of them is not involved in the collection process and just purchase valuable wastes (except organic wastes) from waste pickers or intermediaries of Mandalay or of nearby cities. They further sort out the wastes, package them and sell them out to recycling factories based in Mandalay. The sale of the wastes to the recycling factories is usually triggered by the need to free space. Indeed, wholesalers usually have limited storage capacities. In some cases, the sale can however be triggered by the increase of the purchase price by the recycling factories.
- The shop does not collect paper/cardboard, tins or plastics, as the returns are too small for the volume collected and handled.

- **Table 6.1 Local Current Recycling Quantities and Prices**

No.	Item		Price paid (kyats/kg)	Quantity (kg per week)	Sold to whom And where	Comments
1		Plastic bags	488	n.a	Sold to Agent	
2		Plastics – thermoplastics such as drinking cups, yoghurt containers, cleaner bottles	366	n.a	Sold to Agent	
3		Plastic- PET such as water and soft-drink bottles	305	n.a	Sold to Agent	
4		PVC plastic pipe	244-366	n.a	Sold to Agent	
5		Cardboard	85-110	n.a	Sold to Agent	
6		Newsprints	85	n.a	Sold to Agent	
7		Bond paper	152	n.a	Sold to Agent	
8		Iron / steel	244-378	n.a	Sold to factory	
9		Nails from construction sites	134-171	n.a	Sold to factory	
10		Tins / cans	91-110	n.a	Sold to factory	

11		Aluminium	1159	n.a	Sold to factory	
12		Bottles – glass	1098	n.a	Sold to agent/ factory (depend on market and price)	
13		Broken glass (cullet)	No place to recycle/sale	n.a		
14		Copper – grade (A)	4268-9146	n.a	Sold to factory	
15		Copper – grade (B)	2622-3354	n.a	Sold to factory	
16		Lead- eg. bullet, screws and pipes	915	n.a	Sold to factory	
17		Galvanized steel roof	915	n.a	Sold to factory	
18		Rubber	366	n.a	Sold to agent	
19		CD ROM	976	n.a	Sold to agent	

Different junk shops collect different types of recycle wastes in small or big sizes. Junk shop owners make daily choices for selling the product to the intermediaries depending on the prices and market conditions.

International prices for recycled products are listed below and are current as at 2015.

- **Table 6.2 International Recycling Material Prices**

Material	Form provided	$/Tonne	Remarks
PET Bottles	Clear flake	254- 308	600 mL = 78,000/ tonne
HDPE postconsumer	Natural flake	258-276	
HDPE industrial		199-221	
PVC clear industrial	Flake	186-213	
Aluminium Cans	Baled (crushed)	850- 1200	35,000 / tonne
Steel White Goods		60	
Steel – cars	flattened bodies	140 - 217	High rate green strip body
Steel	Sections, plate	340	
Lead	Drained battery	300- 800	
Lead	Solid	2600	
Glass	Clear bottle cullet	200 typical	

6.2.3. NGO's

No NGOs are involved in Mandalay Municipality for the waste recycling activities. But some NGOs in other cities in Myanmar are volunteering themselves to conduct waste recycling business activities. The income from waste recycling activities is used for the education of orphans from orphanage centre.

Well-wishers donate funds for the procuring recyclable waste collecting boxes and the humanitarian aid organizations organize their members to use collection boxes for collection and selling of recycle wastes. The Cleansing department in MCDC may like to introduce similar program by facilitating NGOs and CSOs to implement in Mandalay.

6.3. Issues Limiting Recycling

The main limitation is the fluctuation of Chinese currency value and instability of market. Recyclable wastes are mainly exported to recycle factories in China. Almost all recycle waste businesses are family business and the owners benefitted from the experiences of their family members. Sorting activities are carried out at junk shops and therefore the owners have some space limitation to store and sort out wastes at the same time when the market demand is slacking and products moving slowly. These are difficult time for the wholesalers. However, news of market fluctuation can be obtained easily from an open and transparent market. Some of business owner have their own factories for reprocessing goods from the wastes and these factories are mainly located in the industrial zone.

6.3.1. Categories of Recyclable Wastes for Diversion

Plenty of business diversity exists in the recyclable waste industry and private business owners are adept in taking appropriate advantages. A large quantity of different commodities manufactured from recyclable waste enter the market every year. They range from iron, brass and nickel wares to very small pieces of plastic.

The results from the waste characterisation activities validate waste generation estimates.

6.3.2. New and Expanded Recycling Facilities

To encourage the participation of the general public in the recycling activities and to stimulate the market for these recyclables materials, facilities will be set-up in strategic locations all over the Municipality, following the IEC recommendations and programs. Likewise, mechanisms that will facilitate the coordination with manufacturers and recyclers to collaborate in the implementation of such programs will be put in place.

The Municipality will seek the assistance of various resource groups to implement proactive recycling measures such as buy-back and material reclamation programs.

Products with toxic components must be appropriately dealt with. Reclamation programs for these products will be organised in close coordination with its manufacturers and recyclers who can deal with them.

6.3.3. Possible Revisions to the Building Ordinances

There could be new legislation to require newly-constructed buildings and buildings undergoing specific alterations to contain storage space, devices or mechanisms that facilitate source separation and storage of designated recyclable materials to enable the Municipality to efficiently collect, process, market and sell the designated materials.

Such recommendation will include, but will not be limited to separate chutes to facilitate source separation in multi-family dwellings, storage areas that conform to fire and safety code regulations, and specialised storage containers.

6.3.4. Demand for Products Containing Recovered Materials

The Municipality welcomes proposals that will stimulate the demand for production of products containing post-consumer and recovered materials for as long it meets the acceptable quality standards and consistent with the set guidelines. Members of the Municipality coming from the recycling, manufacturing/packaging sectors and NGO should spearhead the development such proposals.

6.4. Specific Waste Types

The international recycling trends in glass cullet, paper, cardboard and some metals such as iron are highly varied. Some components have been over-subscribed, such as paper and cardboard and the market value once reduced from $200/ton to $20/ton internationally but has now recovered. In 2015, the cost of virgin PET pellets was lower than the cost of recycled pellets because of low oil process. Others remain perennially attractive such as aluminium and copper.

Organics (Food waste and green waste) and plastics represent major waste components and these are addressed in separate chapters following.

Not all materials have to be sold to be recycled. For example, builder's rubble can be used for drainage blankets or gas collection layers in landfills rather than just dumped into the cell as waste, or using excess soil for cover material. This type of recycling just requires some forward planning. Similarly, greenwaste can be chipped and then

as a protective layer for the exposed cover material prior to grass establishment to prevent erosion of landfill batters, or used on internal roads during wet weather.

Basic charging policies, container deposit legislation and extended producer responsibility are not considered suitable and effective approaches for maximising the recovery and recycling of PET bottles.

6.5. Adopted Approach

6.5.1. Overview

The Municipality supports the concept of recycling. Based on this, the Municipality will;

- Commit to the principles of encouraging and supporting recycling efforts. The improvement will come through activities such as;
    - Implementing waste segregation
    - Municipality investigations of recyclables' markets, including regional junk shop operators
    - Municipality identifying specific people from the Municipality to assist with recycling
- Accept that the private sector and particularly the market will decide what items and how much is to be recycled
- Accept that the most efficient schemes are those operated by the private sector such as existing junk shops.
- If the volume of goods being recycled increases substantially, the Municipality will develop some livelihood programs for Municipality residents
- Investigate the use of non-saleable recyclables as raw materials for making a range of handicrafts
- Scavengers at the Controlled Landfill will be licenced by the Municipality to avoid any disagreements over who can undertake the recyclables recovery activity and subsequent sale.
- Organics and plastics are addressed separately below

6.5.2. Recycling Program

Recycling Programs are required to address the generation of both biodegradable and non-biodegradable wastes. Specifically for biodegradable wastes, the Municipality will mobilise programs since these wastes can be converted into compost – a useful product that the agricultural activities within and outside the Municipality can benefit from or use as animal feed at householder level:

- **Table 6.3; Proposed Recycling Focus**

Areas to address	Recycling Program
Bio-degradable wastes	The department is now planning to implement a composting program under the business operation plan. The drawing of the plan is supported by the UN-Habitat and the plan will be implemented in collaboration with the private investors for the production of fertilizer. The department will finish the final business operation plan at the end of 2016 and will try to implement in 2017 for the composting of organic waste. Other programs are; Facilitate collection services to obtain the domestic, commercial and possibly some agricultural waste for conversion into compost soil conditioner/organic fertiliser for use in the area. Encourage at source segregation so food scraps are used for animal feed at the household level The department has also a new public education program to separate dry recycle waste and food waste before disposing. This program is especially targeting households at community level to educate them on a better waste management system.
Non-biodegradable wastes: post-consumption	Manufacturers to set-up 'Buy-back/redemption centres' for these wastes
	Promote the use of post-consumer recyclable materials in production (material cycling)
	Educate the junk shop operators to better coordinate their eco-aides to improve collection efficiencies at the household level
	Focus recycling on products presently not recycled such as plastics and paper/cardboard, as well as expand the metals and glass recycling.
	Processing of materials into products that can be reintroduced into the market (i.e. tin cans can be re-sized into smaller units for consumer use, polystyrene can be moulded to produce new products like mouldings and frames)
	For materials that the Municipality does not have any technology for recycling, the Municipality will coordinate with agencies and academic institutions dealing with R&D on this area.
	The department is also trying to establish a small factory for the cleaning of recyclable bottles. The department is expecting to provide bottle cleaning services for private operators in more efficient and space-saving way than the manual cleaning service which they currently are using. The department can also generate income from their own business.
	The department would like to improve the local design of the current plastic bin production factory which was established in 2008. They also would like to improve the quality of plastic wares by using clean chemical (sulphate) to mix with the raw plastic grain reprocessed from recycle plastic bags.

The results of waste characterisation activities and waste composition analysis described earlier in this document and any further information obtained in the course of past collection of solid waste by the Municipality can define the type of waste streams available for recycling. Recommendations with respect to increasing the number of materials designated for recycling will be generated and will form part of the actions necessary in order to operate the ISWM Plan.

6.5.3. Implementation Schedule

Guided by the simple goal setting specified below, the Municipality will develop a municipal-wide implementation schedule that consolidates all recycling initiatives in their area. The Municipality must also ensure that resources are mobilised towards the achievement of these deliverables.

- **Table 6.4 Recycling Implementation Schedule**

Implementation Goals:	
Year 1: 2016-17	Education program for the waste segregation will continue at the community level. Following the preparation and the Committee's approval of the business operation plan, the department will start to implement the composting program The department will try to modify the current state of plastic bin production factory to increase productivity The department will establish and operate the bottle cleaning factory for the cleaning of recycling bottle and generate income for the department.
Year 2:	Efficient collection scheme operationalized Basic Orientation on Eco-Waste Management for the general population through Neighbourhood train-the-trainer programs Development of necessary ordinances to facilitate the ISWM Plan Implementation
Year 3:	Set-up and full operation of any Neighbourhood MRFs (Eco-sheds) in urban Neighbourhoods, although the focus will remain at the centralised landfill. Research and Development activities on waste processing Training/Education Program for households and business on reduce, reuse, recycling approach to waste management Incorporation of the Ecological Solid Waste Management concepts in the school curriculum Expansion of existing operations Full implementation of fines and penalties for prohibited acts, non-compliance and violations
Year 4-6:	Enforcement/gradual phase out of the use of avoidable non-biodegradable packaging through legislation Expansion of product lines from waste processing (inputs from R&D activities)

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7. Organics Composting

7.1. Introduction

The Cleansing Department is now undertaking feasibility study as a preparation for drawing a plan for the Organic Composting. The plan is based on the business operation plan concept and it is being led by the UN-Habitat. The team leader of that study is the branch head of the Cleansing Department. The business operation plan is expected to be finalized and submitted at the end of the year 2016. It will be instrumental for the department in attracting potential investors in the composting business. The composting plan will be a medium scale industry and the department will try to implement it in 2017.

Composting is often promoted as a suitable scheme for managing organic wastes such as food scraps (15 to 50+% of total waste stream) and green waste (10 to 50% of total waste stream). However it has not been a consistent success in many other developing and even developed countries where it has been adopted, especially where food scraps are introduced into a centralised facility.

Composting trials and facilities were very popular in the 1970s and 1980s. However the failure rate for these facilities approached 100% for a variety of reasons discussed elsewhere. Lately there has been renewed interest in composting however the focus is more on composting chipped green waste rather than the waste food and vegetable scraps.

Composting is the biological process in which organic matter is broken down into simpler compounds by the action of micro-organisms. Compost is the product of decomposition of organic matter. It is a suitable soil conditioner, as differentiated from fertiliser.

7.2. Suitable Materials for Composting

The proposed implementation site will be near the Kyar Ni Kan landfill and organic anaerobic digestion process will be used in producing fertilizer. It will use biodegradable waste such as food waste and other organic wastes as raw materials and the fertilizer will be used to boost organic farming. Since the proposed site is near Kyar Ni Kan, the production of organic waste will reply on the organic waste coming from the northern three townships.

Food wastes that are vegetable or fruit based are fine not compost, as are greenwaste, papers and other carbon sources. Generally meat and dairy products and anything containing oil should be avoided at the household scale

The need to reach a certain C:N ratio of about 30:1 as well as the right moisture content impacts upon what is finally added to the compost system.

In summary for household scale schemes

- YES: fruits and vegetables, such as apples(peels and core), cabbage, carrots, celery, coffee grounds (and filters), eggshells, grapefruit, lettuce, onion peels, orange peels, pears, pineapple, melon rinds, potatoes, pumpkin shells, squash, tea leaves, tomatoes, turnip leaves, etc. Also greenwaste can be added provided that it is not too big. (In composting terms, greenwaste is called “browns” indicating a higher C:N ratio.) Paper can also be added (good source of C) provided that it is not waxed or plasticised in any way.
- NO: dairy and meat products, including butter,bones, cheese, chicken, fish scraps, lard, mayonnaise, meat scraps, milk, sour cream, rice andyogurt. Do not compost

foods containing oils or fats such as peanut butter, salad dressing, margarine, and vegetable oil

For commercial or centralised schemes, meat and dairy products can be accepted in small quantities. These schemes have sufficient mass to facilitate higher temperature compost reactions which minimise the odours and general attractiveness of these items to pests.

The collection system must ensure that these types of waste are appropriately segregated and handled during collection to facilitate transfer to the municipal MRF.

The ongoing waste characterisation and generation estimates will be the main input in determining the categories of biodegradable/organic waste present in the waste streams. The data gathering activities will be conducted at the Neighbourhood level, to be consolidated by the designated Municipal ISWM team.

7.3. Greenwaste

Green waste mainly comes from the Playground, Parks and Garden department of MCDC. That department is mainly responsible for nurturing green vegetation at the parks, playground and along the road and public recreation areas. Although the department has big trucks allocated for their activities under the arrangement of Motor vehicle and Transport Department, the green waste collection is done by the labour from Cleansing Department. The proposed composting process will use green waste as basic raw materials.

Once the amount of greenwaste increases, a chipper should be purchased to allow the green waste to be broken down into small pieces if larger sized material is being collected. These greenwaste chips can then be composted, perhaps with the addition of animal or treated human waste to provide the correct carbon and nitrogen ratio. Alternatively greenwaste can be used around the landfill site for applying to gravel roads during wet periods and also applying to external batters to limit erosion of the cover material.

The greenwaste is mixed throughout the comingled total waste stream and rarely is collected as a consolidated entity from one location. Because of the small size and non-rigid nature of the greenwaste, it would be very difficult to specifically remove it from the comingled waste mechanically using a screen or trommel.

Separating it out by hand would be exceedingly labour intensive for the benefits gained, based on the waste audit experiences.

At source segregation will also be virtually impossible as the major source is street and compound sweeping where green waste is comingled with dirt and soil.

7.4. Food waste

There is still no legal requirement for waste segregation in solid waste management system so far and people are used to throwing their food waste together with other domestic waste. This traditional way of waste throwing make it difficult for segregating food waste from the mass. The fact that people put food in plastic bags to throw into garbage bins is another factor for increasing plastic waste. A different scenario takes place where food wastes are collected by some livestock business owners to feed their animals especially pigs. In some cases livestock business owners need to pay for the

food waste and in other cases, it is the reverse; a restaurant owner has to pay as compensation for collection services of their food waste. The payment can be different from 1000ks/month to 3000ks/month based on the available amount of food waste.

For the next step in the department's education program, education on segregation of organic waste and other domestic waste will be given emphasis. This is expected to increase the mass of raw materials for composting and create a business potential for composting in the future.

There are limited options for the reuse or recycling of food waste.

The food waste consisted mainly of fruit and vegetable peelings and trimmings, or spoiled fruit and vegetables.

There was also some rice as well as some meat and cooked food in the samples audited and observed in primary dumping locations as well as waste disposal sites.

The most obvious recycling opportunity given the current financial capacity of the communities is to simply feed the household food waste to animals such as chickens or goats or use home composting. This presupposes that households segregate their food waste so it can be recycled directly at-source by the householder.

Once the community wealth increases and the quantity of food waste increases, then consideration could be given to centrally composting the food waste.

However as the photographs indicate, the food waste is fully mixed throughout the comingled waste and is not in selected pockets, and therefore would have to be segregated at source. This at-source segregation will be required of the following:

Householder will have to segregate prior to either placing the food waste in a dedicated food scraps bin for door to door collection or carrying it to the primary dumping location where separate community bins will have to be provided for food scraps

Commercial premises such as restaurants and hotels will have to segregate waste and then dispose of the food scraps as for the households, depending upon whether there is door to door collection or not.

Market vendors will have to keep food waste separate and place in dedicated food scraps bins.

At all levels, an IEC campaign will be required to ensure that only things that can be composted are placed in the Food Waste bins.

7.5. Composting Scale Options

Despite the very important part of organic wastes in the total quantity of wastes generated and collected (55% to 65%, see above), no composting activity is carried out by the Cleansing Department of the MCDC or by private actors. It is also likely that some individuals also carry out such compositing activities but at a very small scale.

Finally it is noteworthy that the Department of Agriculture, Livestock and Breeding has been carrying out composting activities and biogas generation since 2008 in the area of Yay Tagon (Patheingyi Township). Compost is produced from straw, hyacinth and algae to produce fertilizer.

According to the data at hand, the daily production would be about 25 bags (cement bag of 25 kg), each bag being sold at 2,300 MMK. Besides that, the Department of Agriculture, Livestock and Breeding also manages a small electricity production plant

from biogas in the same area. The electricity generated supplies a livestock building, Thayet Taw village and a small hamlet of 60 households (see document SW5).

7.5.1. Domestic Scale

The Cleansing Department actually has had previous experiences in compost making. The department used to implement the composting program from 1996 to 1998. Then it was stopped because of the financial loss due to lack of technology. Similarly, Agriculture, Livestock and Breeding Department under the MCDC has been operating a composting program since 2008 with the production capacity of 25kg bags per day. That composting process used straw, hyacinth and algae as raw materials for the production of fertilizer. The price per bag is 2,300 kyats. According to the findings from the interview, the production level this year is lower than previous years because of lower market demand and higher production costs. Nevertheless, the department management has now planned to implement a medium scale composting programme once they have budget approval

Subsidised or government supported domestic composting schemes are used extensively throughout the world to reduce the amount of organic waste going to disposal. Studies determined that a household composting participation of 15-20% is achievable, realising a 25-30% reduction in domestic garbage quantities in those households. It follows, therefore, that home composting is a valid waste minimisation tool.

Home composting, or at most Neighbourhood level composting, is generally regarded as the most effective level for composting household waste when waste is not source segregated. This allows the organic waste to be used before mixing with contaminating non-compostable materials during haulage and disposal. One exception is market waste that could be composted centrally provided that it is collected in a dedicated service to avoid cross-contamination.

There are several types of manufactured home composting bins available. Municipalities could have schemes whereby bins are made available to the public at discounted rates through either subsidising, passing on savings of bulk purchase to the public or savings associated with sales tax.

Basic low-cost designs are available in the literature, such as in the USEPA "*The Consumers Handbook for Reducing Solid Waste*", 1996. This manual also describes how to operate the compost system and what materials to use.

Alternatively used tyres can be used in a column.

Assuming a 15% reduction in domestic garbage quantities per participating household, and an average of 5 to 6 people per household, this indicates that the economic benefits of composting are substantial, when considered in terms of Controlled Landfill and collection services costs.

The home compost approach is the generally preferred option in the long term, for middle class areas or peri-urban areas where the households have sufficient yard areas to use the compost generated.

The basic scheme can involve above an above ground compost system using old tyres placed in a stack, an in ground pit provided the water table is sufficiently low or a specifically designed system made of plastic trays and bins.

7.5.2. Neighbourhood

A few private households in rural residential areas have small scale composting facilities in their own gardens. But only 16% of population in the municipal area is living in the rural area and it is very rare to find people in urban area making compost from

biodegradable waste. Though the department is now providing education program at school and community levels, there is no education program to enable neighbourhood improve production on a domestic or commercial scale. The education program at this stage only covered the 3Rs and waste minimisation sectors.

This is probably the most appropriate level for the informal settler areas, where there is insufficient land in each individual household for using the compost. However if lot owners still wish to compost the material it can be used in pot plants or given to other potential users via the Neighbourhood network.

These facilities are located within the residential area and such facilities internationally have in the past resulted in odour complaints even if the facility is roofed.

See **Appendix G – Larger Scale Composting Facility Details**for detailson real world experience with neighbourhood and centralised schemes internationally**.**

7.5.3. Large Scale Composting/Mulching

There is no large scale composting for now for a small municipality.

Depending on the type of biodegradable wastes, the following aerobic methods can be used:

- In-vessel composting using motor driven drums or silos.
- Static pile method – using permeable membranes stacked in such a way to allow maximum ventilation, as used at Sun Valley currently.
- Windrow method – 2-3 metre high windrow heaps turned regularly for aeration, utilising compost activators.
- EM Technology – another method of aerobic composting using concentrations of beneficial bacteria to provide high quality compost.

For most schemes, static pile composting would be appropriate.

All composting operations must maintain a maximum temperature of 60 C. Exceeding this level will result to the extermination of the beneficial microorganisms in the composting process. This can be done using thermometers inserted in compost piles. Methods of reducing heat include watering and constant turning of the compost piles until the temperature goes down to the ideal level. Those portions of compost waste with high nitrogen component should be reduced to lower the compost temperature. An ideal carbon-nitrogen ratio must be maintained to avoid over-heating.

Schemes are being trialled internationally for the separate collection of garden waste and the subsequent composting of this material. All green waste is composted in Melbourne Australia at the Deer Park landfill serving over a million people.

Internationally, some Municipalities have proposed schemes whereby the householder can pick up "free of charge" the composted green waste product. However, in doing this, Municipality should be aware of their liability and need to also inform the public of possible weed and plant disease problems. Rehabilitation of former controlled and open dumps, and landscaping of buffers at current operational dumpsites, are other possible uses for the mulch. Mulch has also been used as a substitute for "*end of day*" cover in landfill operations although this is not advised due to the low barrier to rodent and rainwater intrusion.

There are few if any functioning full scale MSW compost schemes operating in developing countries in SE or South Asia. All have failed through a lack of a viable

market for the product, poor product quality, lack of funds to continue operation (as they are not self-funding) or ultimately conversion to composting other more suitable material such as animal manure. The one exception is a large scheme handling 1000t/d operates in Lahore, but that is a PPP arrangement where compost contamination is not an issue (as one of the PPP partners is the adjacent farmer using the compost and he does not mind if the compost has foreign objects therein) and finally compost is applied to high value food crops.

Therefore centralised composting must at least await full waste segregation and then undertaking a comprehensive marketing effort to confirm (or otherwise) that market demand is sustainable. Sustainability investigations must include the fact that users are willing to pay a gate price that makes composting economic for the Municipality or that the Municipality is willing to fund the composting scheme with an ongoing financial loss.

One issue to be considered is the risk management required. For example, Municipalities have been sued for damages due to poor compost such as causing crop damage due to excessive microbial activity, or personal injury from sharps accidentally included in the compost product in some countries. Even if the compost is given away, there is an inferred warranty that the material is fit for purpose.

Waste must be fully segregated at source to make this option sustainable as centralised waste segregation of mixed waste is unreliable and costly. This means that centralised schemes are possible only for long term consideration locally, not for immediate introduction.

If there was a larger fraction of greenwaste that could be separated out at source, then that may be viable to compost as it is many other countries, provided that there is a sustainable market and that there is a supplementary source of Nitrogen such as dried sewage sludge (bio-solids) from a sewage treatment plant.

To facilitate the processing of biodegradable/organic waste into compost, the following must be put in place:

Table 7-1 Biodegradable/ organic waste processing actions

Household Level	• Information Campaign on Household level Waste segregation: (bio and non-bio waste, etc.) • Appropriate containers or bins (Compost bins can be shared among a number of households to maximise resources. Also basic designs using used tyres or in-ground trench system can be developed at low cost) • Distribution of free mulch/compost for use in home composting
Neighbourhood/ Community Level	• "Eco-Sheds" strategically located in urban communes. Common Eco-Sheds can be shared among a cluster of communities, wherever applicable. • This system may not be appropriate now, but may be developed at a later date if required to supplement the household facilities.
Municipal/City Level	• Municipal Composting Centre designed to handle the consolidated volume of pre-segregated wastes to its final conversion to compost • Coordination of compost sales and marketing activities within and outside the City. • Transport system that can facilitate the transport of final product or pre-processed compost to its destination. • Possibly not appropriate at this time given waste is comingled (and is likely to continue to be mixed for some time) and little established market for compost at this time.

In all levels of these activities, the Municipality has the option to consider partner entities or groups to facilitate program implementation and augment resource limitations, as most of these activities might require additional investment.

7.6. Market Development Activities

The organic products that will be derived from the organic processing operations will need to be marketed using a range of schemes. All large volumes of organic products from composting activities should be sold to farmers and agricultural cooperatives. In order the develop the market and demand for compost, the Municipality should consider a partnership or Joint Venture options with regards to developing the potential economic activities that will need a steady supply of compost such as farms for various crops.

Many of the local agricultural soils are poorly structured, and would greatly benefit from applications of compost. The compost will improve soil moisture retention capabilities, increase soil CEC levels to improve fertiliser retention and also a general improvement in soil structure with the addition of compost organics.

However experience elsewhere suggests that few farmers are willing to pay a significant price for compost especially when it used on lower value crops and when supplementary fertilising is still required. In the Philippines, there was a stockpile of over 8000 tonnes of compost which the operators cannot even give away as local farmers are insisting that the landfill operators pay the haulage and distribution costs of the compost throughout the farm.

Storage sites will be required;

- for off-specification product,
- during periods of no sales or wet weather when farms cannot accessed, or
- when there is no market demand due to cropping cycle constraints.

The international trend is to have substantial buffer requirements around compost facilities, because even the best run compost scheme is odorous at some times. Some countries require up to a 5 kilometre buffer from large facilities to residential development, but up to 1 kilometre would be appropriate for a Municipal level scheme.

7.7. Alternative Biodegradation Schemes

Vermi-culture is an alternative to composting. Locally there has not been too much success with vermin-culture schemes because of worm deaths and the costs involved. Generally the market does not seem willing to pay the additional costs of the vermicast.

There is potential for worm sale (fish food) and castings sale (soil conditioner, like compost). Advantages are less odour risk, no enzyme costs, castings are safe from sharps, pathogens but may still be toxic due to heavy metals or inorganic biocides, etc and disadvantages such as labour intensive, need some technological skills, cannot handle all putrescible wastes, etc.

7.8. Summary

There are records of Cleansing Department producing EM Bocashi from market wastes in 1990s' with the support of local technology. The production was stopped for financial reasons and since then no attempt to make composts was made by the department.

Cleansing Department will need budget approval to revive compost making activities, though the department is planning to implement activities by collaboration with private investors in a joint venture agreement. In that case the department is highly recommended to make use of adequate compost making technology. Comprehensive marketing strategies will also need to be developed at the beginning stage of new production to reduce the risk of financial loss which was encountered by the department in their previous ventures. There needs to be a private operator who is interested in PPP to cooperate with the department.

The compostable material must be completely separated from the rest of the waste. This is best done at the source - by the householder or commercial operator. However, this requires considerable co-ordination and encouragement from Municipality's and Neighbourhoods. Separation can be done at the MRF or Landfill, however this adds significantly to the cost and effort required and is never 100% successful with residual contaminants remaining in the compost.

Separation of the waste needs to be thorough as an occasional piece of metal or other solids in the waste stream causes faster wear or even partial destruction of the shredding equipment and lowers the overall quality of the compost, and presents health and safety risk as do glass shards or sharps.

The initial outlay and operating costs of a centralised composting facility would be substantial. Well in excess of USD100k is required to establish a mechanised system that will handle only a few tonnes per day. Technical expertise would be required to operate the facility and market the end product. Basic systems using open weave bags and little mechanisation are more appropriate locally, if the Municipality is interested in centralised composting of just some selected waste stream components.

A sustainable market needs to be found for the compost generated from the material. This often proves difficult as demand is low and there are many other better and cheaper sources of compostable material. Also farmers advice that they are disinterested in having to apply two items to their crops namely compost and supplementary artificial fertilisers. Composted waste is relatively low in nutrients and so farmers need to add additional nutrients in most cases.

It may be better to encourage home level composting by subsidising the cost of composting bins and by providing free advice on the associated benefits and methods. This would help to reduce the overall volume of waste.

Neighbourhood level composting may be appropriate where the community is impoverished and individual households do not have the compound area available to utilise the compost produced. However all compost operations are odorous at some time. Some operations emit odours which are almost continuously detectable at a distance of more than one kilometre from the operation. This odour issue has resulted in many neighbourhood schemes being forced to close.

The other factor is heavy rain. Excess water in the compost pile reduces pile aeration, which reduces efficiency and increases odours. Roofing the operation would be prohibitively expensive, unless a high rate in-vessel system was adopted. In-vessel composting systems require purpose built reactor tanks and are expensive to construct and operate.

Assuming that all the above issues can be overcome, a sustainable market needs to be found for the compost generated from the waste material. This always proves difficult as generally demand is low. The addition of chicken manure, treated sewage sludges or inorganic fertilisers to increase nutrient content may assist in making the compost more marketable. If this later stage is to be undertaken, then a PPP should be established with a local landholder who will commit to taking all compost generated and not suing the Municipality in case of any compost-derived crop or soil contamination, or worker injury from glass or metal shards.

Therefore, at this stage, encouraging householders to undertake composting at home is strongly supported. This will require Municipality and Neighbourhood support in terms of education and/or supply of subsidised compost bins or used tyres. In the longer term, trials of regional or centralised composting facilities using chipped greenwaste together with sewage sludge or some or other nutrient rich source may be worthwhile.

However the fact remains that a compost scheme, be it a household, Neighbourhood or centralised facility, will not be able to manage all wastes generated, either in terms of volume or waste type. It is a worthy supplemental scheme however, and is discussed in later sections in more detail.

7.9. Adopted Approach

The Municipality is interested in supporting composting schemes, through;

- Primary support for household level composting, but NOT making it compulsory. Support would include the following;
    - Issuance of compost starter kits or leaflets if using shallow burial method to households and also running an IEC advising them how to compost. This will be as part of the overall IEC, and is to be funded by the Municipality and Neighbourhood in partnership.
- Funding of Neighbourhood composting facilities is not supported at this time.
- For centralised facilities such as at the proposed landfill, the Municipality notes that only 65% of the total waste stream is food waste. Therefore the Municipality considers that a centralised facility could not be justified for such a small waste component at this time, unless expensive chipping and milling systems were installed to process the greenwaste for co-composting. However, if the overall waste stream volume increases dramatically, then a centralised composting scheme for residual biodegradables and processed greenwaste will be investigated.
    - This level of composting will only succeed if a stable market for the compost is developed and maintained and a rigorous quality control program is in place.

8. Population Projections and Waste Generation

8.1. Background

Preliminary estimates have been made for both population projections and waste generation rates for 30 years.

The population projections are primarily based on the Census figures and adopted growth rates.

There are many growth rates available including those addressing tourist increases etc. The ADB TA-8572 MYA Preparing Mandalay Urban Services Improvement Project adopted CATZ growth rate of 0.38% per year which has been adopted for this investigation. This is less than the overall growth rate of 1.3% for planned development and 1.64% for full development growth. CATZ Township is fully developed and so growth will only be as a result of densification.

Tourism impact has been investigated in the Safege report (Assessment of Waste Collection within the PPTA project area in the service area of MCDC Mandalay – Myanmar Urban Service Improvement Project, 2015) that concluded for the 15 year projection with a waste PE of over 2M PE that tourists only account for 10,000 PE so the waste surcharge associated with tourism may be ignored.

By contract, the impact of commercial activities is very evident in CATZ Township with the main hospital, main markets and many commercial institutions present in the waste collection area.

8.2. Waste Generation Allowance

Detailed waste generation data in the municipality is available from the truck records and weighbridge results.

At present, 177 tpd of waste is delivered on average form the CATZ Township to the northern dumpsite. The 2016 population CATZ township is 146,000 persons giving a waste generation rate of 1.2kg/p.d going to landfill after local waste segregation and sale of recyclables as well as scavenging from primary dumping locations. This rate does not differentiate between commercial and household waste as it is mixed during collection and weighed collectively at the landfill. Therefore the population projections assume the same level of commercial waste increase over time as the HH waste generation rate increases. Given the very small population growth rate, the waste generation rate per person has been enhanced to account for greater commercial activities occurring within the township.

This quantity also ignores waste not collected or dumped illegally.

Projects in other developing countries like Vietnam and the Philippines often use a rate of at least 0.5 kg/p.d going up to 0.65 kg/p.d for provincial cities. However in Thailand for example it can be as high as 1.5kg/p.d. Developed countries can generate up to three times this amount.

These amounts account for at source (in-house or in-institution) recycling and reuse. Higher value recyclables such as glass, metal and paper are already being recycled at source. This is typical of most developing countries where these high value recyclables traditionally account for 3 to 5 per cent of the total waste stream for each component.

The waste generation allowance was therefore set at 1.68kg/p.d initially increasing to 2.26 kg/p.d over 30 years to account for increasing community wealth and therefore,

higher per capita waste generation rates as well as more intense commercial activities occurring over time.

8.3. Collection Allowance

The current percentage of waste collection is estimated to be 80% in the core. Significant quantities of waste are being illegally dumped into drains and creeks at present as well as road table drain systems.

The ultimate aim is of course to approach 100% collection efficiency, but this may only achieved in the very long term following cultural changes which accept that littering is not desirable, and supported as well by a campaign of fines associated with littering. However, significant changes in the community attitude towards littering will be generational and not expected to be significant in the life of the controlled landfill proposed.

With the recommended improvements in this report, it may be expected that the collection percentage will increase to over 90% in the long term.

It was also assumed that the effective service area will increase form 95% to 100% as very hard to access areas are better serviced in future.

8.4. Recycling Allowances

As the wealth of the community increases, the amount of waste generated will increase.

However, this does not translate into a proportional increase in the quantum of waste to be collected and disposed of. The key changes with increasing wealth relates mostly to increased packaging, for such as paper, cardboard, tins and bottles. So as the amount of waste generated per person increases, so does the amount of recyclables, resulting in much smaller growth rate for the waste to be disposed of compared with the total increase in the mass of waste generated.

The percentage of waste recycled from the primary disposal locations, as well as during transport to the landfill has been set at 5% at present increasing to 10% over the 30 year planning horizon.

At the landfill itself, the recycling percentages is also expected to increase from the current 15% to 20% as well. This excludes possible future significant changes associated with perhaps green waste recycling, composting schemes or waste-to-energy activities.

8.5. Soil Cover Allowance

Three types of soil cover are required to operate a landfill correctly. The first and possibly most critical is the application of daily cover to a thickness of 100 to 150 millimetres. This cover provides a multitude of engineering interventions including a reduction in water infiltration leading to less leachate generated, less vermin on site, reduced bird numbers on site, reduced litter and reduced odours.

If an area of the controlled landfill is to be left unused for a period of a few months or more, intermediate cover to a thickness of 300 mm should be applied.

Final cover usually consists of two layers. The first layer is a 600 millimetre thick clay or silty clay cap to prevent rainfall infiltration. This should be topped with a layer of growing medium of compost or top soil to facilitate plant growth.

The application of cover can contribute some 15 and to 25% of the total landfill volume. However, smaller percentages are possible at well run landfills by recovering the daily soil application prior to commencing another lift of waste.

For this study, it has been assumed that 10% of the total landfill volume will be cover material initially. This is because it is expected that the daily cover may in fact be only applied on a weekly basis or at some other lesser frequency. Over time this will increase to 20% as operations improve.

8.6. Compaction Allowance

There are two options for providing compaction at the controlled landfill. The most common is the use of a tracked bulldozer which at the usual size of a D6 or D7 equivalent. However, for larger landfills, a purpose built landfill compactor can be used:

The typical waste density then achieved at the landfills assuming that the waste arrives relatively uncompacted as it was hauled in a mix of compactor trucks and open trucks:

- no compaction - 300kg/m^3
- 500kg/m^3 minimum with bulldozer or tracked loader
- 650kg/m^3 minimum with smallest specialised landfill compactor (handles 500t/d working with a bulldozer)
- 1,000kg/m^3 minimum with largest specialised landfill compactor (handles 1000t/d working with a bulldozer, so only for very large landfills)

Because of the size of the controlled landfill, it is proposed to assume a D6/& bulldozer in association with a 20 tonne landfill compactor at each landfill, which will be a suitable combination to be able to push and shape the waste quantities and provide good compaction.

The adopted initial density is 650kg/m^3 increasing to 950 kg per cubic metre over time as the operations improve and larger equipment is used.

8.7. Waste settlement

Waste settles over time and it has been assumed that 5% of the volume will be lost in the first year, in accordance with recorded results from many landfills.

The waste will continue to compact at 0.5% per year on average over the following 30 years.

8.8. Airspace Consumption

Based on the above assumptions, the cumulative waste volume taken up at the controlled landfill has been calculated on an annual basis.

At present CATZ waste is directed to the existing Northern dumpsite which may be expanded or a new common site developed. Regardless of the future landfilling approach and siting, the data below provides guidance on the airspace required for future planning.

For example, a new site would require an area of 200m by 150m to last 5 years just for CATZ waste. Over 30 years, CATZ waste alone will require an area some 200m by 600m long growing to a height of 40 metres and with excavation to over 4 metres to obtain sufficient cover material.

Given that CATZ waste is roughly 20% of the total waste stream, then the total landfill area required in 30 years (without major interventions such as waste to energy) would

be 5 times this size or some 60 hectares if a long narrow site with waste placed to 40 metres high, or 40 hectares if a square site say 600m by 600m and waste is placed to 80 metres high

Based on this theoretical waste volume, the controlled landfill stages could be sized. Traditionally the first stage or cell at a controlled landfill should provide some 5 year's capacity. Typically, the overall controlled landfill site selected should have capacity for at least 30 plus years operation.

In reality there are numerous factors that could eventuate and impact upon the assumptions and predictions for this predicted landfill life in the coming decades. However, these impacts can be counteracting, such as a lower growth rate than that predicted could be contrasted against a higher per person waste generation rate and so on.

Therefore, it is recommended that the following table of cumulative waste volume be adopted as the best available predictions at this time. Any variations to the many components intrinsic to this prediction will only alter the life of the controlled landfill and not the concept nor the basic design approach. If the cumulative waste volume at the controlled landfill is either significantly larger or smaller compared with the predictions below, then the later cell sizes can be amended to compensate for these variations.

These projections will obviously be refined during later stages as the interventions are refined and agreed, and also at the time of detailed design.

Table 8.1 Population and Waste Load Projections - Detailed

YEAR	Qalat Annual Growth Rate	TOTAL Population	Serviced Area Percentage of Township Area	Projected Serviced Population	Rate of Waste Generation (post HH Direct Recycling)	Daily Waste Generated in Serviced Area	Percent Collected in Serviced Area	Percent Recycled Post HH	Daily Waste Delivered to Landfill	Percent Recycled at Landfill	Waste placed into landfill	Landfill Insitu Waste Density	Annual Totals (with no allowance for settlement)			Cumulative Totals					YEAR
	%	Persons	%	Persons	kg/p.d	t/d	%	%	t/d	%	t/d	kg/m^3	t/yr	%	Cubic Metres	t	Cubic Metres	Cubic Metres	Cubic Metres	Cubic Metres	
		Agree base population and percentage growth rates	Often assume percentage increases with future collection equipment upgrades	Persons	Input current rate and increasing over time. Based on recycling at home or at source	Tonnes/ day	Increasing as illegal dumping and self disposal reduce	Includes recycling from primary disposal locations. Usually increases over time. Does not allow for major diversions which are possible in future such as WtE	Tonnes/ day		Tonnes/ day	Waste density usually increases over the years as better equipment utilised.	Tonnes/ year	Percentage of Cover (Often initially 10% and increasing to 20% or more as operation improves)	Total Airspace Consumed (with no allowance for settlement)	Tonnes Disposed	Cover material required (m3)	Total Airspace Consumed (with no allowance for settlement)	Settlement and Consolidation	Cubic Metres of Airspace Consumed (Allowing for settlement)	
2016	0.38%	146,000	95%	139,000	1.68	234	80%	5%	177	15%	151	650	56,000	10%	87,000	56,000	8,000	87,000		87,000	2016
2017	0.38%	146,600	95%	140,000	1.70	238	80%	5%	181	15%	154	650	57,000	10%	88,000	113,000	8,000	175,000	5,000	170,000	2017
2018	0.38%	147,200	95%	141,000	1.71	242	81%	5%	185	15%	156	650	58,000	10%	90,000	171,000	9,000	265,000	11,000	254,000	2018
2019	0.38%	147,800	96%	142,000	1.73	246	81%	5%	188	15%	159	650	59,000	11%	91,000	230,000	10,000	356,000	17,000	339,000	2019
2020	0.38%	148,400	96%	143,000	1.75	250	81%	5%	192	16%	162	800	60,000	11%	76,000	290,000	8,000	432,000	24,000	408,000	2020
2021	0.38%	149,000	96%	143,000	1.77	252	81%	6%	194	16%	164	800	60,000	11%	76,000	350,000	8,000	508,000	30,000	478,000	2021
2022	0.38%	149,600	96%	144,000	1.78	257	82%	6%	198	16%	166	800	61,000	12%	77,000	411,000	9,000	585,000	37,000	548,000	2022
2023	0.38%	150,200	96%	145,000	1.80	261	82%	6%	202	16%	169	800	62,000	12%	78,000	473,000	9,000	663,000	44,000	619,000	2023
2024	0.38%	150,800	97%	146,000	1.82	266	82%	6%	206	16%	172	800	63,000	12%	79,000	536,000	9,000	742,000	51,000	691,000	2024
2025	0.38%	151,400	97%	147,000	1.84	270	83%	6%	210	16%	175	800	64,000	12%	81,000	600,000	9,000	823,000	59,000	764,000	2025
2026	0.38%	152,000	97%	148,000	1.86	275	83%	6%	214	17%	178	850	66,000	12%	78,000	666,000	9,000	901,000	67,000	834,000	2026
2027	0.38%	152,600	97%	149,000	1.87	279	83%	6%	218	17%	181	850	67,000	12%	79,000	733,000	9,000	980,000	76,000	904,000	2027
2028	0.38%	153,200	97%	150,000	1.89	284	83%	6%	222	17%	184	850	68,000	13%	81,000	801,000	10,000	1,061,000	85,000	976,000	2028
2029	0.38%	153,800	97%	150,000	1.91	287	84%	6%	225	17%	186	850	68,000	13%	81,000	869,000	10,000	1,142,000	94,000	1,048,000	2029
2030	0.38%	154,400	98%	151,000	1.93	292	84%	7%	229	17%	189	850	70,000	13%	83,000	939,000	10,000	1,225,000	104,000	1,121,000	2030
2031	0.38%	155,000	98%	152,000	1.95	296	84%	7%	233	17%	193	850	71,000	13%	84,000	1,010,000	10,000	1,309,000	114,000	1,195,000	2031
2032	0.38%	155,600	98%	153,000	1.97	301	85%	7%	237	18%	196	900	72,000	13%	81,000	1,082,000	10,000	1,390,000	125,000	1,265,000	2032
2033	0.38%	156,200	98%	154,000	1.99	306	85%	7%	242	18%	199	900	73,000	14%	82,000	1,155,000	11,000	1,472,000	136,000	1,336,000	2033
2034	0.38%	156,800	98%	155,000	2.01	311	85%	7%	246	18%	202	900	74,000	14%	83,000	1,229,000	11,000	1,555,000	147,000	1,408,000	2034
2035	0.38%	157,400	99%	156,000	2.03	317	85%	7%	251	18%	205	900	76,000	14%	85,000	1,305,000	11,000	1,640,000	159,000	1,481,000	2035
2036	0.38%	158,000	99%	157,000	2.05	322	86%	7%	256	18%	209	900	77,000	14%	86,000	1,382,000	11,000	1,726,000	171,000	1,555,000	2036
2037	0.38%	158,700	99%	158,000	2.07	327	86%	8%	260	18%	212	900	78,000	15%	87,000	1,460,000	12,000	1,813,000	184,000	1,629,000	2037
2038	0.38%	159,400	99%	159,000	2.09	332	86%	8%	265	19%	216	900	79,000	15%	88,000	1,539,000	12,000	1,901,000	197,000	1,704,000	2038
2039	0.38%	160,100	99%	160,000	2.11	338	87%	8%	270	19%	219	900	80,000	15%	90,000	1,619,000	12,000	1,991,000	210,000	1,781,000	2039
2040	0.38%	160,800	100%	161,000	2.13	343	87%	8%	275	19%	222	950	82,000	15%	87,000	1,701,000	12,000	2,078,000	224,000	1,854,000	2040
2041	0.38%	161,500	100%	162,000	2.15	349	87%	8%	280	19%	226	950	83,000	20%	88,000	1,784,000	15,000	2,166,000	238,000	1,928,000	2041
2042	0.38%	162,200	100%	163,000	2.18	355	88%	8%	285	19%	229	950	84,000	20%	89,000	1,868,000	15,000	2,255,000	253,000	2,002,000	2042
2043	0.38%	162,900	100%	164,000	2.20	360	88%	9%	290	20%	233	950	86,000	20%	91,000	1,954,000	16,000	2,346,000	268,000	2,078,000	2043
2044	0.38%	163,600	100%	165,000	2.22	366	88%	9%	295	20%	237	950	87,000	20%	92,000	2,041,000	16,000	2,438,000	283,000	2,155,000	2044
2045	0.38%	164,300	100%	165,000	2.24	370	89%	9%	298	20%	239	950	88,000	20%	93,000	2,129,000	16,000	2,531,000	299,000	2,232,000	2045
2046	0.38%	165,000	100%	165,000	2.26	374	90%	10%	303	20%	241	950	89,000	20%	94,000	2,218,000	16,000	2,625,000	315,000	2,310,000	2046

9. Development and Evaluation of Collection Alternatives

9.1. Background

A recent approach adopted by MCDC was to regulate the timing of household waste disposal and collection during the day. The timing was arranged 2 shifts a day; one in the morning from 5 to 8 am and the other in the evening from 5 to 8 pm. Citizens were informed of the arrangement and signboards were also established to remind households of the time of disposal. The aim was to keep litter out of sight on the streets and at garbage bins during daylight and thus improve the clean image on the streets and around garbage bins. Municipal waste collection fleet would move into the residential wards at 6 to 6:30 in the morning and evening for collection. Loud hailers were used during the time to alert people to come and disposal waste.

Disposal beyond the scheduled time was discouraged and subject to fine. Cleansing Department informally assigned members of its labour forces (mostly daily waged workers who were living in the wards) as watch groups to prevent households from throwing garbage at off-hours. Fine against non-compliance was based on the volume or weight of disposed garbage and ranged from 1500 MMK per bag to 3000, 5000 and 10,000 MMK. However, there was discussion among the MCDC personnel at policy making level as to the logic behind the specific timing for waste disposal. The department is now planning to change the waste disposing time from the evening 5:00pm to the morning 8:00am.

Business owners are instructed to disposed commercial waste at specified waste pit or call for municipal garbage truck to collect. Commercial waste taxes are charged at a rate of 35,000 MMK per 1.5 ton.

While it is relatively easy to collect commercial tax from business owners, it is not so easy to collect fines from individual households, for many obvious reasons; the inflictor would point out other inflictors who have escape punishment and accuse of the department of unfair treatment or he or she would counter-charge the department for non-performance of services or even react with hostility to regulation enforcing personnel, Moreover, it is not clearly defined in MCDC Laws whether the Township Executive Officer or staff authorized by him or her is empowered to fine a person on site.

The collection system can impact upon 3R implementation, particularly the recycling aspect, and less so the waste minimisation/reuse issues. These later aspects can be impacted by source segregation requirements if for example a multiple bin collection approach is adopted.

Appendix H – Background to Waste Containers, Segregation and Collection System provides an overview of the options and how they interact, as well as description of the types of equipment available and their relative advantages and disadvantages.

Therefore some consideration of the collection system, and therefore the waste segregation issues and their interactions, is appropriate.

Further, significant recycling happens during waste hauling as the collection staff scavenge through the waste on the way to the dumpsite. Therefore if compactor vehicles are proposed in the future, then waste recovery needs to happen either at source (Household or enterprise), in the primary dumping areas or at the dumpsite, but obviously not during haulage activities.

9.2. Existing Collection System

The existing system is door to door supplemented with community bins for litter collection, apartments, hard to access areas and for commercial/institutional waste.

The present fleet for CATZ Township is tabulated below. It should be noted that much of the tipper truck equipment is decades old and some is non-functioning at present.

Also the mix is heavily weighted to inefficient tipper truck collection and hook lift bins, neither of which provide any compaction making haulage inefficient.

There are only 10 compactor vehicles available for the whole fleet, and most are small vehicles.

- **Table 9.1 - Detailed Vehicles information**

	Type of vehicle	No.	Vehicle Registered number	Departmental Registered number.	Price of vehicle (MMK)	Arrival Date to the department	Remark	Picture
1	AMT	1	9L/26583	AMT-21	2646000	31.7.2012	For desludging of the drain	
		2	9L/26571	AMT-22	2646000	2012		
		3	9L/25872	AMT-25	2646000	2012	For desludging of the drain	
		4	9L/26065	AMT-06	2646000	1996	AMT is the name of vehicle imported company	
2	Tipper + Faw	1	8A/9540	Blue-45	1665000	1995		
		2	1B/9566	Blue-11	1625000	1995		
		3	8A/9548	Blue-24	1625000	1996		
		4	8A/9543	Blue-37	1665000	1996		
		5	8A/9540	Blue-45	1665000	1996		
		6	8A/9946	Blue-47	1265000	1996		
		7	8A/9943	Blue-52	1265000	1996		
		8	8A/9536	Blue-63	1265000	1996		
		9	8A/9535	Blue-65	1265000	1996		
		10	1B/5684	Blue-81	1625000	1996		
		11	1B/5683	Blue-83	1625000	1993		
		12	1B/5670	Blue-90	1625000	1996		
		13	1B/9551	DF-1	1625000	1994	DF is the brand of vehicle but the type is FAW	

3	Hook Lift Truck Tank Carrier (TC)	1		TC-04	19500000	31.5.2010		
		2		TC-23	19500000	31.5.2011		
		3		TC-27	19500000	31.5.2012		
		4		TC-28	19500000	31.5.2013		
		5		TC-31	19500000	31.5.2014		
		6		TC-36	19500000	31.5.2015		
		7	6K/1690	TC-40	23800000	18.11.2015		
		8	1L/5610		27000000	16.12.2015		
		9	3L/7191		49900000	9.10.2014		
4	RC	1	4E/6599	RC-08	23000000	2.11.2012	RC (Big)	
		2	4E/6604	RC-16	23000000	27.12.2012	RC (Big)	
		3	4E/6592	RC-01	23000000	2012	RC (Big)	
		4	7E/2568	RC-25	23000000	30.1.2013	RC (Big)	
		5	7E/2554	RC-33	18800000	27.12.2012	RC (small)	
		6	7E/2585	RC-35	18800000	30.1.2013	RC (small)	
		7	7E/2573	RC-37	18800000	30.1.2013	RC (small)	
		8	7E/2556	RC-31	18800000	30.1.2013	RC (small)	
5	Dump truck	1	2C/3487		56800000	2009		
		2	5B/3941		18500US$	2002		
		3	7K/3378		34500000	14.12.2015		
		4	3l/7187		49900000	9.10.2014	ten wheel	
		5	5B/3839		18500 US$	18.7.2010		

6	TE Tipper	1	Q/793		2819000	1087	listed in the number of vehicles supported by the motor vehicle department but not functional	
		2	J/3291		2819000	1989	Both for collection & desludging of the drain as well	
7	Compactor	1	5J/6203			9.4.2015	Compactor (Small)	
		2	5J/6219			9.4.2015	Compactor (Small)	
		3	5J/6292			9.4.2015	Compactor (Small)	
		4	5J/6257			9.4.2015	Compactor (Small)	
		5	5J/6306			9.4.2015	Compactor (Small)	
		6	5J/6126			9.4.2015	Compactor (Small)	
		7	5J/6254			9.4.2015	Compactor (Small)	
		8	9K/9431			12.1.2016	Compactor (Big)	
		9	9K/9637			12.1.2016	Compactor (Big)	
		10	9K/9461			12.1.2016	Compactor (Big)	
8	Tribike	1	1Ha/1289	C-02	2500000	2010	Small bike/ no cover at the top	
		2	1Ha/1469	C-08	2500000	2010		
		3	1Ha/1384	C-09	2500000	2010		
		4	1Ha/1297	C-06	2500000	2010		
		5	1Ha/1312	C-25	2500000	2010		
		6	1Ha/1493	C-32	2500000	2010		
		7	1Ha/1317	C-33	2500000	2010		
		8	1Ha/1320	C-34	2500000	2010		
		9	1Ha/1448	C-36	2500000	2010		
		10	1Ha/1449	C-37	2500000	2010		
		11	1Ha/1407	C-38	2500000	2010		

		12	1Ha/1454	C-39	2500000	2010		
		13	1Ha/1451	C-40	2500000	2010		
		14	Ha/8590	C-78	2500000	2010		
		15	Ha/8596	C-81	2500000	2010		
		16	Ha/8866	C-89	2500000	2010		
		17	3Ha/4424	C-100	2600000	25.9.2012	With Box/ cover	
		18	3Ha/4425	C-101	2600000	25.9.2012		
		19	3Ha/4426	C-102	2600000	25.9.2012		
		20	3Ha/4427	C-103	2600000	25.9.2012		
		21	3Ha/4428	C-104	2600000	25.9.2012		
		22	3Ha/4429	C-105	2600000	25.9.2012		
		23	3Ha/4430	C-106	2600000	25.9.2012		
		24	3Ha/4656	C-136	3200000	11.10.2012		
		25	3Ha/4660	C-140	3200000	11.10.2013		
		26	3Ha/4671	C-151	2580000	22.7.2018		
		27	3Ha/4676	C-156	3200000	11.10.2014		
		28	7Ha/1681	C-163	2300000	17.3.2014		
		29	7Ha/3372	C-170	2580000	22.7.2014		
		30	7Ha/3366	C-175	2580000	22.7.2015		
		31	7Ha/3362	C-179	2580000	22.7.2016		
		32	7Ha/3363	C-189	2580000	22.7.2017		

- **Table 9.2 – Primary dumping location types and numbers**

Type	Number	Remark
Brick Tank	16	Masonry brick tank
TC tank	40	Hook lift bins
Open dump site	57	"Informal" uncontrolled dumping on footpath/road verge

9.3. Collection System Planning

In terms of haulage capacity, Identifying goals, objectives, and constraints can help guide the planning process. Issues that should be considered include the following:

- **Level of service**: What level of services is required to meet the community's needs? What materials need to be collected and what are the requirements for separate collection of these materials? What needs and expectations exist with respect to the frequency of pickup and the convenience of set-out requirements for residents?

- **Roles for the public and private sectors**: Is there a policy preference regarding the roles of the public and private sectors in providing collection services for wastes and recyclables? If collection is to be performed by private haulers, should the municipality license, franchise, or contract with haulers?
- **Waste reduction goals**: What are the community's waste reduction goals and what strategies are necessary or helpful in achieving those goals? For example, source reduction and recycling can be facilitated by charging customers according to the volume of wastes discarded, by providing convenient collection of recyclables, and by providing only limited collection of other materials such as yard trimmings and tires.
- **System funding**: What preferences or constraints are attached to available funding mechanisms? Are there limits on the cost of service based on local precedence, tax limits, or the cost of service from alternative sources?
- **Labour contracts**: Are there any conditions in existing contracts that would affect the types of collection equipment or operations that can be considered for use? How significant are such constraints and how difficult would they be to modify?

Communities can select the level of services they wish to provide by choosing how often to collect materials and the point from which materials will be collected at each residence. The greater the level of service, the more costly the collection system will be to operate. Factors to consider when setting collection frequency include the cost, customer expectations, storage limitations, and climate. Internationally, most municipalities offer collection once or at most twice a week in tropical climates. Some wastes such as segregated greenwaste is only collected every two weeks quite often.

Crews collecting once per week can collect more tons of waste per hour, but are able to make fewer stops per hour than their twice-a-week counterparts. A USEPA study found that once-a-week systems collect 25 per cent more waste per collection hour, while serving 33 per cent fewer homes during that period. Some communities with hot, humid climates maintain twice-a-week service because of health and odour concerns.

At present, collection frequency is highly variable and ranges from twice a day to less than once a week. A number of options exist for each of the first three components. Choice of which option to develop is dependent upon existing practices, new planned activities, and input from ISWM staff and stakeholders. From an inventory of existing municipal assets and equipment, the current waste management practices (primary collection, secondary collection and existing disposal practices), feedback from the stakeholders, and acknowledgement of the limitations of budget, a plan can be formulated that will address the goals established for environmentally sound ISWM.

9.4. Household/commercial production, storage and collection

This primary system is necessary to ensure waste stored at source is collected regularly and not discarded in streets, drains, water bodies, etc. It is important that this step is designed to synchronize with the secondary waste collection step to ensure complete system functionality.

Waste density is highly variable and for non-compacted waste in developing countries (with typical municipal waste characteristics) it can be as low as 150kg/m^3 or as high as 350kg/m^3 if auto-compacted during haulage due to travel vibration as well as walking over by jumper boys during collection and if the waste contains a high proportion of street sweepings (dirt and sand). Based on the density determinations conducted as part of the waste audit, the adopted density is therefore 220kg/m^3.

Commercial premises can vary greatly depending upon their commerce. Their waste containers must be appropriate for their waste production, or they will need multiple containers.

9.5. Primary waste collection process

9.5.1. Background

There are a number of approaches to collection of waste from residences and commercial producers. Together these are illustrated together in the Figure below, and described in detail as follows. Presented here are some of the possibilities.

- Householder separates the organics and fines, composts them at the house, and then places residuals in a small household bin. Door-to-door collection of home bins with manually operated handcart by community worker.
- Door-to-door collection of home bins with manually operated handcart by community worker.
- Door-to-door collection of waste piles by community worker.
- Householder takes waste to community bins as it is produced.
- Householder places waste in indiscriminate piles, to be collected by community worker.

Since more than 50% of the waste has been measured as organics and food scraps, it means that composting at the household level has the potential to have beneficial impacts on ISWM management from primary collection to final disposal.

Depending upon space available, there may not be enough room to compost on-site. However, a mini enterprise for private company could be developed, that could get paid a small amount to take the waste away, than can sell the final product to farmers.

Diversion of the organic waste also reduces the odour and vector attraction of waste stored at the household and subsequently in primary dumps if a community based system is adopted.

At present, many households and commercial establishments dump their wastes in relatively uncontrolled piles that may or may not be formally designated.

Piles are subject to animal scavenging and scattering of the waste and is the least preferable option. Although virtually no coordination is necessary between the household and the collector is required, uncontainerised waste requires collection crews to hand-collect loose waste from the street, which is a hazardous and time-consuming practice.

One of the key factors that requires a concerted effort and buy-in on the part of the community is proper use of waste drop sites. In many instances, a trash dam is not properly used, so the result is not dissimilar to having an open trash dump site with similar visual, odour and health concerns. This may require an aggressive education effort.

Changing to waste bins (Hook-lift or skip bins) also require some community engagement to ensure that the waste is placed in the bin by the householder or commercial institution, and not just dumped near the bin.

9.5.2. Door to door system

The present system is a mix of door to door collection and community/commercial bins. This is necessary because of access difficulties precludes full door to door and commercial activities require bulk bins, such as the large markets

9.5.3. Community and commercial/institutional bins

A number of both formal and informal drop sites exist for:

- commercial/institutional solid waste collection at present.
- Primary dumping locations for the tricycle and pushcart waste being collected door to door

This confirms that a certain level of flow from primary to secondary to final deposit already takes place and is accepted by the community.

With most of the options, the waste is collected through the primary collection system and temporarily stored at community collection drop points – “trash dams,” bins, or skips - prior to being transported in bulk to the waste treatment or disposal site, or possibly a transfer station. The function of this component is solely to provide an interim storage site to make operations more efficient. As such, it is very important that they are:

- capable of holding the entire amount of waste brought to them during a set period (for instance, to be able to hold a week’s worth of contributions from primary collection if that is adopted as the collection frequency),
- emptied prior to new cycle of waste being brought to them – that is, they are synchronized with primary collection, and
- easily emptied and accessible for transport vehicles.

There are a number of alternatives for drop points (primary dumping locations), including

- not using formal drop points – just allowing uncontrolled open dumping
- uncontainerised, open piles in agreed locations
- trash dams (permanent concrete or steel bunkers)
- hook-lift bins matched to the collection truck.
- skip bins matched to the collection truck

The open pile alternative is by far the least desirable; the hook-lift bins or skips are the most efficient and clean, but are by far the most expensive initial cost requiring specialized matched equipment. Concrete bins are the midway option.

Hook lift bin systems do not provide any compaction and even partially full hook-lift bins will sometimes need to be transported. Bins cannot be added to one another to fill one bin (to maximise haulage efficiencies) unless waste is manually shovelled from one to the other.

Skip bins are loaded into a compactor truck where not only is the partially full bin issue then overcome, but the compactor truck can then double or treble the waste density making haulage far more efficient.

Locating any of these containers is an important decision. It is important to consider:

- Containers are located strategically, taking into account where community workers or households have established past drop practices.
- There is adequate space to place one or more containers, and access by the collection vehicle.

- They do not obstruct the entrance of any building, or hinder traffic.
- Neighbours will not vandalise them if the waste become odorous or if feral animals spread the waste
- The walking distance from the edge of the bin catchment is sufficiently short so that residents will take waste to the primary dumping location and not fly dump or litter instead. Anything less than 150 metres is usually considered sufficiently close, but reducing this to a 100 metre maximum walk if possible has been found to reduce illegal dumping to very low levels.

The value of locating at existing informal waste disposal sites is that the community is used to these drop locations, and the change in appearance (when a bin, skip or trash dam is placed) is a noticeable visual improvement. Thus objections from the community should be minimal in that case.

- **Table 9.2 Selected alternatives for community waste collection.**

	Open piles	Trash dams/Bunkers	Hook-lift Bins	Skip bins
				
Price/unit	- 0 -	US$400 to $600	US$600 to $1500	US$400 to $1200
Vehicle required	Non-specific	Non-specific	Hook-lift truck matched to bin	Forklift-type compactor truck matched to bin
Positives	• Low cost • Disposal points presumably established by community needs	• Static so residents have defined disposal point • Relatively inexpensive • Requires no special equipment • Fabricated locally	• Bins easier to relocate as they are not fixed • In an emergency, small bins can be lifted by crane trucks which are relatively abundant, known by mechanics & operators • Fabricated locally • Easily removed, cleaned, repaired and replaced • Bins replaced immediately by empty bin	• Bins easier to locate as they are not fixed • In an emergency, skip bins can be lifted by crane trucks which are relatively abundant, known by mechanics & operators • Fabricated locally • Easily removed, cleaned, repaired and replaced • Skip bins recycled immediately and waste is compacted in truck
Negatives	• Alternative that most results in waste being irresponsibly discarded on streets. • Requires collection crews to hand collect loose waste from the street, which is a hazardous and time-consuming practice. • Allows animal access to scatter waste • Difficult to locate as residents don't like them beside house	• Difficult and slow to access & awkward to empty • Manual labor required to empty exposing workers to health hazards • Difficult to locate as residents don't like them beside house • Often vandalized and any metal doors stolen	• Requires specific hook-lift truck matched to bin • Lifting and unloading can cause damage to containers. • Very low risk of container being stolen • Does not allow compaction in transit to landfill	• Works best with specific fork truck matched to bin • Lifting and unloading can cause damage to containers. • Low risk of container being stolen • Does allow compaction during transit to landfill

9.5.4. Adopted Primary Waste Collection System

The privatised collection system will be door to door primarily supported by community bins for waste collected from hard to access areas or apartment building. Household Bins such as MGB/plastic wheelie bins will not be provided by the Government or private contractor. Therefore the system will be similar to the present where householders must bring out their waste at the appointed times as the vehicle and collection team approach.

These bin types will also serve as community litter bins and also for commercial and institutional activities.

A mix of standard large bins (4.5 cubic metres) and smaller bins (1200 litre) is considered appropriate.

9.6. Secondary collection

Depending upon the particular system and configuration, the number of trucks or tractor-trailers required can be determined. This also depends upon how long it takes to load the waste and how far it is to a landfill/disposal site. For instance, shovelling out a concrete trash dam or a scattered pile takes much longer than it takes to pick up a skip or hook-lift bin. But it is also possible that a dump truck can hold more than the amount of waste in two trash dams, whereas it may be that the flatbed associated with a crane can only transport two skips/bins.

Table 9.3 Selected alternatives for community waste haulage

	Tractor/Trailer	Tip Truck	Hook-lift Bin Truck	Skip bin Truck
				
Price/unit	US$25,000	US$90,000	US$120,000	US150,000
Bin required	Non-specific	Non-specific	Hook-lift bin – various sizes	Bin matched to Forklift-type compactor truck – various sizes possible
Positives	• Equipment is relatively cheap with good availability. • Has a good short turning radius, so it is fairly easy to access tight spots, such as within communities. • Still has maintenance issues with hydraulics associated with the trailer lifting ram (and possibly the front bucket system)	• This system is very similar to the first alternative, but uses a truck with potentially much greater haulage capacity than a trailer pulled by tractor. • Dump trucks are moderately priced with good availability and mechanical support. • Is capable of good road speed when going to the landfill. • Can access replacement trucks easily as these vehicles are used for many other haulage purposes	• Truck has large haulage capacity • Fast to load, empty and replace • Can take up to 30 cubic metres in one bin as no real limit on lift capacity • Trucks are moderately priced with good availability and mechanical support. • Is capable of good road speed when going to the landfill. • Can lift many different bin sizes to suit location needs	• This system is a very quick and clean way to collect containerized waste. • Low labour requirements and costs. • Relatively high weekly waste capacity • Compacts waste up to 3 times the density • Good road speed
Negatives	• Fairly labour intensive to fill trailer by hand. • Shovelling waste is a hazardous and time-consuming practice. • A tractor is very slow on the way to the landfill. • Consider using a transfer station to overcome the tractor's slow speed. • No waste compaction	• Fairly labour intensive to clean out trash dams. • Shovelling waste is a hazardous and time-consuming practice. • A large truck has poor turning radius, so may not be able to negotiate some narrow roads, or turns. But can use a variety of truck sizes to suit road widths in the city • Truck has hydraulic systems for tipping requiring maintenance (same as tractor-trailer systems) • No waste compaction	• Requires specific hook-lift bin • A large truck has poor turning radius, so may not be able to negotiate some narrow roads, or turns. • Does not allow compaction in transit to landfill • Cannot be replaced with other truck types such as tip trucks • Truck has hydraulic systems for tipping requiring maintenance (same as tractor-trailer systems)	• The most expensive in terms of capital investment, and not generally available locally. • Requires significant room to turn, and bin must be aligned with truck. Smaller rear lift vehicles are available for narrow street areas • May require advanced training for mechanics.

9.6.1. Adopted Secondary Waste Collection System

The preferred approach is to use compactor vehicles for door to door collection of wast, carried in bags from the household to be placed in the rear trough. This will be supplemented by tricycle bikes collecting waste from hard to access areas and hauling it to skip bins for collection by large front-lift or small rear-lift compactor trucks. Both large and small bins will be required depending upon locally specific access restrictions.

The bins will also be used for commercial and institutional users, and emptied by compactor trucks.

The proposed collection fleet will be refined by the private operator contracted to collect the waste form CATZ township.

9.7. Proposed collection fleet

The proposed list of fleet requirements below is the absolute minimum amount of fleet required and does not include any redundancy or backup whatsoever. This total of 19 in-service vehicles is compared with the present 45 vehicles (excluding trike bikes).

It also assumes that the small compactors make 3 trips a day to the landfill and the large compactors 1.5 trips a day on average. This assumes that there are no restrictions on landfill operating hours as well as well as collection hours.

In reality, and following a street by street investigation, it is likely that more equipment will be required, especially if working hours are limited for traffic or other reasons by MCDC prior to tendering out the collection services.

Therefore the following list is the bare minimum of operational (no redundancy) required if the road system can accept the large compactors, operating hours are not too restrictive and the bins are placed efficiently so that the truck empties near full bins most of the time. If bin distribution is sub-optimal, with trucks often emptying partially full bins or having to clean up litter around overfull bins, then additional fleet and bins will be required.

No allowance has been made for street sweeping as contractors may decide to use mechanised sweepers rather than manual.

- **Table 9.4 Minimum fleet and bin requirements**

Item	Quantity
Waste skip bins - 4.5 cu.m.	250
Waste skip bins - 1.2 cu.m.	330
Waste compactor collection trucks (28 cu.m. capacity) -	7
Waste compactor collection trucks (8 cu.m. capacity)	10
10 wheeler tipping dump truck	2
Small motorised carts (Trikes with high lift dumping direct into skip bins)	30
Pushcarts	70

Staff numbers have been estimated assuming no redundancy and very efficient vehicle operation with just 2 staff per vehicle as well as the driver. This assumes that householders will be required

to bring their wastes out from their compounds to the truck/collectors and the collection workers do not have to enter the house compounds at all.

- **Table 9.5 Minimum staff numbers (excluding drain cleaning and street sweeping)**

Item	Number
Sanitary Inspector Wages/senior foreman	7
Truck and trike drivers - spare drivers included for 7 day week rostering	49
Garbage Collectors/Sanitary Workers. Assume 2 garbage collectors per large vehicle (in addition to the driver) - additional workers included to allow for 7 day week rostering	44
Pushcart staff	70

10. Review of Waste Processing and Disposal Options

Even with waste minimisation education and maximised recycling efforts, there will still be a need for a final disposal option. Alternative methods of waste disposal were investigated as below:

- Incineration;
- pit burners;
- baling;
- composting;
- “Zero Waste” fully-integrated approach and
- Waste to energy

The composting and waste to energy options are presented in separate chapters.

10.1. Incineration

Incineration of waste would considerably reduce the volume of waste for landfilling. A large facility would need to be constructed to burn waste material, thus converting carbon and hydrogen compounds to carbon dioxide, water and other residues. In the process of burning this waste it is possible to generate some energy. The proceeds from energy sale would not offset the entire running costs, let alone redemption on the capital investment.

The negative side of incineration is the need to sort the waste stream prior to burning as not all waste material can be burnt. The most significant disadvantage is the generation of exhaust gases (some potentially harmful gases) and the visual intrusion of the chimney stack. Specialist knowledge is required to operate and maintain an incineration facility which adds significantly to the life cycle costs.

Incineration was not considered a viable option due to the disadvantages and high capital and operating costs of such a facility. Costs of up to $100 a tonne for incineration would not be unusual, converting to about $90 per cubic metre at 900kg/cubic metre density. For example, the Perth Solid Waste Study reviewed incineration costs and determined that a new incinerator in Hawaii was operating at a cost of $105 per tonne.

The long-term proposal to reuse greenwaste would significantly reduce the calorific value of the waste, necessitating fuel supplements, particularly in wet weather periods.

10.2. Pit Burners

Pit burners are used as a relatively low cost method of burning selected waste, building materials and timber. They are cheaper than incinerators, however the exhaust gases are less controllable. Pit burners can reduce the volume of waste requiring landfill significantly, however, not to the extent of incineration. Operation in protracted wet weather would be difficult. .

Due to the difficulties in meeting exhaust gases emission requirements and expected public objection to the odours and visible plumes which would result, a pit burner system was not

considered viable for the total waste stream. It may be appropriate for large timber pieces and tree stumps, especially following any natural disasters.

10.3. Baling

Baling domestic waste is a technique similar to compaction and uses pressure to bind the waste into a tight mass ready for disposal. This process significantly reduces the volume of waste and makes handling and transportation easier. However, baling plants are costly to purchase and operate. They are also prone to mechanical breakdown due to the highly variable nature of the waste stream, including items such as large metal off-cuts and rocks. The baled contents of the landfill take longer to degrade and stabilise, thereby making the aftercare and utilisation of the site more difficult.

It was considered that baling of waste was not an economically viable option in the study area, especially given the relative closeness of the landfill to the city meaning haulage is already efficient.

10.4. Composting

See separate chapter above.

10.5. "Zero Waste" Integrated Approach

A number of such schemes are in various stages of operation or development globally. Such a scheme involves is a multitude of components to theoretically manage all waste streams resulting on no residual waste mass.

In summary the zero waste approach has the following components:

- Receivals area where large objects are removed;
- A system to break open any bags;
- A trommel screen to separate out small components which are usually the organics;
- Magnets and Eddy current systems to remove all metals;
- Manual segregation of the remaining waste into various recyclable components;
- An organics composting facility;
- A compost screening, drying and bagging process;
- An incineration system for plastics and other inorganic waste;
- A brick making facility to utilise the ash from the incinerator;
- A crusher to allow a recycling of construction and demolition waste; and
- Appurtenant works such as gas scrubbers and other odour control systems.

The aim of such facilities is very clear, that is, to have a zero waste operation. Such zero waste facilities are the ultimate aim for all Waste Management operations but to date have not succeeded in a sustainable way anywhere globally in a traditional community setting. There have

been many pilot and short-term trials which have the theoretically achieved a zero waste position, but none in a sustainable real world application.

In reality however the long term expectations are not positive because of operating costs for energy alone as well as maintenance costs for all the mechanical equipment which is operating in a very harsh environment. Also high level of operator skills are required to operate the facility as well as maintain the equipment, especially items such as incinerators.

The key issues regarding sustainability are on-going funding and plant complexity. Experience indicates that such funding often tails away when higher priority local funding requests eventuate, usually associated with higher profile local authority activities.

In summary, it is simply impossible to recycle or reuse every component of a real-world mixed domestic waste and commercial/industrial waste stream. Even internally to the ISWM operation, composting is not a completely predictable activity. Compost facilities utilising more traditional waste streams like green waste or sewage sludges--always have some batches that do not meet specification for some reason either biological or due to contamination. These off-specification batches have to be dumped and there is no facility at this style of plant for such a large volume to be disposed of.

10.6. International Comparisons

There are no functioning full scale MSW compost schemes operating in developing countries in SE Asia which are self-funding. All have failed through a lack of a viable market for the product, lack of funds to continue operation (as they are not self-funding) or ultimately conversion to composting other more suitable material such as animal manure. A large scheme handling 1000t/d operates in Lahore but that is a PPP arrangement where compost contamination is not an issue (as one of the PPP partners is the adjacent farmer using the compost and he does not mind if the compost has foreign objects therein) and finally compost is applied to high value food crops.

Waste incineration is generally only practiced in locales where land costs are so high to preclude landfill development. They are banned in some counties like the Philippines because of concerns about the stack emission being environmentally damaging and even carcinogenic. The Government there does not believe that incinerator scrubber and filter systems will be maintained in the long term thereby allowing toxins to escape into the atmosphere.

The unfired bricks can only be used for local non-structural drainage projects which will eventually be fulfilled. Also incinerator ash can contain many contaminants such as heavy metals. Unless a pozzolanic material such as cement is added to the mix, then the heavy metals will be mobile and can leach out causing pollution.

10.7. Summary

Most of the above methods can be used for reduction of the volume of waste; however a landfill is still required for some part of the waste stream.

A typical zero waste approach is considered very unlikely to be sustainable for the many reasons listed above. The high capital and operating cost of such a process makes the process nonviable unless the provincial or national government is committed to subsidising the operation for the life of the operation.

Given the cost of the above methods, landfilling is considered the most appropriate method for disposal. Only the remnant wastes will be landfilled.

11. Waste-to-Energy

11.1. Technology Review

A range of technologies are available for each of the thermal treatment processes. Those that will be reviewed for the purpose of this comparative assessment are:

- **Moving Grate Incineration**
- **Fluidised Bed Incineration**
- **Rotary Kiln Incineration**
- **Gasification**
- **Plasma Gasification**
- **Pyrolysis** (conventional pyrolysis)

11.1.1. Moving Grate Incineration

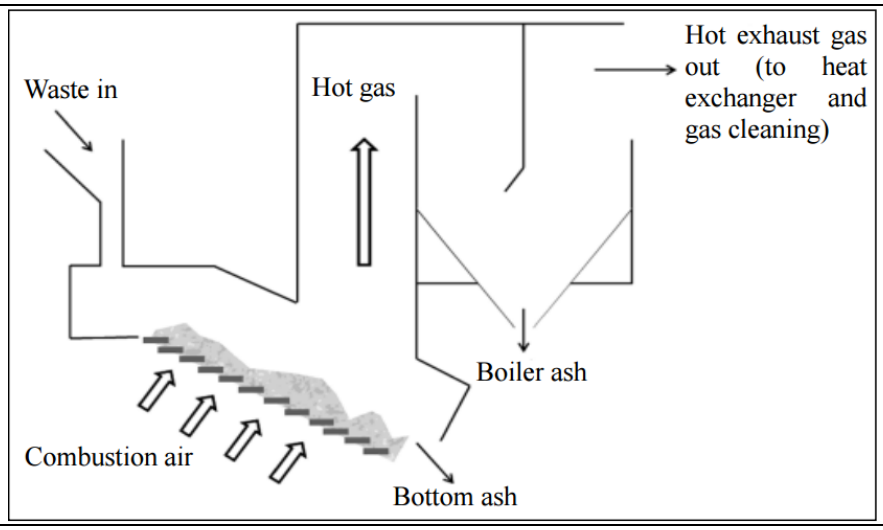
Moving Grate Incineration (see **Figure 11-1** and **Table 11-1**) is an incineration system equipped with an inclined moving grate system which keeps the waste moving through the furnace during the combustion process. It is one of the most widely used MSW incineration technologies worldwide with an extensive commercial track record. The moving grate system has high efficiency to operate regardless of the composition, calorific value and moisture content of the MSW. Therefore the MSW feedstock does not require extensive pre-treatment before undergoing the incineration process.

In comparison with other thermal treatment technologies, the plant capacity of the moving grate incineration system is the highest, which range from 20 to 4,300 tpd of mixed MSW, respectively. Moving grate incineration system is the only system which has been thoroughly proven to be capable of treating over 3,000 tpd of mixed MSW without requiring any pre-treatment or pre-processing to achieve a homogeneous waste nature.

Process:

- Feeding hopper is filled with MSW, which seals the furnace from the outside and prevents backfire.
- MSW is fed via the chute into the grates. The grate is made up of moving parts, which push the waste through the combustion by grate movement.
- Primary air is injected through the grate from below and secondary air is injected above the grate into the flame region. MSW is first dried on the grate and then combusted at high temperatures (typically 850 – 950°C)
- Heated flue gasses are passed to a heat recovery boiler.
- IBA is transferred from the discharge chute into a quench bath for cooling before further disposal.

- **Figure 11-1: Schematic Diagram of Moving Grate Incineration Process**



Source: *Harrison, R.M. (2014).*

Table 11-1: Technology Characteristics – Moving Grate Incineration

PARAMETER	DESCRIPTION
Process Type	Thermal, Direct Combustion, Excess Oxygen
Typical Feedstock	Raw MSW
Track Record	Strong
Plant Capacity	20- 4,000 tpd
Pros	• Large treatment capacities (up to around 4,000 tpd). • Mature technology with worldwide application and with extensive commercial track record. • High reliability and comparatively low maintenance costs. • Little / no pre-treatment of MSW required • Flexibility regarding variations in calorific value and moisture content. • Low levels of particulates in flue gas. • Well-developed environmental/emissions controls systems widely available. • IBA (Incineration Bottom Ash) is sterile, and recycling of metals from IBA is possible.
Cons	• Not suitable for liquids or powders. • Heat exchange may not be even, resulting in hot and cool spots within the waste stream. • Energy recovery efficiency is not as high as some other systems (e.g. fluidised bed filter). • Combustion residues may become melted to the grate, requiring periodic cleaning. • Waste gases produced when incinerating MSW typically include NO_x, dioxins and furans; therefore effective emissions control systems are required.

11.1.2. Fluidised Bed Incineration

Fluidised Bed Incineration (see

Figure 11-2 and **Table 11-2**) is an alternative design to conventional combustion system in which the moving grate is replaced by a floating bed of granular materials, such as sand, which can understand high temperatures. There are two main types of fluidised bed: bubbling and circulating bed types.

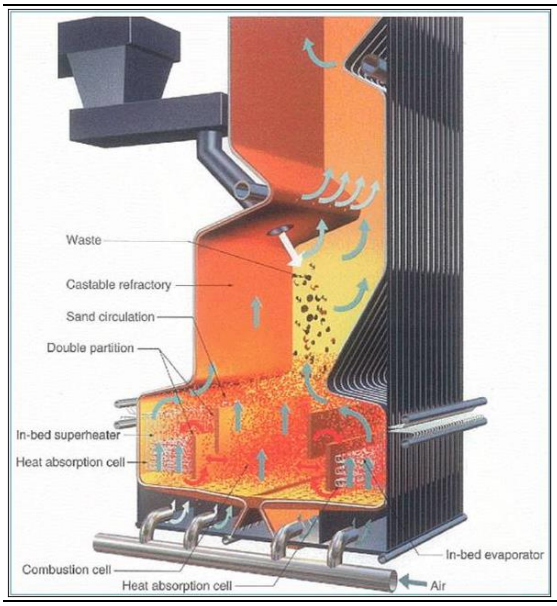
The pre-treatment of MSW is required in this system, usually by shredding, drying and pelletizing. The process efficiency may also be improved by co-combusting waste with other homogenous, high-calorific materials such as coal or woodchip.

The application for waste combustion using fluidised bed only began around 50 years ago. This included treatment of sewage sludge, as well as industrial and municipal wastes such as plastics, paper and tires (all of which had to first be processed and homogenised). Comparing to moving grate incineration, the fluidized-bed incineration system generally offers more uniform mixing, longer residence time (typically 4-5 seconds) and better residue burnout (typically less than 1% unburned carbon).

Process

- The MSW are shredded, dried and pelletized before introducing into the system
- An air distribution system forces large volumes of air through the sand bed, causing it to circulate and become partially suspended, thereby acting in a fluid-like manner.
- The processed MSW is introduced and combusted as a result of the elevated temperature and available oxygen (air temperature is typically 850-950°C, whilst sand bed temperature is typically 600°C)
- The incineration process is controlled by varying the waste feed rate and the air flow rate to the furnace.
- If combustion is interrupted for a short period of time, the sand bed temperature is typically maintained at 450-550°C which allows quick recovery to full operating temperatures.
- Ash is discharged through the base of the combustion chamber.

- **Figure 11-2: Typical Fluidised Bed Incineration Process**



Source: SSWM Toolbox

- **Table 11-2: Technology Characteristics – Fluidised Bed Incineration**

PARAMETER	DESCRIPTION
Process Type	Thermal, Direct Combustion, Excess Oxygen
Track Record	Medium to Strong
Typical Feedstock	Treated RDF, sludge or other homogenous fuel such as wood chip or coal
Plant Capacity	20-1,600 tpd
Pros	• The waste is mixed and heated up evenly, allowing even incineration process • Particularly effective for incineration of high calorific value wastes. • Higher energy conversion efficiency when compared with moving grate systems. • Less NO_x production when compared to moving grate systems. • IBA produced is sterile.
Cons	• Requires extensive pre-treatment of wastes, usually by shredding, drying and pelletizing. • Might consider co-combusting waste with other fuel sources such as coal to improve efficiency. • Limited flexibility for managing variations in waste composition. • Larger volumes of fly-ash created when compared to moving grate. • High parasitic energy load. • High particulate load in flue gas. • Comparatively high maintenance requirements when compared to moving grate systems (due to wear of the internal cylinder caused by the circulated sand bed and waste feedstock.)

11.1.3. Rotary Kiln Incineration

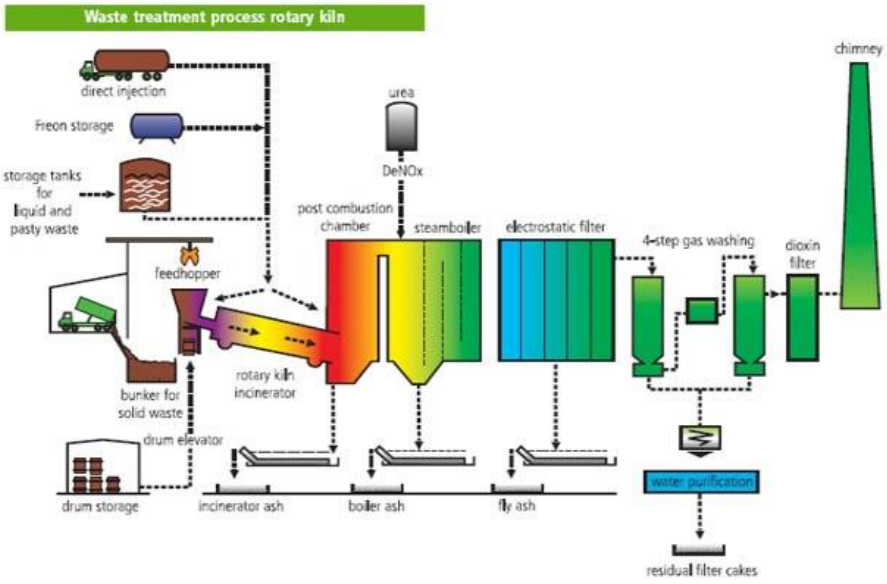
Rotary Kiln Incineration (see **Figure 11-3** and **Table 11-3**) typically consists of two linked chambers – a primary chamber and secondary chamber. The primary chamber comprises of a rotating steel cylindrical shell lined with an abrasion-resistant refractive layer. The rotary system can achieve two objectives simultaneously using rotating motion: (i) moving wastes through the high-temperature combustion zone, and (ii) mixing and stoking the wastes during combustion. The secondary chamber is used to complete gas phase combustion reactions and burns the gaseous by-products from the primary chamber.

The rotary kiln incineration system provides good mixing and stoking of wastes, along with a high level of control of waste residence time; thereby resulting in more complete combustion. A significant advantage of rotary kiln is no waste pre-processing is required, and it is able to handle both liquids and solids. It is therefore commonly used to treat hazardous wastes, including high-energy liquids. However, it has higher maintenance requirements than moving grate systems, and capacity is restricted by limitations in drum size. Energy recovery efficiency is also lower as heat is lost through the metal shell of the rotating drum.

Process

- Wastes and air are injected into the heated rotating primary combustion chamber.
- Chamber rotates to mix/stoke wastes and move them through the combustion zone.
- Gaseous by-products are also formed through volatilization, destructive distillation and partial combustion reactions, and these are passed to a secondary “afterburner” chamber to allow combustion of gases
- Heated flue gasses are passed to a heat recovery boiler
- Ash is excavated from the lower end of the kiln

Figure 11-3: Typical Rotary Kiln Process



Source: Waste to Energy International

Table 11-3: Technology Characteristics – Rotary Kiln Incineration

PARAMETER	DESCRIPTION
Process Type	Thermal, Direct Combustion, Excess Oxygen
Track Record	Strong
Typical Feedstock	Solid or liquid wastes including hazardous wastes
Plant Capacity	20-144 tpd
Pros	• Little / no pre-sorting of wastes required. • Versatile, with the ability to deal with liquids and solids, as well as variations in moisture content and calorific value. • Ability to effectively control residence time, resulting in thorough burnout of waste • Particularly effective for treatment of hazardous waste streams, including high-energy liquids. • IBA is sterile.
Cons	• Regular maintenance of primary kiln is required, which increases OPEX. • Lower throughput in comparison to the moving grate system. • Low energy efficiency due to heat loss from the metal shell of the kiln. • Feeder end of kiln may be cooler than other portions, and may result in build-up of incompletely combusted residues such as melted plastic. • Limited capacity when compared with moving grate systems. • High particulate content in flue gas.

11.1.4. Gasification

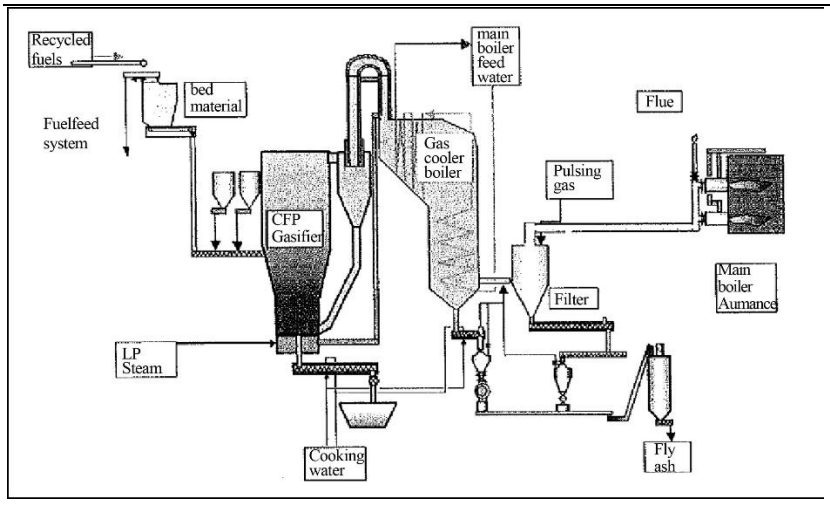
Gasification (see **Figure 11-4** and **Table 11-4**) is an incomplete oxidation of organic compound and convert combustible waste to syngas or producer gas at temperature in the range of 500–1800 ^{o}C. Syngas comprises carbon monoxide, hydrogen, methane, carbon dioxide, water, nitrogen, argon, solid carbon and contaminated substances such as tar, particulate, chloride, alkali metals and sulfide.

The amount of air pollution substrates, particularly dioxins and furans, emitted from gasification typically reported to be less than incineration. Furthermore, the types of air pollution control devices may be similar, but smaller than incineration. This shows higher efficiency and energy recovery along with lower investment cost than that of incineration. Therefore, gasification technology has high potential to treat MSW in the future because of easy handling and burning of syngas, efficient conversion, low air pollution substrates, as well as the capability to scale-down the technology. However, the current gasification plants in operation have a much lower unit and plant capacity than the moving grate incineration plants for mixed MSW treatment in which their plant capacity generally range from 100 to 450 tpd, respectively.

Process:

- The MSW is pre-processed first, sorting out the recyclables
- The MSW feedstock is then heated up in the reactor, with limited supply of oxygen/ air
- The Syngas is collected from the chamber and is typically passed to a combustion turbine where it is combusted to produce energy.
- Additional processes for further “cleaning” of the Syngas may be required to improve combustion efficiency and remove contaminants.

Figure 11-4: Typical Gasification Process



Source: Natural Science

Table 11-4: Technology Characteristics – Gasification

PARAMETER	DESCRIPTION
Process Type	Thermal, By-Product Combustion, Low Oxygen
Track Record	Limited
Typical Feedstock	Shredded waste
Plant Capacity	100-450 tpd
Pros	• Little/no waste ash produced. • Suitable for the treatment of medical or hazardous wastes. • The End products of the process has a higher economic value and has the potential to be further processed into other products such as chemicals, fuels • Syngas can be stored and used for other industrial processes (e.g. production of gasoline) in addition to being combusted directly for energy. • No waste flue gas production.
Cons	• High parasitic energy load (i.e. the energy required to keep the process running). • Complex process to manage and difficulties in optimising (however can be very effective once optimised). • Requires pre-treatment of waste. • Limited capacity to cope with variations in waste composition. • Limited commercial track record for MSW treatment.

11.1.5. Plasma Gasification

Plasma Gasification (see **Figure 11-5** and

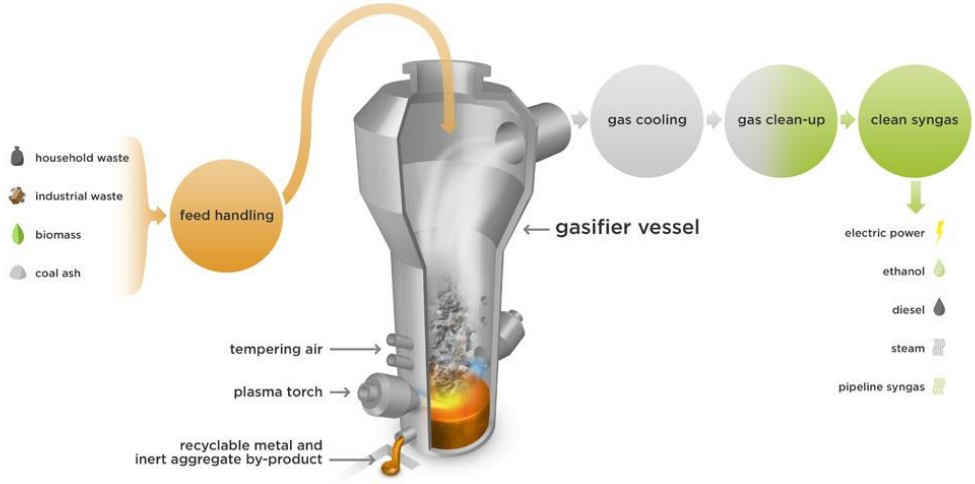
Table 11-5) is a more recent advent in waste treatment technology. It entails the chemical decomposition of waste in a low-oxygen environment, utilising a high-temperature plasma torch. The temperature of the plasma arc typically ranges from 2,700 to 4,400°C; however instances of temperatures up to 10,000°C have been reported. Plasma gasification plants have a comparatively low capacity range (between 20 and 500 tpd), and at present have not been widely-adopted for MSW treatment.

Little or no ash is produced since the carbon-based wastes are completely vaporised, and any non-carbon-based substances such as metals, glass or concrete are melted and turned into slag (for metallic components) or vitrified glass (for silica-based components). No flue gas is produced as the vapour by-products are captured as Syngas, which can be combusted to generate electricity or used as a reagent in other industrial processes.

Process:

- Pre-treated waste is fed into a vertical, cylindrical combustion chamber which has a low-oxygen atmosphere.
- The waste is passed through the arc of an electrically-driven plasma torch, within which it is vaporised to form Syngas.
- The Syngas is collected from the chamber and is typically passed to a combustion turbine where it is combusted to produce energy.
- Additional processes for further “cleaning” of the Syngas may be required to improve combustion efficiency and remove contaminants.
- The remaining slag is collected through an outlet at the base of the chamber.

Figure 11-5: Typical Plasma Gasification Process



Source: Alliance Federated Energy

- **Table 11-5: Technology Characteristics – Plasma Gasification**

PARAMETER	DESCRIPTION
Process Type	Thermal, By-Product Combustion, Low Oxygen
Track Record	Limited
Typical Feedstock:	Shredded waste
Plant Capacity	20-500 tpd
Pros:	• Little/no waste ash produced. • Suitable for the treatment of medical or hazardous wastes. • Good potential for metals recovery/recycling from slag/vitrified residues. • Syngas can be stored and used for other industrial processes (e.g. production of gasoline) in addition to being combusted directly for energy. • No waste flue gas production. • Vitrified slag is largely inert so there is little potential for contaminant leaching.
Cons:	• High parasitic energy load (i.e. the energy required to keep the process running). • Complex process to manage and difficulties in optimising (however can be very effective once optimised). • Requires pre-treatment of waste. • Limited capacity to cope with variations in waste composition. • Limited commercial track record for MSW treatment. • Process wastewater may be contaminated by carcinogenic or toxic compounds formed during the production of Syngas. • Syngas may require extensive contaminant removal before it can be combusted. • High CAPEX and OPEX costs when compared to direct combustion technologies. • Limited workforce with suitable skills available.

11.1.6. Pyrolysis

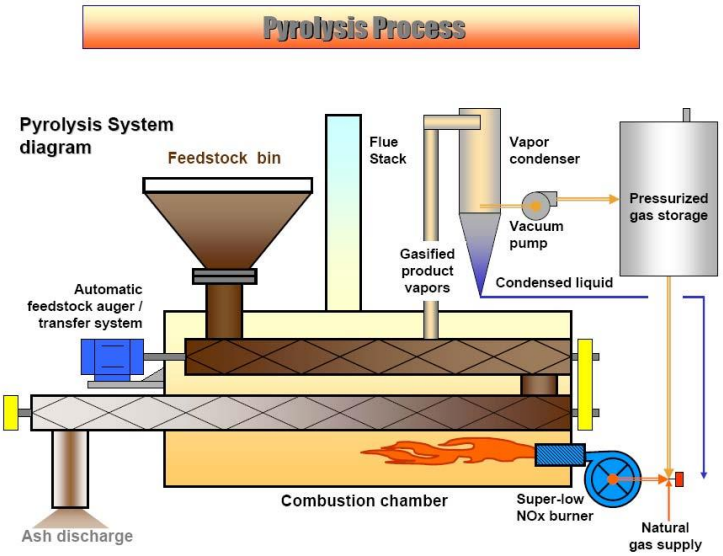
Pyrolysis (see **Figure 11-6** and **Table 11-6**) is an anaerobic indirect-heat process in which organic waste is decomposed to produce oil, carbonaceous char and combustible gases. These by-products are used as a fuel source and are burned to generate heat. Since no oxygen is required in the pyrolysis process, the volume of flue gas generated is lower than incineration and gasification processes. Unlike incineration and gasification systems, which are self-sustaining and use oxygen for waste combustion, an external source of heat is required to drive the pyrolysis reaction. Relatively low temperatures (in the range of 400 to 800°C) are required for pyrolysis. Pre-preparation of the MSW is also required.

Pyrolysis is not yet widely used as a treatment technology for MSW, and there is currently limited information available for review as many projects are still in the pilot stage. Challenges include low energy production (due to the amount of energy required to power the process), difficulties in process optimisation and safety concerns.

Process

- Processed MSW is placed into an airtight hopper
- Waste is transferred from the hopper to a reaction chamber where it is heated in the absence of oxygen and is converted to char, pyrolysis oil and pyrolysis gas (lower temperatures favour formation char and pyrolysis oil, and higher temperatures encourage formation of pyrolysis gas).
- Pyrolysis oil is collected for combustion or for use in other processes, and solid residues are separated.
- Solid residues containing high carbon content may be subjected to an additional treatment.

Figure 11-6: Typical Pyrolysis Process



Source: Waste to Energy International

Table 11-6: Technology Characteristics – Pyrolysis

PARAMETER	DESCRIPTION
Process Type	Thermal, By-product Combustion, No Oxygen
Track Record	Limited
Typical Feedstock	Processed MSW
Plant Capacity	100-500 tpd
Pros	• Pyrolysis oil can be stored and used in other potential industrial applications in addition to combustion for WTE (e.g. production of bio-diesel). • Lower flue gas emissions than conventional combustion technologies. • Particularly effective for volatile, high-energy waste fractions.
Cons	• Require pre-treatment of wastes. • Pyrolysis oil typically contains toxic and carcinogenic compounds. • Solid residue may not be completely combusted. • Low overall energy efficiency. • Limited track record for MSW management. • Solid residues may have high heavy metal content. • Additional treatment may be required to produce a sterile IBA.

11.2. Comparative Summary of Selected Thermal WTE Technologies

Sections **11.2.1** - **11.2.6** provide a comparative review of the key characteristics of the selected thermal WTE processes and technologies, which is in turn summarised in **Table 11-7**.

- **Table 11-7: Comparison Summary of Selected Thermal of Treatment Technologies**

PARAMETER	MOVING GRATE INCINERATION	FLUIDIZED BED INCINERATION	ROTARY KILN INCINERATION	GASIFICATION	PLASMA GASIFICATION	PYROLYSIS
Plant Capacity Range	200-4,000 tpd	20-1,600 tpd	20-144 tpd	100-450 tpd	20-500 tpd	100-500 tpd
Waste Type	Solid only	Solid and sludge	Solid, sludge or liquid	Solid or liquid	Solid or liquid	Solid or liquid
Flexibility	High	Low	Medium	Low	Low	Low
Energy Gen. Efficiency	Medium	High	Medium	High	High	Low
Relative Facility Size	Large	Large	Large	Medium	Small	Small
Relative CAPEX	Low	Medium	Low	Medium	High	High
Reliability	High	High to medium	High to medium	Low	Low	Low
Relative OPEX	Low	High	Medium	High	High	Medium
Track Record for MSW	Strong	Moderate	Moderate to strong	Limited	Very limited	Very limited
Flue Gas Emissions	Medium	High	High	Low	Low	Low
Requires Pre-Treatment	No	Yes	No	Yes	Yes	Yes

Engineering Factors

11.2.1. Flexibility in Waste Composition

Moving grate incineration technology possesses a high level of flexibility to deal with variations in waste quality and composition. It also does not require pre-processing of MSW, such as shredding or grinding, whereas this is a requirement for other systems apart from rotary kiln incinerators. Moving grate incineration is also flexible in terms of treatment capacity, with effective facility sizes ranging from 20 to 4,000 TPD.

A limitation to moving grate technology is that it can only handle solid, non-powdered waste. Rotary kiln incineration has the flexibility to deal with both liquid and solid waste; however its capacity efficiency is lower than that of the moving grate. The other technologies reviewed all require varying degrees of waste pre-treatment.

11.2.2. Electricity Production Efficiency

The greatest potential energy recovery efficiency is from both gasification and plasma gasification as the chemical energy from MSW is converted into Syngas. This Syngas can be sent to a combustion turbine where the energy released during combustion directly powers turbines. This potential energy recovery efficiency is however offset by a relatively high parasitic energy load (i.e. the energy required by the process), meaning that in practice the comparative efficiency is much lower.

For conventional incineration systems (moving grate, fluidised bed and rotary kiln), energy in the MSW is recovered through a near complete waste burning process and the heat energy is then diverted to waste heat boilers to generate steam for electricity generation using steam turbines. This process results in greater heat loss as the energy is exchanged between the various systems, and so has less efficiency potential than gasification.

The lowest energy recovery potential at present is from pyrolysis due to the large amount of carbon which is often not fully converted, as well as the high energy input requirements needed to sustain the process.

11.2.3. Reliability and Track Record

Broadly-speaking, the greatest operational reliability at present is provided by moving grate incineration systems. These are by far the most widely used technologies for both energy recovery from MSW, as well as incineration without energy recovery. They have been proven to be robust and easy to maintain in comparison to other technologies.

Arguably, the lowest reliability and weakest track record for MSW treatment is currently provided by pyrolysis and plasma gasification technologies as these are still in a development phase and with limited track record.

11.2.4. Land Requirements and System Complexity

The possible land requirements for the various technologies are subject to the number of units needed to treat the target waste load of MSW, as well as the footprint size of the various units. The moving grate incineration plant occupies a large footprint; however each process unit has a large treatment capacity. Therefore a smaller number of units are required to deal with a large volume of waste. In contrast, gasification, pyrolysis and plasma gasification units occupy a relatively smaller footprint; however

each unit has limited treatment capacity, thereby requiring a larger number of units to be installed.

As such, if incineration of large volumes (e.g.: 500 or more tons per day) of MSW is required, moving grate and fluidized bed facilities frequently provide an optimal combination of treatment capacity in comparison with the required facility footprint.

11.2.5. Capital and Operating Costs

CAPEX and OPEX costs vary significantly across projects, countries and regions, and thus a relative ranking has been provided rather than absolute cost ranges. When considering cost efficiency (i.e. the treatment capacity in comparison with CAPEX and OPEX investment), the most efficient systems are often moving grate incineration. This is because of their large treatment capacity (reducing the number of treatment units required), relative operational simplicity, and widespread application. Additionally this technology does not require pre-treatment of wastes thereby further reducing OPEX costs.

The lowest cost efficiency is typically realised with pyrolysis and plasma gasification systems as these are relatively recent innovations for MSW treatment, and many functioning units are prototypes. As such their development and maintenance is expensive when compared to conventional combustion technologies. Additionally the process units have limited capacity, thereby increasing the number of units are required to manage a given volume of waste. Under these circumstances, moving grate incineration remains as the most favourable option as it has the low CAPEX and OPEX.

Environmental Factors

11.2.6. Air Emissions

Plasma gasification generally generates a lower volume of flue gas and associated pollutants than other incineration technologies since the vapours are largely captured in the Syngas. The low oxygen, high-temperature environment also significantly retards the production of dioxins and furans. Syngas often undergoes a “cleaning” process to remove toxic contaminants, and if this is done effectively it burns cleanly to produce CO_2 and water vapour.

When comparing direct combustion technologies (namely moving grate, rotary kiln and fluidised bed), the lowest volume of flue gas emissions are produced by moving grate incineration. These emissions may contain various toxins and pollutants, and as such the application of appropriate APC technologies are required to reduce these emissions.

12. Review of Current Disposal Sites

12.1. Background

The city is serviced by two landfills with Kyar Ni Kan serving the northern townships of the city and Thaung inn Myount inn serving the southern townships.

This split of waste is roughly 60% of the city's waste goes to the northern landfill and 40% to the southern site.

The specifics of each side are described below.

However both sites are very similar in terms of layout and operation so the general commentary applies equally to both sites.

12.2. Northern landfill

The northern landfill is approximately 17 kilometers from the city and parts of the site have been operating for approximately six years. It occupies an area of approximately 6 hectares and the average waste thickness is approximately 20 m, and most of this waste is below ground in old quarry pits.

The nearest surface water is more than 3 km from the site. The ground water depth is unknown exactly but expected to be more than 15 m below ground level.

Soil type is essentially sandstone with reducing fractures at depth.

No liner was installed at the bottom of the site and cover application is very infrequent. The nearest village is approximately 2 km to the waste.

At the time of inspection, there was little leachate escaping from the site even though aspects of the current operation are inappropriate.

The current operation has the following shortcomings as a minimum:

- Waste is not covered with soil regularly.
- Waste is placed it too flat slope sir rein in fort rights and forms leachate because the rain cannot run off the site
- Landfill is located in fractured sandstone so leachate within the old quarry pits is possibly seeping into the local groundwater system
- External drains contain significant amounts of litter which will be washed off the site

If the site is redeveloped in terms of a traditional landfill with the external batters of one vertical to 2.5 horizontal, waste is adequately compacted and covered and the site is developed to the maximum possible engineering height of approximately 30 meters, then there is approximately three years of life remaining.

Some parts of the site are surrounded by adjacent hills. If the footprint of the site is extended to cover the sales and the waste audit increased, then there are many decades of life available on the site for waste disposal at the projected waste generation rates.

12.3. Southern landfill

The southern landfill is approximately 3 km from the city southern boundary. It has been operating for over five years.

It occupies an area of more than eight hectares including all zones. The depth of waste varies over the site but is between 5 to 7 m on average and is approximately 5 m above natural surface level at present.

In addition to the landfill operation on site there is also an incinerator for medical waste which operates intermittently and a plastic bag recycling facility converting plastic bags into waste bins.

The nearest surface water is less than 2 km away however there is an open floodplain area between the landfill and this watercourse.

No liners been installed and cover application is very infrequent.

The water table is only 2 to 3 metres below the ground water level as a minimum and the soil below is a sandy clay with the permeability of 10^{-5} m per second.

The nearest village is approximately 1 km away.

Given that the site is poorly operated with very little cover material applied and no profiling resulting in the waste being at a very flat angle, then most rain water falling on the site would simply infiltrate and become leachate. The waste has been placed in old pits in a clay profile and this significantly reduces the possibility of leachate migrating into the groundwater table, however this could not be guaranteed without a full engineering investigation.

However these old pits will be filling with leachate assuming they are not leaking quickly, and eventually the leachate will overtop the old pits resulting in significant leachate emissions throughout the site.

At the time of inspection, leachate was observed exiting the site and flowing towards the local water courses. It is believed that the leachate flow is significant in the wet season as at the time of inspection during the dry season there was still leachate escaping from the landfill site.

If the waste is compacted and profiled as per normal engineering design and with a 1 vertical is to 2.5 external batter, then there is approximately five years of life remaining on the site it all zones are utilized.

12.4. Common issues

Both sites are poorly operated at present and this is resulting in contamination at least from the southern site based on leachate migration from the site and possibly also groundwater contamination at the northern landfill.

The present waste has not been properly compacted as the bulldozer is being operated inefficiently on a flat surface. Furthermore waste is being pushed over too long a distance because of poor control over where waste is placed.

The two key issues are that large areas of waste remains uncovered with soil which will result in significant rain water infiltration leading to a leachate generation, and also will allow windblown litter, odour, rodents and other environmental issues to occur.

The other key issue is that the waste is generally placed at a very flat grade. This results in most rainwater infiltrating into the waste forming leachate.

The edge of the mounds are also not properly shaped, compacted nor covered with soil.

The local soils are appropriate for cover material with the conglomerate and sandstone at the northern site with some sandy clay and schist at depth at the southern site. Therefore cover material would not have to be imported but could be won from the site thereby significantly reducing operational costs.

Both sites are receiving typical municipal waste containing green waste, food waste, but with few high value recyclables such as glass, metals plastic bottles and paper. This would indicate that efficient recycling activities are already in place.

The perimeter batters at both sites are essentially just waste which is uncovered, uncompacted and placed at the angle of repose. The external batters should be profiled to the correct slope of one vertical to 2.5 horizontal, compacted and then covered with soil. The daily soil that should be 150 mm, intermediate cover of 300 mm and final cover of at least 600 mm.

Overall the southern site presently indicates the most significant contamination with leachate springs common around the lower areas of the perimeter of the bound. In the wet weather periods, greater leachate generation would further increase the quantity of leachate expressing through the perimeter bund and entering the local water courses.

However, suitable environmental interventions are possible at a relatively small cost at both sites.

12.5. Summary of operation

Overall, the sites are poorly run and not all the shortcomings can be attributed to the budget limitations. Fundamental operational and design errors are compounded with the budget limitations also impacting on suitable equipment and material availability such as an adequate supply of soil cover for daily, intermediate and final cover application.

To reiterate, there were basic operational errors which could be remedied through better planning and operation and would not impose any additional cost. For example the limited current covering activities involve placing soil at almost zero grade resulting in a flat plateau for the final mound shape. Such a flat slope will ensure that any heavy rainfall will significantly infiltrate into the refuse resulting in the formation of excess leachate. This leachate will eventually be expressed through the toe or the lower slopes on the external batters and migrate from the sites resulting in further complaints from local residents and ongoing environmental impact.

There is no additional cost in remediating the site to an appropriate standard by planning and profiling, and therefore additional expertise is required to operate the site as well as remediate previously worked areas to a suitable standard.

12.6. Remediation Priorities

The highest priority is always fire control .It is critical that any actively burning surface waste and smouldering buried waste is fully extinguished and cooled prior to the new landfill commencing operations.

Small surface-only areas of combustion in the existing dump can be controlled with water and subsequent application of soil cover material .But the only way to completely extinguish subsurface fires at dumps is to excavate waste until the combustion source is reached .Therefore, there is little choice in the remediation of this site but to adopt a cut and carry approach to remove all actively burning and smouldering material and

wet it prior to replacing and covering in accordance with a final design. Some of this burning material could be incorporated into the borrow pile and covered until it can be used as daily cover for later stages of the landfill. Therefore, the extinguished waste pile will need to be well clear of initial landfill development stages to avoid double handling.

In parallel, action is required to prevent new fires starting anywhere in the active dumping areas and to stop the fires in previously worked areas. Initially the surface fires should be extinguished and then deeper fires progressively excavated and extinguished as part of the initial activities leading to eventual full remediation. It is critical that no fires are allowed to start within the landfill proper either due to purposeful ignition or importation of already burning or hot waste from the previously worked areas or *subsurface burning extending into the landfill cells*.

At the time of inspection, there was no open burning at either dumpsite which is commendable. However it is critical that this situation remains and the operators must ..fires starting on the site be vigilant to prevent any

12.7. Parallel Operating Period

One possibility at both sites is to develop a landfill on top of some of the old waste and extend the site to provide a sufficient life overall. This is especially true at the northern site where waste could be placed against the adjacent hills and many decades of life would be achieved.

While the landfill is being constructed and commissioned, waste will continue to arrive at the site and will require management.

One option is to upgrade the current operation is by providing operational guidelines to improve the operation making it closer to a Controlled Landfill. Apart from banning all fires and extinguishing existing fires, the main differences would be as follows:

- Formalising the responsibility of the site staff to direct all trucks to only dump at the prepared dumping table;
- Profile the area to minimise rainwater infiltration;
- Improve compaction;
- Prepare cover stockpiles;
- Apply cover on at least a weekly basis, preferably daily.

These basic refinements would result in the site being sustainable until the landfill proper is ready to receive waste.

Most of the remediation can be done prior to landfill completion by using the new landfill equipment which could be purchased early in the project procurement process. The equipment can then be used to complete the remediation and as training for the new operators. The costs for the fuel consumed can just be drawn from the site's general operations budget.

Later stages of landfill development would then need to progressively incorporate this waste into the lined cells as they advance across the ultimate footprint. By the time the later landfill stages are being developed, most of the "contemporary waste" from earlier stages would be essentially inert and could be used as daily cover supplement anyway, avoiding utilisation of active landfill airspace.

13. Appropriate Standard for a Waste Disposal Facility

The selection of the design and operational standard for the disposal facility will be based on the table below. This presents four options ranging from uncontrolled open dumping to a fully engineered sanitary landfill.

The first option of open dumping is essentially what is happening at present, or even somewhat worse, and cannot be supported in the future.

The second option is a controlled dump but this still does not have waste compaction and soil covering, leading to significant ongoing environmental impacts. This option also could not be supported.

The third option of a Controlled Landfill has most of the environmental and operational benefits of the final option (a fully engineered sanitary landfill) but without the technical complexities of leachate treatment plants for example, and social dislocation of banning all waste pickers form site. The Controlled Landfill option can be upgraded with scale-appropriate additional interventions for leachate and gas management, but not burdened with the additional constraints of the full sanitary landfill option which are undesirable for such relatively small operations as at Dili.

The fourth and most complex option is a fully engineered sanitary landfill. This compulsorily includes the following requirements in addition to those of a Controlled Landfill (the third level of complexity):

- a leachate treatment plant;
- mechanised material recovery facilities;
- mandated removal of all waste pickers from site; and
- full gas control and use.

This combination is considered too expensive for the relatively small city and far too complex to operate sustainably without ongoing external technical support at least for some years. Also the additional operating costs for items like the landfill are significant but yield little environmental gains at this scale. Furthermore the required removal of all waste scavenging and animal husbandry activities from the site would have significant social impacts at this time.

Given that there is little difference in cost or operational difficulty between a controlled dump and a Controlled Landfill, but the Controlled Landfill has significantly better environmental benefits, a Controlled Landfill is the most appropriate disposal system for the city.

- **Table.13-1 – Controlled Dump and Landfill Options**

Type	Characteristics	Advantages	Disadvantages
Open Dump	• poorly sited • unknown capacity • no cell planning • little or no site preparation • no leachate management • no gas management • occasional or no cover • no waste compaction • no fence • waste burning • no record keeping • uncontrolled waste picking • no groundwater monitoring	• easy access • low initial cost • low operating cost • aerobic decomposition • access to waste pickers • materials recovery	• high environmental impacts • unsightly • groundwater contamination • surface water contamination • high risk of explosion, greenhouse gases • vectors/disease transmission • reduced lifetime of dump site • inefficient use of landfill area • breeds vermin - rodents, flies • no record of landfill content • air pollution
Controlled Dump	• sited with regard to hydro-geology • planned cell development • grading, drainage in site preparation • partial leachate management • no waste covering • no compaction • fence • basic record keeping • uncontrolled waste picking • waste burning • no gas management • no groundwater monitoring	• moderate environmental impacts • permits long term planning • improved stormwater control • less risk of leachate release • controlled access and use • access to waste pickers • materials recovery	• moderate environmental impacts • groundwater contamination • surface water contamination • moderate risk of explosion due to gas • vectors/disease transmission • reduced lifetime of dump site • inefficient use of landfill area • breeds vermin - rats, flies • no record of landfill content • air pollution • high health risk to waste pickers
Controlled Landfill	• sited with regard to hydro-geology • planned cell development • grading, drainage in site preparation • improved leachate and surface water management • regular (not usually daily) cover • waste compaction • fence • basic record keeping • controlled waste picking • gas management provisions • monitoring of groundwater	• low environmental impacts • permits long term planning • improved stormwater control • reduced risk of leachate release • controlled access and use • reduced risk to waste pickers • materials recovery • waste is covered by soil • efficient use of landfill area • reduced breeding of vermin - rodents, flies • extended lifetime of landfill site	• still reduced environmental impacts • still limited potential for groundwater contamination • still limited potential for surface water contamination • still low risk of explosion due to gas • still reduced risk of vectors/disease transmission • little or no record of landfill content • some air pollution
Sanitary Landfill	• site based on environmental risk assessment • planned cell development • extensive site preparation • full leachate and surface water management • full gas management • daily and final cover • daily waste compaction • fence and gate • record waste volume, type, source • no waste picking	• minimized environmental risk • permits long term planning • improved stormwater control • minimized risk of leachate release • reduced risk from gas • vector control • improved aesthetics • extended lifetime • controlled access and use • eliminate risk to waste pickers	• high initial cost • high operating costs • longer development time • slower waste decomposition • minimized risk of vectors/disease transmission • minimized risk of vermin – rodents, flies • displacement of waste pickers • loss of recyclable resources • optimum use of landfill site

Source: Adapted from Municipal Solid Waste Management. United Nations Environmental Program, 2002.

Based on the above, the proposed disposal system is a Controlled Landfill but with some aspects to suit local conditions.

14. Controlled Landfill Development

14.1. Introduction

The existing disposal sites are effectively operating as uncontrolled pumps, with only minor elements of a controlled dump site being implemented.

Therefore it is appropriate that the current dump sites could be converted into the controlled landfill while at the same time remediating the existing waste mounds. If a completely new site is to be developed as the long term landfill, then the existing waste mounds will still require remediation. Therefore there are significant benefits in continuing to operate the existing dump sites but improving the operation to a controlled landfill standard and integrate ongoing operation with remediation.

Landfilling is the most cost-effective system of solid waste disposal for most urban areas in developing countries .Composting of solid waste costs 2-3 times more than controlled landfill, and incineration costs more than landfilling unless energy is recovered.

A landfill is a contained and engineered bioreactor and attenuation structure, designed to encourage anaerobic biodegradation and consolidation of compacted waste materials within confining layers of compacted soil .At a proper controlled landfill, there are no nuisance impacts of constant burning, smoke, flies, windblown litter, and unsightly rubbish heaps .Waste in a proper controlled landfill is not directly exposed to rainfall, surface runoff or groundwater .Leachate generation is derived only from a limited quantity of infiltration which reaches the waste deposit and captures the by-products of waste biodegradation .While little leachate is generated in a controlled landfill compared to an open dump, leachate concentrations are much higher -- organics are higher by a factor of more than 10 --and thus leachate needs to be properly managed.

Controlled landfill design needs to provide for cover of fresh waste, incorporate mitigative measures to manage leachate and gas produced within the landfill cells, provide for a final soil and vegetative cover, and establish an environmental monitoring system of up-gradient and down-gradient groundwater monitoring wells and surface water sampling locations .Typically the daily cover material is soil; however, tarps or inert materials)i.e., construction debris or compost residuals (could be used.

14.2. Landfill Configuration

14.2.1. Initial Stage

A typical landfill development will involve a balanced cut-to-fill arrangement whereby soil is excavated prior to basal lining or amending the bottom soil to provide a suitable basal liner . In this case 3 metres of soil on average should be excavated over any future stage footprint to provide sufficient cover material for the early site lifeExistign . s stages cannot be excavated for soil recovery as the waste will be remaining initu and progressively remediated as part of ongoing operations ..

So there is no need to excavate the base of the landfill to such a depth as to obtain sufficient cover for the whole landfill life .In such cases of general soil availability around the site, the excavation works for the landfill base would be limited to just achieving the required shape and slopes at the minimum excavation depth, unless the site is very small and deeper excavation is essential to provide the landfill life required .

A three to five year life is common as the first main stage of a landfill development.

14.2.2. Subsequent stages

There is a general approach in developing countries to limit waste to very shallow mounds given a fear of waste collapses .However, this is a very inefficient approach as the expensive basal liner and associated leachate collection facilities are not utilized to their full extent with only a willow layer of waste being applied .This approach also maximizes the waste mound surface area and area of flatter slopes, and therefore the opportunity for rain water infiltration leading to excessive leachate generation .It is far better to place the highest possible amount of waste on the engineered system to maximize financial returns on that investment and minimise potential environmental impacts from leachate generation.

The external batters will initially be at one vertical to 2 ½ horizontally which will settle to one vertical to three horizontal over time as the waste decomposes and auto-compacts .Municipal waste is generally stable at approximately a 45° slope or a one vertical to one horizontal batter .However, flatter slopes are provided to allow reasonable site access and to increase the ability of soil to remain on the batter slopes and not be washed or eroded away.

14.3. Landfill Gas

Other aspects can be incorporated into the landfill design such as landfill gas recovery systems.

Options include passive release, passive collection, gas flaring and productive gas reuse .The recommended scheme will depend upon the quantity of gas likely to be generated .This relates to the mass of waste deposited at the site as well as the organic content .If there is a strong push for composting food waste and diverting green waste into a chipping or mulching system, the quantity of landfill gas generated will be significantly reduced .

Given that the site is already relatively small in international terms, it may be difficult to justify power generation from the relatively small quantity of gas produced .However, there are opportunities for flaring the gas to reduce the greenhouse gas impacts by converting the methane to carbon dioxide .There is also an opportunity to collect the gas and provide it to nearby villages for cooking and heating purposes .The quantity will probably be too small to justify installing gas cleaning and scrubbing systems to make a gas that could be used to power the landfill equipment onsite.

Later stages may be attractive to reuse schemes that just burn the gas to heat brick kilns for example, but not for generating electricity .In summary;

- The controlled landfill is too small to be economic for productive gas reuse such as power generation or scrubbing to make CNG.
- A possible option is progressively installing a gas blanket under the middle third of the final cover cap to collect gas and vent through 6m high passive vents.
- If the methane is later required to be oxidised to reduce greenhouse impact, then a gas flaring system could be installed to convert the methane component to carbon dioxide .These units cost about $350,000 but are not required for at least a decade until the site has sufficient mass to generate enough gas to allow the flare to operate in a stable manner.
- Vertical gas wells can be retrofitted to maximise gas collection only if mandated in the future .The standard design for these vertical wells is to have them at a

50 metre grid pattern spaced over the site .The vents are slotted pipes 150 to 200 millimetres in diameter placed vertically in a 900 millimetre diameter gravel wick, but only extending 2/3 of the depth of the waste .These are usually only installed when there is sufficient waste on site to generate useful quantities of gas for commercial uses, and the earlier acid forming stages of the aerobic and anaerobic breakdown have finished and methane forming bacteria dominate .

Since any one or a combination of all of the above described treatments/controls can be implemented at a later date without detrimental effects, there is no need at this stage to make a final decision on this matter .

Initial comparisons would suggest it will also be too small to attract CDM consideration.

14.4. Surface Water Management

Managing both external and internal stormwater runoff is critical at landfills .Often the uncontaminated stormwater runoff is accidently mixed with the leachate to produce a large volume of very dilute leachate which is hard to manage .

A key element of site drainage will include management of stormwater impounded in the active cells following a significant rain event .While the waste will initially be deposited at the higher end of the cell and worked down slope, there is still a possibility that protracted rain will introduce enough rain water into the cell to allow the impounded water to contact the active waste face .

14.5. Leachate Management

Leachate is one of the biggest environmental issues at a controlled landfill and is traditionally treated and discharged .However, it is proposed to adopt a different approach where leachate generation is minimised and the leachate is either reinjected or irrigated at the site, obviating the need for a leachate treatment plant .The basics of the management strategy are as follows:

- eliminate seepage of leachate from beneath the site by utilising any low permeability soil on site or artificial liner such as GCL under the landfill
- eliminate lateral movement of leachate by grading the base of the site to the central area and intercepting this seepage in leachate interceptor/collector drains.
- reducing the volume of leachate generated by using filling, compaction, shaping and covering procedures which severely inhibit direct rainfall entry.
- reducing the volume of leachate generated by intercepting and by-passing all upstream surface water catchment areas around the fill area in surface drainage channels or bunds for floodwater.
- monitoring the groundwater quality hydrogeologically upslope and downslope of the site.

In this manner it is anticipated that there will be no excess leachate requiring treatment and then disposal to the local water environment.

With the available size of the site and the many years that will be associated with each stage of the development of the final landform, there is ample time available to modify the system if required, and monitoring programs will be sufficient to detect problems on site before they become a potential problem for downstream users.

Managing both external and internal stormwater runoff is critical at landfills .Often the uncontaminated stormwater runoff is allowed to mix with the leachate to produce a large volume of very dilute leachate which is exceedingly difficult to manage .

The best approach is to always ensure that leachate and uncontaminated stormwater remain separate .The drains will continue to run along the outside of the landfill perimeter road and immediately inside the landfill fence .A smaller internal drainage system will be provided on the inside of the landfill perimeter road to collect stormwater runoff from the landfill mound as it develops.

In summary, uncontaminated stormwater will be kept completely separate from the leachate interception and collection system to minimize the volume of contaminated water requiring management at the facility.

Leachate is one of, if not the biggest, environmental issue at a controlled landfill and is traditionally treated and discharged .However, it is proposed to adopt a more contemporary approach where leachate generation is minimised and the leachate is either reinjected or irrigated at the site, obviating the need for a leachate treatment plant .The basics of the management strategy are as follows:

- reducing the volume of leachate generated by using filling, compaction, shaping and covering procedures which severely inhibit direct rainfall entry;
- reducing the volume of leachate generated by intercepting and by-passing all upstream surface water catchment areas around the fill area in surface drainage channels or bunds;
- eliminating seepage of leachate from beneath the site by installing either an artificial liner or a compacted clay liner that can be reworked to provide the usually required permeability of less than 10^{-9} m/s
- eliminating lateral movement of leachate by grading the base of the site to the central area and intercepting this seepage in leachate interceptor/collector drains;
- monitoring the groundwater quality hydro-geologically upslope and downslope of the site.

With the available size of the site and the many years that will be associated with each stage of the development of the final landform, there is ample time available to modify the system if required, and monitoring programs will be sufficient to detect problems on site before they become a potential problem for downstream users.

The average moisture content of municipal waste ranges from about 20 to 45 per cent in the dry season doubling in the wet season of not collected efficiently, with most of the moisture being held in foodstuffs and green waste .Commercial and industrial waste mixed with non-putrescible municipal waste has a moisture content of less than 20 per cent .

There is evidence that local waste streams are wetter because of elevated food waste content but this needs to be confirmed through detailed auditing of the mixed waste stream. In any case, the waste entering the site is unsaturated and therefore has the capacity to absorb moisture before leachate mobilization occurs. This means that by minimizing rainfall infiltration during the wet season that any leachate being collected at the base of the landfill can be reinjected at the top of the mound to allow ongoing absorption.

The degradation of the organic component of the waste mass produces a small quantity of liquid leachate and gaseous by -products .The leachate produced is partially absorbed into the dry waste mass and partially lost as vapour due to the heat

of the biodegradation process . Under these conditions virtually no free liquid is produced.

Due to unavoidable direct rainfall entry over operational areas of the landfill, the volume of liquid within the waste mass increases .The direct entry of rain is expressed as a percentage of the rainfall on the site .Well run sites with excellent surface water controls have limited their annual leachate production to less than 5 per cent of annual rainfall .Poorly run sites where even external runoff water from adjoining catchments has not been excluded have an annual leachate production in excess of 100 per cent of annual rainfall.

Once the moisture content of the waste mass approaches 70 per cent or so, the waste becomes saturated and any water excess becomes free to move by gravity .Under these conditions, leachate collects at the base of the landfill or above low permeability soil layers within the waste mass and expresses itself in springs around the toe of the landfill or even up the sides of the perimeter batters.

14.6. Maximising Landfill Capacity

As far as is practicable, the capacity of the site to accept waste should be maximised . The utilisation of all the necessary environmental control measures and other infrastructure such as access roads can then be maximised economically.

The maximising of a site's capacity to accept waste usually involves the provision of relatively steep perimeter batters .Although compacted waste can be safely constructed on very steep batters)1H:1V (because of its inherent strength through a range of internal "reinforcing components) "plaster, timber, wire, metal, branches etc(., it has been found that final batter slopes are best designed at about 3H:1V so that a final soil and vegetative cover can be more easily established and maintained .An initial exterior slope of 2.5H:1V has been adopted which will settle over time to 3H:1V .

The upper level of the mounding is usually restricted to about the level of the surrounding topographic high points .

This upper area of the landform should have a minimum final gradient of 5 per cent to encourage surface water runoff, allowing for some inevitable differential settlement of the waste mass over the long term

14.7. Site equipment

An excavator is used to move waste around the site, clear waste out of drains, load soil to be used as daily cover, intermediate of final cover .

A bulldozer is used for both compaction and profiling activities .

In addition to these items, a body tip truck is required to be able to move soil around the site and assist with any drain clean-ups)litter removal (and other site haulage activities.

A desirable piece of equipment would be a dedicated landfill compactor for sites receiving more than five hundred tons of waste a day .This will achieve much higher compaction densities than a bulldozer and therefore significantly increase the life of the site .

However, in addition to the benefits of increased site life, higher compaction densities also have other significant additional benefits such as reducing leachate generation, providing a more stable batter slope which then reduces the risk of rain water infiltration through differential settlement areas, reduces the likelihood of vermin infestations and also leachate expressions .

A further controversial benefit of having a landfill compactor, as opposed to larger bulldozers, is the landfill compactor is a specialist piece of plant that can only be used at landfills .There are many cases where large bulldozers purchased for landfill operations have been moved to other activities associated with higher profile benefits such as road improvements and never returned to the landfill for their original purpose.

14.8. Summary

The facilities to be provided for the possible controlled landfill development on the current dumpsite would be as follows:

- An initial cell)Cell 1 (of the proposed ultimate system required, including associated bulk earthworks and liner system;
- Various building upgrades are required including a reception/gatekeepers hut, ablution blocks, meeting rooms, storage room, generator building, etc.;
- Access roads both internal and external to the site necessary to reach the first Stage
- Areas to allow processing and stockpiling of recyclables .This will increase in importance over time as the community becomes wealthier and as a result the amount of packaging and therefore recycling opportunities increase;
- Leachate pipe collection systems and pump station;
- Stormwater drainage systems;
- Potable and non-potable water supply;
- Ancillary works such as landscaping, lighting and fencing;
- Operating equipment such as a landfill compactor, bulldozer, excavator and tip truck .

15. Management of Specific Waste Types

Management of the waste entering the site will be critical for both environmental and personnel safety.

The presence of medical waste observed during the audit confirmed that management of incoming waste needs improvement and the following details set out a possible approach, to be refined during project implementation.

15.1. Summary of Waste Categories

The waste entering the Site may be categorised as follows, with some examples given;

- Acceptable Wastes (General) – general household and commercial waste;
- Acceptable Wastes (but Difficult) – tyres, mattresses;
- Special Wastes (Sometimes Acceptable) – asbestos, liquid waste;
- Prohibited Wastes – radioactive waste.

The first two categories are always accepted, but the second category requires some special management. The third category may be acceptable based on quantities involved, actual waste characteristics and so on, and is decided on a case by case basis. Prohibited wastes are never allowed into the Site.

It is critical that all loads are inspected when they arrive at the Site gate or any future transfer station in the collection system.

15.2. Acceptable Wastes (General)

The following general wastes will be accepted at the Site;

- domestic solid waste, as collected by city or private vehicles on a regular basis;
- acceptable commercial and industrial waste regularly collected by contractors;
- garden waste (i.e. green waste or yard waste) that may or may not be collected separately to municipal waste;
- inert waste, i.e. construction and demolition debris including concrete, timber, masonry, bricks, etc. These should be stored separately as they can be reused for gas collection blankets, etc.

15.3. Difficult Wastes (but always Acceptable)

Difficult wastes are those wastes that are allowed to be tipped at the Site, but require special treatment to ensure that the best compaction/disposal is achieved. This class does not include hazardous or dangerous wastes. See **Appendix I – Difficult Waste for details**.

- Tyres;
- Mattresses;
- Whitegoods (fridges, freezers or stoves);
- Car bodies;
- Drums.

15.4. Special Wastes (sometimes Acceptable)

These are other wastes that may be accepted on Site, but will have to be decided on a case-by-case basis, and would include some hazardous and dangerous waste. More details will be provided on how to manage these materials during project implementation, such as;

- Asbestos;
- medical waste, including "sharps";
- dead animals;
- pathogenic wastes;
- “dry” sludges, such as treatment plant sludges;
- low level radioactive waste;
- liquid waste, including paints and thinners;
- toxic substances, such as acids and biocides (pesticides and herbicides); and
- contaminated soil.

See **Appendix J – Special Wastes** for details.

15.5. Prohibited Wastes

Items always unacceptable in the Site will include;

- hot loads, greater than 50oC in temperature;
- pressure cylinders e.g. Condemned gas cylinders, fire extinguishers;
- recyclables, except to the recycling area, such as greenwaste, bulk metals or reusable demolition waste;
- large volumes of liquid waste;
- radioactive waste;
- large containers which cannot be crushed; and
- dangerous goods, such as reactive chemicals, explosives including unexploded bombs and so on. Dangerous goods are those wastes that can affect a person’s health or the environment. Some wastes appear to be safe when delivered to the Site but when tipped can react with the air, water or other wastes to form a dangerous material. Typical dangerous goods include***;***
  - Chemical wastes which can react to form dangerous gasses, liquids or solids. Chemical wastes can be either liquid or solid.
  - Radioactive wastes. These can come from hospitals, universities, research institutes and private companies.
  - Liquid wastes can be dangerous. These include oils, pesticides, solvents, paints, etc.
  - Asbestos (can be safe if correctly packaged, but dangerous if dry and powdery).
  - Medical waste (may be safe if autoclaved or pre-treated in some other manner, but very dangerous if containing untreated used sharps and syringes).

There are many dangerous goods that can be delivered to a Site, and Site staff must be trained to exercise extreme caution when dealing with these wastes. An Operations Manual will need to be developed prior to operating the new landfill.

15.6. Pathogenic and Medical Waste

This material represents a very small part of the total waste stream, but is particularly dangerous to workers and scavengers. Therefore it needs to be addressed in detail during project implementation.

Local hospitals have incinerators and reportedly have a waste segregation policy in place. The infectious material includes general domestic waste which has come in contact with infectious material such as cleaning equipment, as well as sharps. The simple, but effective segregation procedure should ensure that the most dangerous components, namely the sharps and infectious material, are sent to the incinerator on site rather than mixed with the domestic waste. This reported segregation activity has not been confirmed, but will be reviewed during the next stage of the project implementation.

Incinerators at the hospitals are reportedly not fully functional and the World Bank is attempting to assist the hospitals in upgrading these items. This will be reviewed during project implementation.

Various local small medical facilities, such as medical clinics, have inadequate facilities to correctly handle all their special waste. This has been confirmed by some medical wastes appearing in the waste dump locally.

The main issue of concern is sharps (needles, scalpels). Assuming that incineration is not available, these should be managed by either:

- placing in a puncture proof container, disinfected and co-disposed with waste in a dedicated cell at the Site, or
- destroying by burning in dedicated cardboard boxes fuelled by petrol or in special desk-top electric incinerators, for example. This is usually done at the Site of waste generation.

The key issue is that all medical facilities must segregate their waste at source prior to collection. That will ensure that only small quantities of the dangerous wastes are generated for special handling.

- Red bag for infectious waste,
- Black bag for general waste, and
- Yellow puncture proof containers for sharps
- Sometimes Orange for radioactive waste

The ultimate solution is to require medical waste incinerators at the various institutions. Ash residual could be safely co-disposed with the general waste at the landfill. The general requirements for a medical waste incinerator are that the temperature should be over 1 200^{o} Celsius and have a residence time of 2 seconds. However, the cost would be prohibitive for small facilities.

Due to local cost constraints, a dedicated disposal area at the Site for pre-treated medical and other special wastes will need to be considered at this stage. An alternative is autoclaving the hospital waste either at source or centrally at the ISWM site.

In summary, infectious waste should be disinfected at the hospital or medical clinic and then deposited in a dedicated location within the landfill cell, along with household and other hazardous waste.

More options will be developed and refined for managing these wastes. The exceptions are the larger hospitals which have their own waste incinerators and adequate segregation procedures in place.

15.7. Household Hazardous Waste

The waste inspections identified only a very small quantity of household hazardous waste in the waste streams, such as used fluorescent tubes. Following the Information and Education Campaign and possible implementation of basic waste segregation, all household hazardous waste should be deposited in a dedicated cell within the landfill.

This dedicated portion of the cell would also be used to accept other appropriate hazardous waste. The cell would usually have an operational life of only six months before it is then covered with clay soil, and an adjacent clay trench constructed within the overall cell.

16. Climate Change Issues

The time scales for climate change and waste management are similar. For instance, landfill sites can be operational for decades and still remain active for decades following their closure. Therefore, there is a need to consider potential changes in waste management over significant timescales and respond appropriately. The temperature across Myanmar has been projected to increase by 0.8 ^{o}C to 1.4 ^{o}C by 2050 and by 2.8 ^{o}C to 3.5 ^{o}C by 2100[1]. The rainfall pattern of Myanmar has become unpredictable due to vulnerable climate change. The projections of average annual rainfall indicate that there will be an increase in rainfall across the country by ~158.2 cm per year in the coastal region and by ~20.9 cm in the hilly regions by 2100[2].

Since 2011, severe droughts have occurred due to an extended dry season and extreme temperatures mainly in the central region of Myanmar (e.g., Mandalay, Magway, etc). The conditions of these areas are worst hit in past five years, where people have been suffering due to water scarcity[3]. In February 2016, Myanmar Meteorology Department reported that Mandalay could face severe drought during March-May which could affect 40,500 ha. of farmland cultivation[4].

The rainfall and temperature can cause critical impact in each stage of ISWM such as waste collection, transportation and final disposal. The summary of impact of climate change across various stages of ISWM is discussed in **Table 16.1**

[1]Myanmar's National Adaptation Programme of Action (NAPA) to climate change, 2012
[2]Myanmar's National Adaptation Programme of Action (NAPA) to climate change, 2012
[3]http://frontiermyanmar.net/en/drought-the-dry-zone
[4]www.news.xinhuanet.com

Table 16.1: Climate change impacts on ISWM

ISWM Activity	Climate change variable	Impact
Waste collection	• Rainfall increase	• Increases moisture content and density of the solid waste to be collected. • Damages collection bins/facility • Washes out solid wastes along with storm water thereby decreasing the collection efficiency.
	• Temperature increase	• Increases decomposition rate of solid wastes, resulting in insect infections and bad odour. • Damages collection bins/facility. • Demands frequent waste collection from the collection centers. • Reduces productivity of the collection workers.
	• Droughts	• Increases dust generation and outdoor air pollution.
Transport	• Rainfall increase	• Disrupts waste transfer due to flooding in collection centers, roads and landfill sites. • Increases weight of waste to be transferred due to increase in moisture content of the same. • Increases time between waste transfers
	• Temperature increase	• Increases frequency of waste collection to avoid rapid decomposition at the collection center. • Increases heat stress to the staff.
	• Droughts	• Increases dust generation and outdoor air pollution during waste handling and transport.
Thermal processing (Waste to Energy)	• Rainfall increase	• Alters feed's moisture composition. • Causes flooding of waste to energy plant site.
	• Temperature increase	• Increases rate of decomposition of wastes kept in storage bunkers leading to generation of odour, insect infestation and aerosols. • Alters feed's moisture composition. • Increases possibility of fire accidents. • Reduces productivity of workers.
	• Droughts	• Reduces water availability for site management.
Final disposal	• Rainfall increase	• Causes flooding of landfill sites, buildings, weighbridges, etc. • Alters the site hydrology. • Increases leachate generation. • Increases erosion and slope stability risks.
	• Temperature increase	• Alters the waste decomposition rate. • Reduces productivity of outdoor workers. • Affects site infrastructures due to heat stress. • Increases stress on vegetation in site premises.
	• Droughts	• Alters the site hydrology. • Reduces water availability for site management. • Increases strength of leachates. • Increases shrinkage of clay linings and capping layers

The consideration of adaption and mitigation measures at each stage of the ISWM system is an effective way to fight against the climate change impacts. The general climate change-related adaptation measures taken into consideration in planning the ISWM with the final controlled landfill disposal are provided in **Table 16.2**.

- **Table 16.2: Climate change adaptations/mitigation steps**

No.	Project stage	Climate change adaptation/mitigation steps
1	Definition of the project scope	Impacts of climate change variables on ISWM project taken into consideration
2	Assessment of project feasibility	• Climate threats, vulnerabilities, impacts to solid waste collection, transport and disposal facilities assessed • Alternate options and mitigation measures identified
3	Project design	• Waste to energy plant and residue landfill location sited away from floodplains, wetlands or areas with high water tables • Landfill site kept away from the drinking water supply sources • Water catchment systems designed that can keep pace with the projected rainfall and drought patterns • Extreme event evacuation plan prepared
4	Construction, operation and maintenance	• Financial and technical resources considered assuming more frequent maintenance and repairs • Plans to prevent the erosion of landfill slopes, covers and roads into and around the landfills prepared • Storm water catchment systems designed to ensure proper function
5	Monitoring and control	• Regular inspection of the water catchment systems and the containment walls, particularly after extreme rains or storm events • Periodic monitoring of waste segregation, storage and feeding equipment and emission levels from waste to energy plants • Regular monitoring of the landfill site for its ground water table and possibility of contamination

Thus, the overall impacts of climate change on the ISWM infrastructure will be assessed and adaptation measures will be considered during the design and implementation phase of the proposed ISWM.

17. Privatisation Opportunities

17.1. Background

Expanding private sector involvement in the collection aspects is traditionally the most promising opportunity and this the reason why a pilot private collection concession is the topic of the pre-feasibility report under RETA 8566. It is critical to consider the length of contracts for privatisation success however. Short contracts of a year or two duration are insufficient to allow the investor enough time to recover Capex exposure. Any privatisation contracts requiring extensive capital injection by the operator must be at least 5 years in duration, but preferably a minimum of 10 years, to allow amortisation of the capital cost, such as providing a new waste compactor collection fleet. Alternatively, the recommended collection fleet to be purchased under the loan could be leased by the city to the private sector operator.

At present, either individuals, NGOs or commercial companies are undertaking recycling activities. So there is little PPP opportunity for traditional recycling, unless at a very large scale such as adopting centralised composting or development of a mechanised material recovery facility.

Regarding the landfill operation, the private sector may not be attracted because of the low potential for innovative technical or management solutions that will make the private sector price cheaper than the City operating cost.

Operation of the controlled landfill is probably not of great private sector interest given the relatively small size and low technology approach recommended for this project, although again this could also be tested in the market place on a non-committal basis. A Design Build Operate Scheme for a new international standard sanitary landfill could be of interest to qualified private sector contractors if funded under the MUSIP program. Payment would usually be on a per ton basis, with operational performance style specifications setting out recycling, environmental and operational criteria. In that case, the City would change to becoming a regulator rather than an operator.

Another option for private sector involvement may be a composting or mulching scheme for greenwaste. Whilst a full scale centralised composting scheme for food scraps recovered from comingled waste is unlikely to be recommended for reasons listed elsewhere in this report, a composting scheme could be established in partnership with local agricultural companies. Such a public private partnership would require a private agricultural company agreeing to take and pay for the compost generated. A different ownership model such as a PPP may be appropriate and will be considered in the future when appropriate.

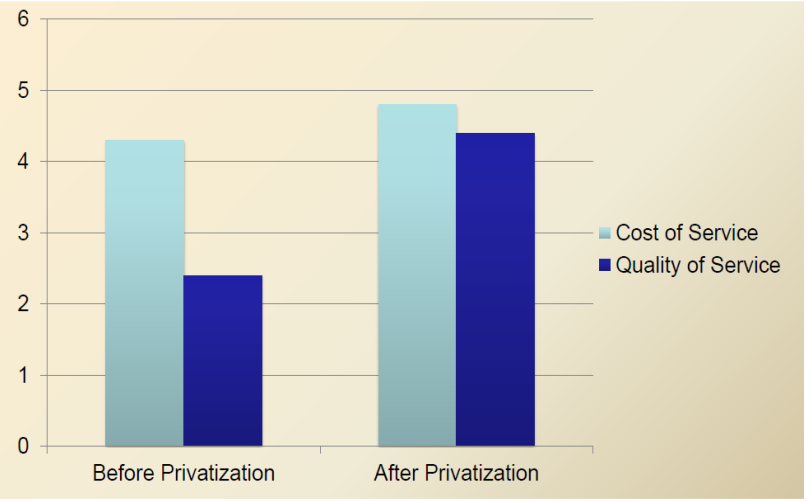
Even more critically than the payment agreement, there will be a need for the private company to agree to avoid any form of litigation against the City if the compost contains foreign objects such as glass, plastic or metal residues or other contaminants. Legal cases against the suppliers of contaminated compost have resulted in many plants closing in Europe and America.

These and other options for private sector involvement, particularly based on performance contracting, will be investigated during this project.

Overall, if the city is interested in seeking greater private sector involvement, it can be sought on a non-commitment basis. This means that the city can seek tenders for one or more components of their waste management services and compare the offers. In any case, it is likely that the collection, recycling, and disposal aspects will be undertaken under different arrangements, contractual or otherwise.

17.2. Value for Money Concept

A key aspect that must be presented to the community is that privatisation does not normally lead to lower up-front fees or prices. The key factor is the "Value for Money" assessment wherein the service quality improves but the cost increases, but the cost does not increase as much (to reach the better level of service) if the old cost structure was simply extrapolated. The cost per ton of waste of collected reduces but the overall cost increases for example.



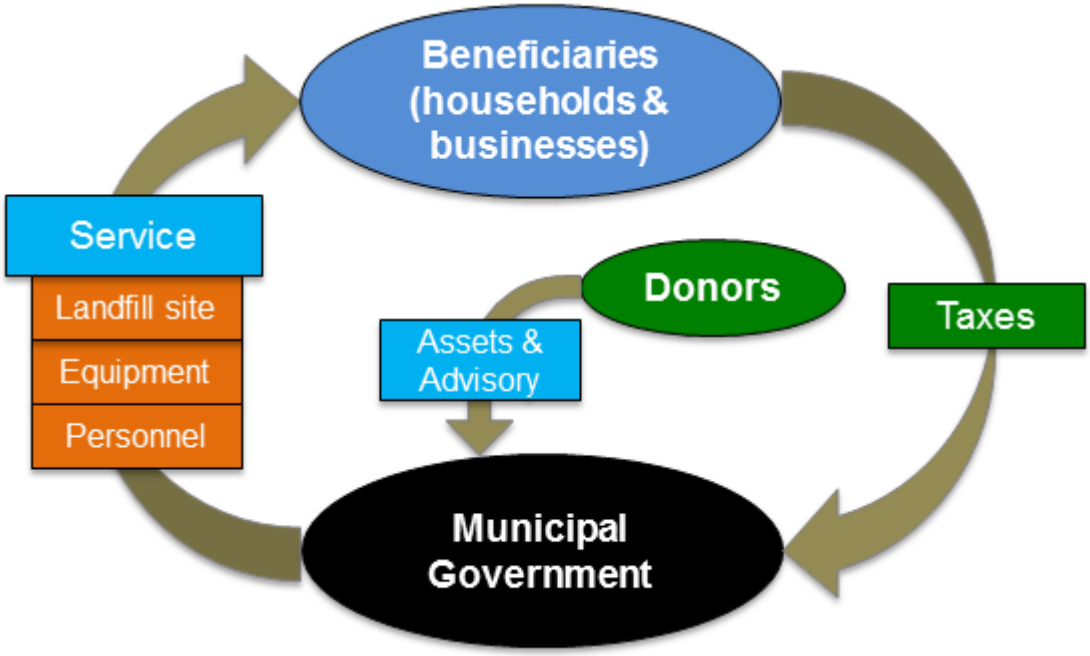
- **Figure 17.1 – Quality of Service = Value for Money**

17.3. Modality Options for Privatisation

17.3.1. Background

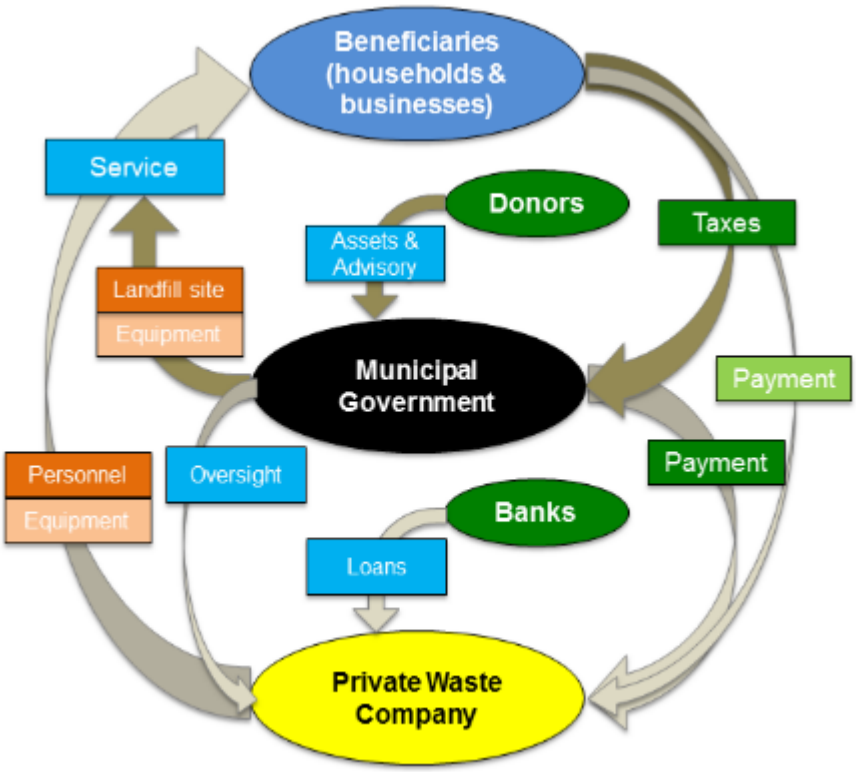
The present public-based structure for ISWM is presented below.

Further details of some options are presented in **Appendix K – Privatisation Options.**



- **Figure 17.2Municipality-led institutional model for managing a ISWM plan.**

There are a large number of options for private sector involvement in Solid Waste Management. These range from very simple short-term service contracts through complete Privatisation and asset sales. The options will vary depending upon numerous factors, such as the ownership of the equipment or the disposal site, such as a possible fleet of collection equipment including expensive compaction vehicles.



- **Figure 17.3 Public-private institutional model for managing a ISWM plan.**

Operations and maintenance financing can come from a number of sources: municipal taxes, private fees, and donor/central government funds. Eventually for a program to be sustainable, it needs to be self-funding. A potential scheme could have these components:

- Private collection fees providing funds for primary collection to a community based organization or municipality,
- Municipal taxes providing funds for secondary waste collection, landfill operation and ditch/street cleaning.
- Donors providing funds for capital improvement and equipment.

In order to achieve this state, the municipality must initiate/strengthen the collection of the Safayi cleaning tax from the population as part of the municipal budget reconciliation process. Payment of private fees must be encouraged through education, transparency and community communication and participation in the neighbourhood cleaning activities.

17.3.2. Service Contracts

These delegate particular operations and maintenance (O&M) functions to a private operator for a short period of time (one to two years) in return for a specified fee. These could be appropriate for operating a Controlled Landfill or collection services if the scale of the operation is sufficient.

17.3.3. Management Contracts

Service contracts allocate responsibility to a private operator for the full range of O&M decisions, typically for three to five years, or longer. The private operator is paid a fee, which may sometimes be linked to performance. It could be appropriate for operating a landfill if the scale of the operation is sufficient.

17.3.4. Concession Contracts

These grant a private operator the right to exploit a given service for a fixed period of time (ranging from 5 to 30 years), assuming full commercial risks and responsibility for a specified program of new fixed investments. A formula is set for tariffs to be paid by the local government to the operator, to cover the full cost of running the service and capital expenditure.

These contracts are only appropriate for large landfill operations, a major collection service or perhaps for a very large mechanised MRF (Municipal Waste Facility). This is not the present situation in the city, but may become the case in the future.

17.3.5. Build Operate Transfer (BOT) contracts

BOT contracts give the responsibility to a private operator (or consortium) both to finance and construct an infrastructure facility and to operate and maintain it for a specified period of time. At the end of an agreed period, ownership of the facility is transferred to the government at a symbolic cost.

The private operator retains all the revenue from operating the facility for the period of the contract, to pay for the capital and operating expenditure. This revenue stream typically consists of fees paid by the public sector user and commercial operators. As contracts are usually 20-25 years or more, the municipality would need to produce financial statements and other material that demonstrate adequate creditworthiness to investors and their banks.

These contracts are only appropriate for large landfill operations, a major landfill or perhaps for a very large mechanised MRF (Municipal Waste Facility). This model is often used for Waste-to-Energy plants which usually involve municipal tipping fee obligations as electricity revenues are sufficient. This is not the present situation in the city, but may become the case in the future.

17.3.6. Private Sale

This involves selling existing public facilities to a private operator, usually by means of an auction. Private sales may involve majority or minority stakes in the state owned enterprise, and certain restrictions on purchasers. The decision whether or not to participate can only be made on a return on investment basis.

17.4. Summary Table of Options

Service Contracts	Management Contracts	Concession	BOT/BOOT	Divestiture
Promotes competition when contracts are bid. Contracts can be re-tendered every 1-5 years.	Promotes competition when contracts are bid. Contracts can be re-tendered every 3-7 years.	Takes over management of operations from government, but concession term (15 to 30 years) must allow return on capital.	Takes over management of operations from government, but concession term must allow return on capital. (15 to 30 years)	A fast, but irreversible, option for improving solid waste manage-ment.
If contract fails, risk is relatively low.	Can improve service while retaining public ownership.	Relieves government of need to fund investment.	Full responsibility for operations, capital raising and investment goes to private sector.	Full responsibility for operations, capital raising and investment goes to private sector.
Duration - if problems with contract — can easily re-tender.	Potential first step to concession contract.	Full responsibility for operations, capital raising and investment goes to private sector.	Potentially large improvements in operating efficiency of assets.	Potentially large improvements in operating efficiency of utility.
Easy/Simple contractual form.	Potential for setting performance standards (with incentives to achieve standards).	Potentially large improvements in operating efficiency.	Mobilises private finance for new investments. Addresses funding shortfall	Mobilises private finance for new investments.
Potential starting point for private sector participation.	Reduced risks to government and contractor.	Full private sector incentives across utility.	Full private sector incentives across utility.	Full private sector incentives. Addresses funding shortfall.
Can increase utility's focus on core business	Can revert to in-house management or contract, may be re-tendered if problems arise.	Attractive to private financial institutions provided	Attractive to private financial institutions.	Private company would have clear incentives to achieve full cost recovery.
Potential for efficiency gains in the area covered by contract	Potential for utility to bring in competition.	Contracts are complex. Need parity in negotiating strength to achieve fair outcome.	Contracts are complex. Need parity in negotiating strength to achieve fair outcome.	Could be successful where there is a good track record of private ownership. Needs strong regulatory oversight.

17.5. Suitable Aspects for Privatisation Locally

17.5.1. Waste Segregation and Recovery

Waste segregation is the sole purvey of the waste generator, be it a household, institution or a commercial operation. Therefore there is no role for privatisation in waste segregation, apart from perhaps an educational role in encouraging waste generator compliance or perhaps funding the provision of separate bins for the various waste streams.

Waste recovery is already happening in the Municipality at the household and waste generator level. In the household, recyclables are generally being recovered, particularly items such as aluminium and glass. There is no role for external

privatisation of these roles apart from perhaps a private involvement in the necessary education campaigns to encourage segregation and materials recovery at source.

Overall, the possible role for the private sector in this phase of ISWM is opportunistic and not commercial.

17.5.2. Collection

The current collection system is barely adequate, and MCDC has indicated it is interested in privatizing at least part of the city collections services. Initially one township will be privatized and the experiences from this can then be used to refine any future tenders.

17.5.3. Recycling/Composting

Traditionally Municipalities only support recycling companies and do not compete with these private entities such as corporations or NGOs.

The Municipality may provide assistance in kind, such as allowing access to vacant land at the landfill for recyclables stockpiles or providing a compactor or chipper. But the aim is always to support the private sector and not compete by establishing their own Municipal schemes.

17.5.4. Disposal

The current disposal sites are being investigated through other donor interventions. Therefore the MCDC will await the results of those studies, however this report notes that the changes to the operation would increase the life of the site as well as reduce the environmental impacts.

17.6. Adopted Approach

The Municipality has decided that the present level of private sector involvement is insufficient and as such proposes to involve the private sector in the collection aspects of ISWM. However, it needs to be recognized that the previous solid waste PPP projects undertaken by Mandalay have encountered difficulties. Yangon City Development Corporation has been more ambitious in opening up its solid waste management sector to PPP investors but also not succeeded in finalizing arrangements to date. Therefore, extra care must be taken in the design of contracts, tender procedures and negotiation of contract documents. Outside consultant familiar with successful cases in other major cities might be retain to assist with funding from donor agencies.

The first pilot township private waste collection project will be implemented by 2017.

18. Information, Education and Communication Campaign

18.1. Introduction

The ISWM Plan must address sustainability issues and not just engineering interventions. So an Information, Education and Communication (IEC) Campaign is essential to upskill and educate the community, city and agency staff and civil society on many aspects of ISWM, ranging from health and pollution impacts to waste minimisation and segregation benefits in the future.

The department is now providing the education programs for the schools and the community. The education programs were started before 2014 and it is still ongoing with the support for the department. The programs are carried out step by step with the objectives of improving knowledge of the environmental and health impacts, poor waste management, waste minimisation, reusing, recycling and increasing the needs of waste segregation especially recycle waste and organic waste.

The programs is ongoing with the following vision;

- To keep the City Clean
- To make the City Beautiful
- To enable the City Dwellers to Enjoy a Pleasant life

The program was started in 2014 and the following activities were taken under the program in last years

Table 18-1 IEC Programs in the Previous Years

Year	Activities under the program
2014 (Year 1)	• Implementation of School Awareness Program for Waste Segregation • Explained about the Waste and Resource • Introduction of 3R • What are the benefits of Waste Segregation • A little about for Environmental Impacts and Climate Change issues related to Solid Waste Disposal • How to reduce house-hold waste
2015 (Year 2)	• SWM Township Center changed to the Public Education Center • Continuing the school awareness program for waste segregation at sources • Essay competition for Environmental Conservation • One week Booth Show at the Flowers and Fruits Expo. • National workshop for sharing knowledge and experience on SWMS, for healthy, green, prosperous and better cities in Myanmar 2030

Mass Media production is also part of MCDC's IEC programmes. Short documentary videos were produced and disseminated to stakeholders for promoting their understanding of solid waste management issues. Educational videos were also produced and broadcasted on national TV programme to stimulate awareness and interest in proper ways of waste disposing and subsequent desire to change behaviour.

School children are commonly regarded as prime targets for IEC campaigns as they are acceptable to new ideas and better equipped with faculties to learn new things. Women Affairs Federation is one of the established institutions which has wide membership and also maintaining a tradition to work closely together with public programmes of government agencies.

It is critical to engage with the community and civil society to bring about a better understanding of the key waste management issues relating to the environmental and health impacts of poor waste management, waste avoidance, minimisation, reuse, recycling, household composting and the increasing need in the future for waste segregation, especially green waste. In summary, it may involve items such as the following:

- Household, community and school meetings involved;
- Literature and pamphlet content to be developed based on existing sources;
- Organize activities integrated with programs in schools, cultural and other venues;
- Organize thematic seminars noting the current state of the environment so that there are specific activities designed to meet the IEC objectives;
- Training will eventually need to extend to the City residents generally and ISWM staff specifically.

In detail, the IEC will need to address stakeholders and issues such as the following as a minimum:

- The community on waste minimisation, reuse and recycling;
- The community on using food scraps for animal feed or home/commune composting;
- The community on the impacts of illegal dumping and littering;
- City staff, waste pickers, site workers, equipment operators and so on for general controlled landfill recycling and disposal operations;
- The community and city staff on segregating waste as it may be required in the future
- Any waste pickers educated on the risks and hazards of being exposed to waste and need for wearing suitable Personal Protective Equipment (PPE);
- Hospital and medical centre personnel on segregation of medical waste;
- The cost implications of providing a higher service standard for both collection and disposal activities.

There is plenty of ready-made literature, and training materials, that can be used and would be available through the multi-lateral donors and International nongovernment organizations (INGOs). For example, a specific education component would be household waste segregation and household based composting and a pilot scheme could be established in one commune. This will require protracted assistance from training organisations, such as a local NGO. Usually such schemes are run by a local NGO with local contacts and a vested interest in the sustainability of the outcome.

Some possible options are listed in the **Table 18.2 – Typical IEC Components** below:

- **Table 18-2 – Typical IEC Components**

Item	Issues	Approach
Environmental Management	Burning garbage causes air pollution and health risks	Explain the environmental damage caused by garbage fires
Environmental Management	Illegal disposal of garbage into creeks, rivers and vacant lots	Explain the environmental damage caused by illegal garbage dumping and littering, and the prosecution liability.
Waste segregation	Essential if mechanised recycling and composting schemes are to be efficient, but costly to have the necessary different receptacles and collection services.	Explain how to do this. Start at Household. level if segregation is desired.
Waste minimization	Purchasing products with the least amount of packaging	Education on benefits of less cost of collection and wasted materials and landfill space consumed
Waste Toxicity	Reduce toxicity of products purchased and segregate hazardous waste for separate collection and disposal	Education on alternatives to certain chemicals, e.g. natural toilet cleaners
Reuse	Reusing containers, such as bottles	Education on benefits as per packaging reduction and other sources
Recycling	Recycling containers, such as plastic bags for garbage containers	Education on benefits as per the above. Also need to market en masse for better prices (e.g. plastics and glass) and also obtain market access e.g. for sale of tin cans
Recycling	Drop off centres for selected items	Consider a centralized system for whitegoods, garden or green waste, hazardous waste, etc
Organic reuse composting	Do it at Household?	Training on methods and equipment required. Market development for local product. Also consider vermiculture? Encourage feeding of domestic animals
Greenwaste	How to manage yard and tree clippings	Chipper needed at the landfill in future. Chipping for mulch for composting is also an option
Privatisation	Community concerns abput cost and reliability/level of service	Community awareness on Value for Money concept, supported by success stories such as Herat.

The benefits will include:

- Compliance with local regulations;
- Community educated about the socio-environmental impacts of poor waste management;
- Community more willing to pay for better service;
- Enhanced recyclable recovery rates. This will be incremental initially and then a major increase when greenwaste and construction and demolition waste are recycled in future years;
- Educated community on waste minimisation and the 3Rs (Reduce, reuse and recycle) including household composting where appropriate.

It has been mentioned in previous studies that the successful implementation of any solid waste management strategy would rely both on an increase in awareness of solid waste management issues and the related firm commitment to resolve waste management issues among the key stakeholders.

These stakeholders include among others, non-government organisations involved in environmental concerns, junk dealers, professional organisations, local government

officials (Neighbourhood and municipal/provincial) national government agencies and the industry sector.

Another equally important factor to the strategy is the training aspect for the identified stakeholders on the elements of a solid waste management system and the specific environmental concerns.

18.2. Possible Community Training Elements

The following items should be considered when developing the detailed training and education program on the ISWM program component.

- **Table 18-3 Typical Training Components**

Item	Issues	Household/Neighbourhood	Municipality/ Province
Environmental Management	Burning garbage causes air pollution and health risks	Explain the environmental damage caused by open garbage fires	Ordinances
Environmental Management	Illegal disposal of garbage into drains, rivers and vacant lots	Explain the environmental damage caused by garbage dumping	Ordinances
Waste segregation	Essential if recycling and composting schemes are to be efficient, but costly to have the necessary different receptacles and collection services.	How to do this. Start at Neighbourhood and Household. Possibly use Neighbourhood eco-aides to collect compostables and recyclables with only one Municipality pick-up service.	Legislation requires segregation
Waste minimisation	Purchasing products with least amount of packaging	Education on benefits of less cost of collection and wasted materials and landfill space consumed	Container Deposits
Waste Toxicity	Reduce toxicity of products purchased	Education on alternatives to certain chemicals, e.g. natural toilet cleaners	Legislation
Reuse	Reusing containers, such as bottles	Education on benefits as per packaging reduction and other sources	Legislation
Recycling	Recycling containers, such as plastic bags for garbage containers	Education on benefits as per the above. Also need to market en-masse for better prices (e.g. plastics and glass) and also obtain market access e.g. for sale of tin cans	National recycling market studies
Recycling	Drop off centres for selected items	Consider a centralised system for whitegoods, garden or green waste, hazardous waste, etc	
Composting	Do it at Household or Neighbourhood levels?	Training on methods and equipment required. Market development for Neighbourhood product. Start at Neighbourhood and then go to Household? Also consider vermiculture?	Establish sustainable markets for compost
Greenwaste	How to manage yard and tree clippings	Chippers at Neighbourhood level as input to composting perhaps. Chipping for mulch not composting is also an option	Can the chipper be funded?

Items required will include the following, but the full list of requirements will have to be developed in consultation with the training and education specialists, as well as the Municipality participants;

- primers (why bother segregating, recycling, etc),
- facts sheets (how to compost and what to look for when operating a compost)
- presentation material for our specialists to “train the trainers” such as NGO’s, Neighbourhood officials, etc. to roll out the program to the community

- presentation material for the “trainers” to use at the actual training and education at the future Neighbourhood meetings or household meetings, NGO meetings, etc.

Much of this material has already been produced by USAID projects and other campaigns such as Shah Shir Sultan, ready for implementation of the training. These materials have already been provided separately to the Municipality.

The recommended approach is the “train the trainers” methodology, in which nominated person swill be identified to roll out the full information and education program.

A second element will be introducing educational material into the school curriculum. This is a longer-term issue that will require support at Provincial or National level prior to implementation.

18.2.1. Operator Training

In addition to community training on awareness issues such as recycling and composting, there is a need to train the site operators in how to run a Controlled Landfill. This would usually be undertaken using the Operations Manual SOP and EMP SOP in a mixture of classroom and on-site classes. These SOPs would form the entire package of training materials required for this activity.

18.3. Possible Communications Strategy Elements

18.3.1. Institutional responsibility

The primary entity for a social marketing campaign should be the Municipality Administration as it has a direct link with solid waste management service delivery through the Clean and Green department. Other organisations can play an important supporting role however solid waste is not their mainstream responsibility.

This department would be the information hub for everything to do with solid waste: they must know who the recyclers are, what they are doing, who to contact, not just so they can give advice to the community but so they can connect with recyclers, composters, community groups, and waste organisations to participate in key events.

Given that community awareness needs to take place at times which are suitable for the community, the Department and others implementing awareness activities need transport and other resources to get to the community and need support to work out of normal business hours – typically the weekend and evening.

Based on the analysis of behaviors, institutions and communication channels, the approach for improving waste behavior is through four main methods: television spots, community outreach, schools program, and general demand based awareness.

18.3.2. Mass media awareness through television spots

These would be prime time advertisements to increase sensitivity and change attitudes about socially unacceptable waste behavior such as littering and dumping. These spots will start people thinking about how their behavior is affecting others such as neighbors, or people downstream (i.e. actions have consequences) and how rubbish does not go away just because it is thrown away.

A prominent local or National personality would be featured as a way to attract attention and importance. These spots would be a high priority and can be started early in the project. Although they are targeting residents through local media, the spill over into other urban centres and rural areas will not be wasted as the messages will be relevant

for those living in other areas or for people who come to the Municipality from outside areas.

18.3.3. Community outreach through contracted NGOs

Depending on the formal recycling proposed, awareness would target residents to increase knowledge and skills in how to separate and sort waste and what waste should be recycled, as well as waste minimisation. An NGO could be contracted for this outreach and to work closely with local leaders. This would include demonstrations, advice and information together with materials such as posters in suco and aldeia offices, stickers, and leaflets explaining any waste separation required and how to do it.

Local offices should have posters on the wall for other issues so they could be a place where solid waste posters, and especially recycling posters or waste minimisation information is available. Local leaders could also have these materials for display (sometimes at their own home). Many of the existing posters are old and it is difficult to know the impact but new instructional posters e.g. how and what to recycle and possibly some motivational posters, should have an impact.

An informational video could also be developed to show how to separate waste – particularly if the separation is complicated. This video could be made available through DVDs and electronic file so it is playable on mobile phones in the suco office or at home.

The Cleaning and Greening Department would write a Terms of Reference for this and supervise the NGO.

18.3.4. Schools program

Given that youth are the future adults, they are already involved in rubbish disposal, they can be influenced by information and can carry that knowledge back to their homes, and they are a growing section of the urban population, schools and school children are targeted for a special program.

Children are expected to do some simple critical analysis in both natural sciences and social sciences. The curriculum should be continuous so even Grade 1 children learn about rubbish and this is carried through other grades at different levels.

For primary schools awareness would be through visits, talks, demonstrations, and action games by a contracted NGO, together with materials that support the new school curriculum e.g. posters, stickers, information packs.

For secondary schools, the emphasis would be on school talks and provision of reference material for student research and assignments.

Specific materials should be developed which are appropriate locally.

Additional activities could include school competitions within the urban areas e.g. art competitions which link art with rubbish themes (the artwork is then made into a calendar, providing 12 months of waste messages); sponsorship of a writing or poem competition about waste and the environment to support literacy; song competitions; video competitions (e.g. using a mobile phone camera); fashion event. Publicising of winners through mass media also brings attention to solid waste issues.

18.3.5. General awareness

General community awareness would be provided by the Clean and Green Department on a demand basis and could include talks to businesses and community groups, mullahs, radio/TV shows and panels, newspaper articles etc. Special events could be added such as organising a show on recycled art; entertainment around

World Environment Day (June 6); competitions around International Recycling Day (May 17). The Department could also develop special campaigns as needed such as plastic bag reduction (minimising at point of sale through awareness of both customer and teller, use of green/reusable bags). Where possible the Department should bring in the particular knowledge of specialists such as composters, recycling companies, collection service managers.

18.4. Communications Approach

As frontline staff interacting with the community on a daily basis, waste collectors (both contractors and staff) should also have basic training in waste: how waste breaks down, the collection service, what is recyclable, who is recycling etc. This could be combined with health and safety training.

A short course will need to be developed which should be delivered twice per year and updated accordingly.

- **Table 18-4 Communication Methods Options**

	Behaviour change method	Informative method
Mass media	Television advertisements Short informational videos on key themes	Television interview, panels, news articles Radio talk back, radio panel Newspaper article
Community Outreach - Key informants	Training of community leaders (direct talk, informational video, leaflet, posters)	Other briefings e.g. government (direct talk, PowerPoint, informational video, leaflet)
Community meetings	community meetings (demonstration, informational video, leaflet, posters)	Interest group meetings e.g. businesses; women's groups (PowerPoint, demonstration, informational video, leaflet, poster)
Schools	Primary school talks, demonstrations, games (video, poster, leaflets, guide) Secondary school talks, information pack (video, posters, fact sheets) Teacher training	Competitions School magazine
Other	Training of waste collectors (video, demonstration)	

18.5. Delivery

A professional approach is important for effective communications, and using a local company also provides opportunity for employment and skills development, while at the same time developing content which is relatable to the majority of the target audience.

New materials must be developed and old ones updated to be tailored to the local situation and the use of materials and approaches simply copied from other countries avoided. There is a risk that the messages miss their target and are ineffective unless they are carefully researched and developed.

School materials may be developed by NGOs and specialist education staff or by a communications company. This will require Regional or National inputs.

Change champions and respected leaders can be effective at influencing attitudes and behaviour Leste however there is a need to choose carefully those who model good behaviour, not those that are promoting a certain cause then demonstrate the opposite

behaviour. A spokesperson should be chosen not just for their fame but also for their personal commitment to the environment.

Change champions should also be selected closer to the time of implementation and service change, as popular public figures may change. It is critical to have a popular figure, even if that person wishes to charge for their services, to attract people to various events and bring attention to the campaign.

18.6. Coordination

The program is implemented with the cooperation of the following organization;

- Ministry of Natural Resources and Environmental Conservation
- Ministry of Education, Department of basic Education
- Regional Government and all administrative levels of the City
- Kitakyushu City
- ASEAN ESC Model Cities Program
- Recycling Business Association of Mandalay City

It is critical that the Clean and Green staff coordinate with other agencies involved broadly in solid waste management, and one such opportunity is through a new ISWM Committee and Working Group. This would be a way to coordinate with other departments and ministries, civil society, NGOs, and so on. Other organisations may be included in the committee/working group and from the private sector and possibly recyclers.

18.7. Monitoring

How community awareness is carried out has a potential wider implication for further awareness in other Municipalities. Therefore it is important that both the method and impact of the awareness is monitored. A few simple key indicators should be developed which could be used on annual basis to monitor changes in waste behaviour. These could include recycling volumes, littering and problem dumping area observations (photographed annually), surveys on attitudes to waste and disposal behaviour, attendance at public events, recall on littering/dumping/recycling messages.

18.8. Proposed IEC Content and Delivery

The above sections provide an overview of the possible content and delivery approaches. It is proposed locally to deliver the IEC by:

- Materials – pamphlets, info-sheets, booklets, cartoons, documentary films, Educational video clips, etc
- Methods – reproduction and disseminating to partner agencies, departments and local NGOs/CSOs, presentation at workshops, Aired on national TV programmes.
- Personnel/NGOs/etc to be involved are - MCDC Cleansing Departments personnel, Township Executive Officers, Ward Administrative Offices, local NGOs and CSOs

IEC Campaign

Currently MCDC Cleansing Department is using 15 Million Kyats for the IEC campaign and that amount is approximately 12000US$ per year but the department is receiving 10,000 US$ external funding from Kitakyushu City for that program.

19. Costs

19.1. Background

The proposed list of fleet requirements below is the absolute minimum amount of fleet required and does not include any redundancy or backup whatsoever. This total of 19 in-service vehicles is compared with the present 45 vehicles (excluding trike bikes).

It also assumes that the small compactors make 3 trips a day to the landfill and the large compactors 1.5 trips a day on average. This assumes that there are no restrictions on landfill operating hours as well as well as collection hours.

In reality, and following a street by street investigation, it is likely that more equipment will be required, especially if working hours are limited for traffic or other reasons by MCDC prior to tendering out the collection services.

Therefore the following list is the bare minimum of operational (no redundancy) required if the road system can accept the large compactors, operating hours are not too restrictive and the bins are placed efficiently so that the truck empties near full bins most of the time. If bin distribution is sub-optimal, with trucks often emptying partially full bins or having to clean up litter around overfull bins, then additional fleet and bins will be required.

No allowance has been made for street sweeping as contractors may decide to use mechanised sweepers rather than manual.

19.2. Capital Costs

Prices were obtained for high quality haulage equipment. The prime movers are either Hino or Isuzu brand and the compaction equipment is imported from Europe. Again with the manufacturer's maintenance program being implemented, these vehicles should last up to 15 years, as would other brands from high quality suppliers and manufacturers.

Much cheaper equipment is available but as for the landfill operating equipment, this much cheaper equipment could be expected to have a much shorter service Life. For example, similar size compactor vehicles are available for less than half the cost but are unlikely to last more than 5 years even with regular maintenance. This is because of many issues such as thinner steel plate on compactor shell, using bushes rather than rollers on moving arms, cheap bearings, cheap motors (diesel, hydraulic and electric), etc

Various supplier prices have been used for the skip bins, tricycle tippers as well as the hand carts.

The costs are summarised below.

- **Table 19.1 CAPEX for minimum fleet and bin requirements**

ITEM	UNIT	QUANTITY	RATE (USD)	COST (USD)
Waste skip bins - 4.5 cu.m.	Item	350	1,200	$300,000
Waste skip bins - 1.2 cu.m.	Item	450	450	$148,500
Waste compactor collection trucks (28 cu.m. capacity) -	Item	12	180,000	$1,260,000
Waste compactor collection trucks (8 cu.m. capacity)	Item	16	145,000	$1,450,000
10 wheeler tipping dump truck	Item	2	90,000	$180,000
Small motorised carts (Trikes with high lift dump direct into skip bins)	Item	30	2,800	$84,000
Pushcarts	Item	70	400	$28,000
TOTAL				**$3,450,500**

19.3. Operational Costs

Staff numbers have been estimated assuming no redundancy and very efficient vehicle operation with just 2 staff per vehicle as well as the driver. This assumes that householders will be required to bring their wastes out from their compounds to the truck/collectors and the collection workers do not have to enter the house compounds at all.

The operating costs listed include a minimal allowance for regular and programmed maintenance as well as replacement parts as the age of the fleet increases. Obviously the operating cost increases over time as the motors become less efficient and more extensive repairs are required. In high-quality programmed maintenance for large compactors, some $1,500 to $2,000 a month is allowed or up to $8/hour. Such high levels of maintenance have not been included in the hourly rates below.

The equipment operating costs do not include a sinking fund contribution to allow for replacing the equipment at the end of its useful life.

An hourly rate allowance has also been made for the on-going operation of selected parts of the existing collection fleet.

The staff operating costs have been determined based on using actual local rates for the sanitary worker staff. A suitable staffing mix has been proposed including some part time senior management through to a number of general hands to ensure street sweeping, litter collection and other essential activities are carried out.

The number of staff in each of the five categories presented is based on Bank guidelines which give the number of sanitary workers required per household. The number of more senior workers is then determined based on a proportion of the general sanitary worker numbers.

- **Table 19.2 – Operating Costs for minimum fleet operations**

Item	Number	Hours/ year	Cost/hr. (USD)	Annual Total (USD)
Waste compactor collection trucks (28m3 capacity)	7	2,912	20	407,680
Waste compactor collection trucks (8m3 capacity)	10	2,912	12	349,440
Waste body-tipper litter/cleanup collection trucks (say 1t/load and 2 loads/day)	2	2,912	15	87,360
Small motorised carts (primary collection to secondary sites)	30	2,912	3	262,080
Pushcarts	70	1,248	-	-
Item	**Number**	**Months/ year**	**Cost/Mth. (USD)**	**Total (USD)**
Sanitary Inspector Wages/senior foreman	7	12	200	16,800
Truck and trike drivers - spare drivers included for 7 day week rostering	49	12	140	82,320
Garbage Collectors/Sanitary Worker Wages. Assume 2 garbage collectors per large vehicle (in addition to the driver) - additional workers included to allow for 7 day week rostering	44	12	140	73,416
Pushcart staff	70	12	140	117,600
TOTAL OPEX/YEAR				**$ 1,396,696**

The operating costs are much greater than the current budget. Implementing the upgraded scheme will require community support which will be initiated at least through the information and education campaign, a progressive increase in tariff over a number of years and central or provincial government support in the early years.

19.4. IEC Campaign

The information and education campaign described above for all cost approximately USD12,000 a year at present, and this should be expanded as funds become available.

20. Resources and Funding

20.1. Identify Project Costs

The present cost of ISWM for the Municipality is very hard to isolate from within the general accounts of the Municipality.

Attempts have been made to review the general ledgers and obtain available costs from Municipality records, such as;

- transport costs
- composting or recycling costs
- dump operating costs

A typical review of the ISWM costs would have to include items such as the following;

- Fuel
- Direct labour costs, including vacation and leave provisions
- Equipment repairs and maintenance
- Overhead costs, such as senior Municipality staff management and support staff
- External costs, such as non-Municipality staff costs for legal advice, etc.
- Any promotional and education costs, and
- Miscellaneous costs

The above costs are not listed under a specific vote for ISWM within the general ledger, or logged in a manner that allows the above costs associated with the ISWM operations to be identified.

The future costs can only be reliably estimated once the present costs are determined. These can then be used a base for extrapolating the future costs as various waste management programs are instituted, such as the new collection vehicles or landfill is commissioned.

20.2. Internal Funding Opportunities

The preferred overall approach is to institute methods of Municipality charging which are;

- Direct – the people generating the waste actually pay for their waste,
- Enforceable – non-payment means termination of service
- Adequate for future provisioning – sufficient funds to not only operate day-to-day, but also to invest in a sinking fund for future Capex obligations, such as a new landfill dozer or collection vehicles

The Municipality presently charges allocated portion of its property tax along with collection charges on commercial users to cover, inter alia, cleansing costs but this is inadequate for the present operation and will be even more inadequate if an improved collection and disposal service is provided using the same economic model.

Alternative funding streams must be identified or implement material residential waste collection charges and the collection efficiency also improved. (In developing countries, the collection costs are typically many times that of landfill operation)

20.3. External Funding Opportunities

There is a number of possible external funding mechanisms available to the Municipality as follows;

- Grants or Low Interest Loans from Donor Agencies via the National Government
- Subsidies
- National Funds (Special project funds, such as demonstration projects possibly)
- Donations – cash or in-kind, such as land
- Incentives

The absence of resources for investment in solid waste management facilities has been identified as a major constraint to improved solid waste management.

This is related to the objective of providing finance to Municipalities for capital investment in ISWM infrastructure and cost sharing basis with National government accepting its share of the responsibility of upgrading an essential public health service, alongside Municipalities and the private sector. The purpose of the financing program is to assist in the achievement of an improved environmental method of managing municipal solid waste. The financing program will complement the strategy by providing supplementary financial resources necessary to achieve the strategy objectives in a properly coordinated manner within a reasonable time frame.

The financing program will not be a substitute for municipal funding. Rather by providing finance for capital expenditure, it is intended to serve as a catalyst to encourage self-sufficiency, in releasing municipal funds for the operational costs of waste disposal as well as waste collection.

The principal purposes of the financing program are:

- to provide Municipalities access to the kinds of investment finance required by developers of any large capital works project; and
- to act as a catalyst to bring about improvements in municipal financial management.

In particular it is intended to rationalise the somewhat *ad hoc* procedures, which currently characterise funding for solid waste management.

20.4. Funding Mechanisms tied to Municipal Government Autonomy

MCDC under existing law operates as an extension of the national government. Should government policy change in the future provide more political and financial autonomy to MCDC, it may be able to develop its own revenue structure to pay for solid waste manage schemes. Such financing sources could be:

- Donor grants or loans made directly to MCDC Municipal lending or bonding structures without using the national government as a conduit or guarantor
- Pay-as-you go schemes

21. Evaluation and Diagnosis

21.1. Background

The monitoring and evaluation of the solid waste management program include detailed recording and assessments of the day-to-day operations. It is important to consider all costs incurred, and what category they fall in to. This is important to assess where resources need to be allocated, or conversely, where program changes might be able to reduce costs.

Secondly, both qualitative and quantitative evaluations of the working of the system need to be made. The assessment of the success of the ISWMP depends upon records of the amount of solid waste collected, frequency of collections of both secondary and primary secondary waste points, cleanliness of the various parts of the systems, and general effectiveness of the program.

Monitoring and Evaluation spreadsheets required would include as a minimum:

- Monthly Landfill Operations: Costs and Evaluation
- Monthly Secondary System: Costs and Evaluation
- Monthly Primary Collection: Costs and Evaluation
- Monthly Primary Storage: Costs and Evaluation

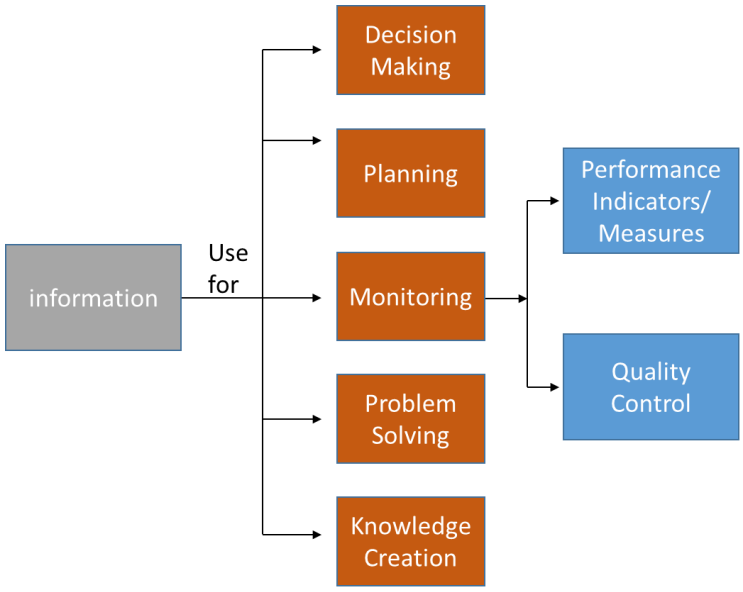
The costs and evaluations information needs to be recorded on a daily basis and turned in to the MSW manager on a weekly basis. The manager should summarize the monthly information and prepare a report to the Mayor on a monthly basis.

More details are provided in **Appendix L – Evaluation and Diagnosis**

The process of ISWM action plan implementation must be monitored and regularly reviewed in order to identify weaknesses in the program and to identify actions to update the process. The following sections discusses this aspect of plan evaluation using indicators and measures of ISWM performance and with reference to specific worked examples of implementation monitoring.

21.2. Performance Monitoring For Solid Waste Management Services

Throughout this Plan the need for collecting and utilising information has been stressed. Large amounts of data are being collected and processed into useable information. But it has to be kept in mind that information *per se* is only valuable when it is focused and being used to a specific end. The diagram below shows the various possible uses of information.



- **Figure 21.1 Use of Information**

21.2.1. Why Improve Performance Monitoring?

The monitoring tools frequently used to assess performance of the ISWM system are, among others,

- visual observations;
- general feed-back from the work force; or
- customer complaints.

Such observations can lead to inaccurate and unquantifiable results and present an insufficient basis for making planning decision for system improvement. Additionally, at first sight seemingly obvious reasons for an unsatisfactory performance of a ISWM function, may, through a more detailed and formal analysis, turn out to not be the reasons at all for the problems.

Monitoring the performance of a municipal ISWM system has a number of goals:

- To closely observe the quality of the ISWM service provided in order to maintain or improve service quality;
- To encourage the efficient use of available resources;
- To relate the outputs of a service to inputs (and ultimately their cost);
- To improve service quality overall and relative to cost;
- To enforce accountability of service providers;
- To put downward pressure on cost of service provision;
- To compare and assess services provided against the targets set out in municipal ISWM plan;
- To provide information on which management can make policy and management decision about the service;
- To compare the service provided between two or more sub-municipalities or municipalities in a regional association;

- To compare the quality of service provision in a Municipality with a previous month or year;
- To monitor and evaluate the quality of services provided by private service contractors.

The two central questions of ISWM performance monitoring are:

- How effective is the ISWM service that is being provided? Meaning: To what extend does the system presently in place satisfy the need for a ISWM service and where is improvement required?
- How efficient is the ISWM service provided? Meaning: Are we using the available resources in the best possible way and how can we improve their use?

Effectiveness and efficiency are closely related, increases in efficiency lead in most scenarios to increases in effectiveness, provided resources are not cut simultaneously.

21.2.2. Definitions of Performance Indicators and Measures

In order to determine the performance of a municipal solid waste management system in general, and its individual components in specific, data and information called “performance indicators” and “performance measures” of ISWM are used.

Performance Indicators– are quantitative data related to ISWM services such as:

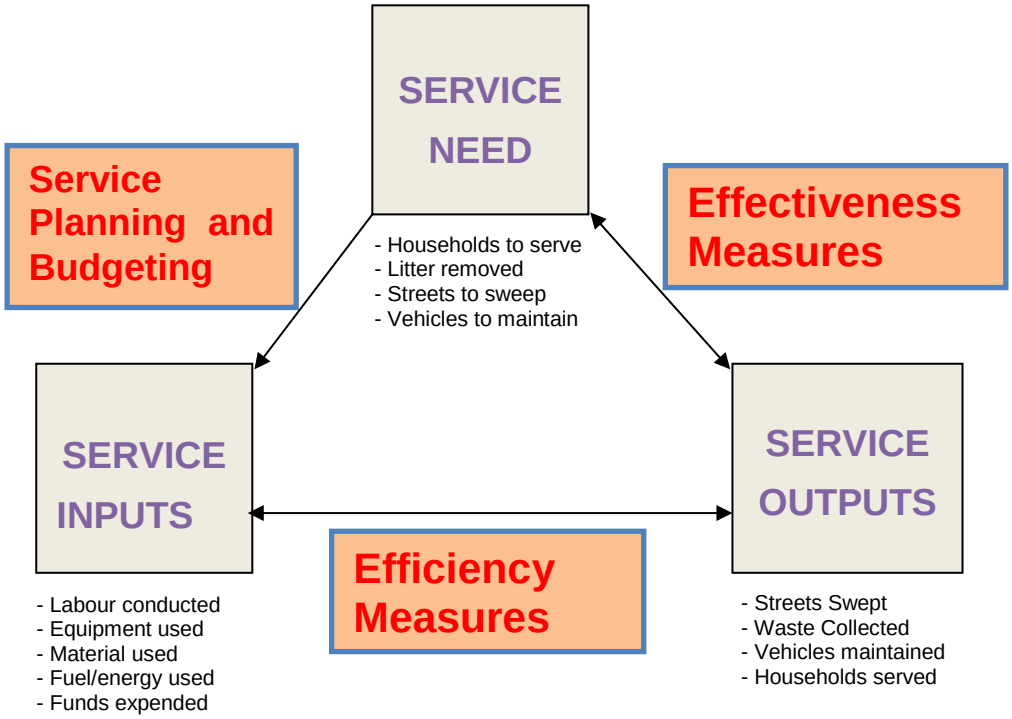
- Number of businesses to be served,
- Kilometres of streets to collect from, or
- Number of employees in service.

Performance Measures– are the result of processing indicators, by relating them to either time or cost, and are the principle tool for assessing the performance of the system under review. For example:

- Cost per ton disposed;
- Number of streets swept per hour etc.

In order to obtain reliable performance measures, the following is needed:

- Accurate, reliable and regular data collection;
- Accurate and reliable cost accounting procedures;
- Weighing of wastes, or estimates based on waste volumes as a substitute;
- Availability of service operating detail;
- Units to which the performance indicators can be related (e.g. costs per 1000 of population served, costs per household served, time per tonne of waste collected etc.)



■ **Figure 21.2 Indicators and Performance Measures**

21.3. Revising and Updating the ISWM Plan

The process of ISWM plan review should be regularly undertaken in a planned and scheduled fashion. A regular review of the progress with implementation of the action program is necessary to ensure that targets are being met in terms of service delivery, financial performance et.

The action plan needs to be flexible and there may be a need for the implementation program to adapt to changing circumstances and conditions, such as, for example, changes in the waste stream (e.g. through increased affluence), development of new technologies to treat and dispose of waste, or institutional changes.

A program of regular review can help to increase the Municipality's knowledge and understanding of the ISWM system through a process of interactive review, problem diagnosis and development of remedial action programs.

22. SWM Plan Summary Output

The outputs from the Solid Waste Management planning exercise are summarized as below:

- **Table 22-1 SWM Plan Summary Output**

GOALS	INDICATORS
To protect the health of the population (*by improvement of sanitation)*	• Incidences of waste-borne health problems in the project area • Percentage of households who express satisfaction on improved health conditions
To promote the quality of life of the urban environment, by reducing the pollution and other adverse effects of solid waste	• Measurement of pollution indexes for the project areas • Community satisfaction on the clean drains, clean street, lack of bad smell in the environment.
To maximize efficiency and productivity	• Average daily tonnage of solid waste collected and transported to landfill • Cost per tonnage of collecting and disposing solid waste • Coverage of households and wards by waste collection services • Time needed for complete daily waste collection
To generate employment and income	• Number of employees in urban waste management and related businesses • Gross income per capita achieved by employees in waste collection industry.
Purpose	
A clean, reliable and sustainable solid Waste Management programme for the agreed areas of the municipality *(project specific)*	• Regular collection of wastes in the agreed districts on time • On time collection and payment of taxes • Waste recovery and recycling projects operational • Appropriate waste disposal facility established and operating in accordance with the Operations • Manual and Environmental Management Plan

Outputs /results	
Waste avoidance is promoted	• Frequency of public awareness campaigns for waste avoidance conducted as planned • Area and population coverage of public awareness campaigns • Percentage of households who are aware of the importance of waste avoidance • Percentage of households who are following waste avoidance practices
Recycling and reuse of waste is promoted	• 30% of the overall waste stream is either recovered, reused or processed
Regular collection system installed and operating in the agreed-wards	• Frequency of waste collection and number of wards covered daily or weekly by collection service
Established functional recovery systems and facilities in the selected wards	• Number of integrated recovery centres (e.g organic composting) established in the wards
Established the functional and appropriate waste disposal facility	• Number of years required for rehabilitation of existing disposal facility (either by closing or incorporating into the new facility) • commissioning of agreed waste disposal facility together with a sufficient operational budget
Functional and capable Solid Waste Management organisation established for the municipality	• Functional organization established with clear delineation tasks, roles and responsibilities as well as sufficient operational budget
Establish an active and functional inspection and monitoring system	• Solid Waste Management municipal regulations drafted and approved, as required. • Environmental inspection team organized and functioning focusing on fly dumping and littering
Establish an active and functional public information program	• Municipal public information team organized and established clear programs integrated into the Solid Waste Management programme unit
Establish active and functional Solid Waste Management Commission	• Solid Waste Management commission formalized and roles and responsibilities as well as staffing finalized

Appendix A - Glossary of Terms

Aerobic process. Biological treatment process that occurs in the presence of oxygen. Certain bacteria that can survive only in the presence of any dissolved oxygen are known as obligate anaerobes.

Anaerobic process. Biological treatment process that occur in the absence of oxygen. Bacteria that can survive only in the absence of any dissolved oxygen are known as obligate anaerobes.

Amenity. The current existence of healthy, pleasant and agreeable (community) surrounding.

Aquifer. A saturated permeable geologic unit that can transmit significant quantities of water under ordinary hydraulic gradients.

Avoidance/reduction. Reducing the quantity of waste produced and the quantity of resources consumed during the manufacture and life-time of the product.

Batch. Samples taken from one site in one day.

Beneficial use. The environmentally benign and useful application or use of a resource which is of public benefit, including welfare, safety, health and aesthetic enjoyment.

Bioremediation. The remediation or decontamination of any contaminated matter by the use of processes involving biological organisms.

Biosolids. The particulate matter, mainly organic, removed during the treatment of sewage.

Building and demolition waste. Solid and inert waste materials, arising from the demolition, erection, construction, refurbishment and alteration of buildings and construction, repair and alteration of infrastructure including roads, bridges, dams, tunnels, railways and airports.

Buffer distance. The distance between the tipping area of a landfill site and a segment of the environment to be protected.

Cell. A section of a landfill.

Clean excavated natural material. Material consisting of clay, soil and crushed rock which is not contaminated or mixed with any other material.

Clinical waste - (also called Medical waste). Any cytotoxic or contaminated solid waste which includes:

- **Sharps:** Any object capable of inflicting a penetrating injury contaminated with blood and/or body fluids. This includes needles, needle or syringe combinations and any other sharp objects or instruments designed to perform invasive procedures.
- **Bulk body fluids, blood and blood products**: Including any vessel, bag or tubing containing body fluids, blood or blood products.
- **Disposable and dressings linen:** Heavily soiled with blood and/or body fluid.
- **Microbiological and pathological waste:** Including discarded laboratory specimens, cultures and materials that have contact with such, and biological reagents.
- **Tissue:** Human tissue, organs, body parts, placentas and products of autopsy and animal tissue.

Commercial and industrial waste. Solid and inert waste generated by businesses and industries (including shopping centres, restaurants and offices) and institutions (such as schools, hospitals and government offices), excluding building and demolition waste and municipal waste.

Composting. The process of the conversion of organic materials by micro-organisms into soil conditioners, compost or humus. By definition, it is a process which must be carried out under controlled conditions yielding cured products.

Construction waste - see Building and demolition waste

Cover material. Approved material for use to cover dumped waste at landfills.

Decomposition. The breakdown of organic waste material by micro-organisms.

Degradation. An environmentally significant natural, physical, chemical or biological transformation to a lower state.

Demolition waste - see Building and Demolition waste.

EIS. Environmental Impact Statement.

EMP. Environmental Management Plan

GFI. Government Financial Institution

Greenhouse Gases. Gases, such as methane and carbon dioxide, which in turn contribute to global warming.

Groundwater. Water saturating the voids in soil and rock; water in the zone of saturation in the Earth's crust.

Hazardous Waste. Waste which, through toxicity, carcinogenicity, mutagenicity, flammability, explosivity, chemical reactivity, corrosivity, infectiousness or order biologically damaging properties, which may present danger to the life or health of living organisms when released into the environment, excluding:

- municipal waste (other than chemical waste specially collected); and
- legal discharge to sewer, subject to trade waste or customer contract.

HHW. Household Hazardous Waste

IEE. Initial Environmental Examination

Industrial waste - see Commercial waste

Inert waste. Wastes which do not undergo environmentally significant physical, chemical or biological transformation and have no potentially hazardous content once landfilled. This waste from building and demolition includes bricks, concrete, glass, plastics, metal and timber. They must not be contaminated or mixed with any other material.

Inert waste landfill. Any landfill that accepts only inert wastes (*see* definition above). Inert waste landfills are usually subdivided into two class:

- **Class 1** - all inert waste including stabilised asbestos cement and physically, chemically or biologically fixed, treated or processed waste.
- **Class 2** - all inert waste except stabilised asbestos cement or physically, chemically or biologically fixed, treated or processed waste.

Landfill Environmental Management Plan (LEMP). A detailed plan for the operations of a landfill site from a greenfield state to a fully rehabilitated state including after-care.

Landfill gas. Gaseous emissions from the decomposition of waste. Also called biogas.

Landfill site. A waste facility used for the purposes of disposing of waste to land.

Leachate. Liquid released by, or water that has percolated through, waste and which contains dissolved and/or suspended liquids and/or solids and/or gases.

Municipality. Local Government Unit

Litter. Solid waste that is outside the tipping area of the landfill site and is not part of the formal waste collection system.

Material recovery. A form of resource recovery of wastes otherwise destined for disposal in which the emphasis is on separating and processing waste materials.

Medical waste - see Clinical and related waste and Contaminated waste

Methane (CH_4). An explosive, odourless and colourless gas produced in a landfill by organic waste undergoing anaerobic decomposition. It is lighter than air.

MRF. Materials Recovery Facility

Mulching. The size-reduction of organic materials using one or more of the following processes: cutting, milling, shredding, grinding and other means.

Municipal waste. Solid and inert wastes arising from the three waste sub-streams:

- **Domestic waste** - household solid and inert wastes placed out for kerbside collection
- **Other domestic waste** - residential solid and inert wastes arising from domestic clean-up and garden waste
- **Other Municipality waste** – municipal generated solid and inert wastes arising from street sweepings, litter bins, parks and garden clean-ups, tree loggings and council engineering work.

Organic waste. One or more of the following types of waste: garden, untreated wood, fibrous, vegetables, fruits, cereals, biosolids, manures, fatty foods, meat, fish and fatty sludges.

PMO. Project Management Office

Poorly stabilised material. A treated material which is prone to further degradation or decomposition.

Public authority. A public or local authority constituted by or under an Act and includes:

- a Waste Board, or
- a department of the public sector, or
- a member of staff or other person who exercises functions on behalf of a public authority , or
- anationally owned corporation or a subsidiary of such a corporation.

Putrescible waste. Waste being food or animal matter (including dead animals or animal parts), or unstable or untreated biosolids.

Recycling. The process by which waste otherwise destined for disposal is collected, reprocessed or re-manufactured and used to make a product.

Remediation. Work for the remediation, rehabilitation and monitoring of premises the subject of a licence and that is required by the conditions of a licence to be carried out:

- While the premises are being used for the purpose to which the licence relates, or
- after the premises cease being used for the purpose to which the licence relates, or both.

Reprocessing. Physical, chemical and biological processing used to transform waste, otherwise destined for disposal, into a raw material used to make a product.

Resource recovery. The extraction and utilisation of materials from mixed waste. Material recovered can be used in the manufacture of new products. Recovery of value includes energy by utilising components of waste as a fuel, production of compost using solid waste a medium, and reclamation of land.

Re-use. A process by which waste otherwise destined for disposal is cleaned or repaired for use, for the purposes of prolonging the original product lifetime prior to treatment or reprocessing.

Run-off. The portion of precipitation that drains from an area as surface flow.

Run-on. Where surface water runs off one site and flows onto the site in question (i.e. the landfill site).

Sludge. Semi-liquid waste produced as a by-product of an industrial process.

Solid waste. Any non-hazardous, solid, degradable waste. This includes putrescible wastes; garden wastes; uncontaminated biosolids; and clinical and related waste. All solid waste will have an angle of repose of greater than five degree (5^0) and have no free liquids.

Stabilised material. Material not prone to further degradation or decomposition.

Surface water. Surface water includes all natural and constructed waterways or channels whether flow is intermittent or not; all lakes and impoundments (except lined dams associated with landfilling activities); and other marshes, lagoons and swamps.

SWM. Solid Waste Management

SWMB. Solid Waste Management Committee

SWMP. Solid Waste Management Plan

Toxins. Substances which are harmful to humans, animals or plants.

TS. - ***Transfer station*****.** A waste facility used to transfer waste from collection vehicles to a bulk haul vehicle, generally in order to achieve long distance transportation efficiency.

Treatment. Physical, chemical or biological processing of a waste for disposal.

Waste. Waste includes:

- any substance (whether solid, liquid or gaseous) that is discharged, emitted or deposited in the environment in such a volume, constituency or manner as to cause an alteration in the environment, or
- any discarded, rejected, unwanted, surplus or abandoned substance, or
- any otherwise discarded, rejected, unwanted surplus, or abandoned substance intended for sale or for recycling, reprocessing, recovery or purification by a separate operation from that which produced the substance, or
- anysubstance prescribed by the regulation to be waste for the purposes of this Act.
- A substance is not precluded from being waste merely because it can be reprocessed, re-used or recycled.

Waste facility. Any premises used for the storage, treatment, reprocessing, sorting or disposal of waste.

Water table. The top level of groundwater lenses

Appendix B- Waste Characterisation Audit and Density Determination Procedures

Introduction

Understanding the materials constituting a waste load is essential in developing any waste reduction, reuse and recycling programs, as well as identifying any materials that would require special management during transport, treatment or disposal.

There are many ways to determine the quantity of waste being delivered to a landfill ranging from desktop studies to making estimates of volumes entering a landfill. However all such methods are at best semi-quantitative as a mass estimate is required as opposed to a volume. Landfill management decisions are always based upon mass and not volume. A second component of waste audits is therefore determining waste density. This then allows the actual mass of waste being delivered to the site to be determined. Because most municipalities do not have access to a weighbridge, then these waste density measurements are necessary.

Aims

The aims of the audit are twofold:

- To segregate and weigh a representative quantity of the mixed waste stream to determine the percentage of various waste components, with a view to improving waste recovery and recycling.
- To determine average waste density and therefore weight of waste in the haulage trucks by weighing measured volumes of waste from selected truck loads, thereby allowing the actual mass per day entering the disposal site to be determined.

Approach to Waste Characterisation

In reality, because most vehicles carry a mixture of waste from different sources (households, market, street cleaning/sweeping, institutions, restaurants, commercial area, etc), there is no opportunity for undertaking audits of individual waste stream types and then recombining the individual waste characteristics. Even if the various waste streams could be segregated into different trucks, such an approach of auditing individual waste streams would not provide statistically valid overall waste data as there is no quantitative manner for combining the audit results of the individual waste streams. This would only be possible if a weighbridge was available to determine the relative mass contributions of the various waste stream types and they could be completely segregated. Because there is no weighbridge available and complete source segregation is not possible, the attempted aggregation of the individual waste stream data would therefore result in major errors.

Therefore the approach is to ensure that a fully mixed waste sample is characterised instead. Audits will therefore be undertaken on a well-mixed sample of the combined waste stream based on selecting representative waste collection days.

In addition, because weighbridges are unavailable, the need to determine the mass of waste entering the disposal site by other means is essential. Various methods are available for estimating the waste mass being hauled but these are only indicative in reality. Therefore the density of selected waste loads will be determined and applied to the total waste volume hauled to site. This will provide a good indication of the daily waste mass hauled to site, which is critical in determining many aspects of the collection, 3RS, waste treatment and finally disposal phases.

There will be different waste sampling procedures depending upon the size of the Municipality, but the actual waste characterisation audit and density determination process is the same at all Municipalities.

Procedure Overview

An audit will be undertaken at an agreed site on the mixed waste being delivered to the disposal site. The audit will take place over 3 days as follows:

- On Day One, the actual audit site will be agreed and the overall procedures discussed with lead labourers, Municipal staff and advisors. The volume of waste in every truck entering the disposal site is to be measured while in the truck body and recorded. Selected typical trucks will then be diverted and the volume of waste in the truck re-measured accurately in-situ. Then the entire load of waste will be weighed to determine the density of waste. This would be done by repeatedly filling rubbish bins with the dumped waste and weighing the bins until the full load has been weighed. The density can then be determined for these specific loads.Samples of waste will be collected from every waste truck (the method depends on the size of the Municipality as described below) and carried to the agreed waste characterisation location.
- On Day Two, samples of waste will continue to be collected from every waste truck (the method depends on the size of the Municipality as described below) and carried to the agreed waste characterisation location. The waste pile is then to be mixed by local labourers hired for the audit. The volume of every truck load entering the site continues to be measured and recorded. Density determinations to continue by weighing selected full truckloads of waste. Waste characterisation will be done by taking waste from the mixed pile prepared over the two days and characterised by segregating the mixed waste into the 14 components for individual weighing.
- On Day Three, both the density and waste characterisation determinations to continue. The amount of waste to be characterised should total about 3 tons and also about 6 tons of waste to be measured and weighed for density determinations.

On all days, the volume of waste in **every truck** entering the site must be measured when in the truck body and the waste volume and truck details recorded.

Procedure Details – Waste Characterisation

- Prior to the audit, determine if the waste stream is the same every day or are some areas of the Municipality only serviced on certain days. For example, is market waste collected every day or only on certain days. Similarly confirm the collection timing for any commercial, institutional or industrial areas. These discussions will be held with Municipal representatives prior to the audit commencing.
- Decide which collection days are the most representative of the overall waste stream. Note for example that if waste from say the market is only collected one day a week, but household waste is collected daily, then the auditing must not be biased by this difference - only 1/7 of the market waste pile should be included in the audit for example.
- The Advisors will confirm with the Municipality to decide the best days for the waste diversion and audit to occur
- The Advisors will also confirm with the Municipal representatives how many trucks come to site each day on average based on as long a period of records as possible. This will be used to determine the volume of waste delivered on an average day, and ultimately the mass of waste disposed per day.

- If it is small Municipality, then the Small Municipality procedure described below will be followed. Mid-size and Large municipalities have different procedures as noted below.
- In all cases, place the waste diverted for characterisation in a separate area and do not mix with other waste being delivered to site.
- Keep all animals and scavengers away from the audit waste pile
- Place a plastic sheet on a flat section of ground at least 6 metres square for the characterisation audit.
- Ensure that the waste is fully separated during the characterisation audit process. For example, a bag full of kitchen waste which is mainly food scraps must be opened and the waste separated. Food stuck to paper or plastic must be shaken off and the food and paper or plastic recorded separately. This is critical or else the results will show too large a fraction of organic waste.
- Completely separate and weigh all waste each time in the characterisation audit pile before adding any more waste from the stockpile. No residual waste should be left before adding more waste for auditing.
- Often there is an amount of small mixed material remaining on the plastic sheet after characterising a pile of waste. The Labourers should be encouraged to continue hand separating the waste components in the residuals pile until it is very difficult to proceed as the pieces are becoming too small to separate.

  Only then place the material in the sieve so the larger material are retained and can then be hand sorted into the usual 14 components.

  The finer material passing through the sieve then needs to be closely examined and proportions allocated to the relevant components, such as 50% “Soil and Dirt”, 30% “Food Waste” and 20% “Garden Waste”. These proportions are then applied to the total mass of the fines passing through the sieve and then the various proportioned weights allocated to the appropriate waste type.

  For example if there was 50 kg of fines remaining after sieving, with the proportions as listed in the example in the paragraph above, then 25kg would be allocated to “Soil and Dirt”, 15kg to “Food Waste” and 10kg to “Garden Waste”.

  To reiterate, it is critical that as much waste as possible is hand sorted and placed into the relevant waste category pile as the highest priority. Only then can the residuals be sieved with the larger retained particles still hand sorted and the fines passing through the sieve weighed and then proportionally allocated to the observed waste categories. The waste types and relative proportions in the sieved fines will vary every time the sieve is used. A finer sieve than that shown in the photograph is preferred at say 10mm aperture.
- Notes must be kept of any unusual waste such as the presence of medical waste. Do not audit dangerous waste but just record its presence and approximate quantity
- Note any hazardous waste such as pesticides, solvents or poisons

- Record the main components of the Miscellaneous Waste category on the data sheet, such as soiled nappies, coconut fibres, etc

SOLID WASTE CHARACTERISATION AUDIT SHEET.

Municipality/City_____ Date____/_____/____

Sheet _____ of _____

Material	Kilograms	Comments
Paper/cardboard		
Glass (bottles, broken glass)		
Plastic bags		
Other Plastic (Drink bottles and containers)		
Aluminium		
Other Metal		
Food waste		
Green/Garden waste (Leaves, branches, grass, etc)		
Building/Demolition Waste (Tiles, concrete, bricks, etc)		
Timber/Lumber		
Soil and dirt		
Hazardous Waste (Describe in comments)		
Leather and Fabric		
Miscellaneous (Describe in comments)		

Procedure Details – Density and Mass Determinations

- Prior to the audit commencing, determine the average number of trucks coming to site every day based on the best available Municipal records. The number of trips made by each truck each day must be determined if different sized vehicles are used.
- Measure the volume of waste in-situ in all trucks entering the site on all three days. Make general observations on the waste type. These data will be used to determine the mass of waste delivered each day. (Do not just measure the external truck body dimensions as each waste load may only fill a fraction of the total capacity of the truck body.)
- Divert selected trucks (which appear to contain waste typical of the overall waste stream being delivered to site) to a second dumping area, when labour resources allow, where the volume of the full load is accurately remeasured while still in the truck.
- The entire waste load is then dumped onto a plastic sheet and then weighed bin by bin, noting that it does not need to be segregated. It is just the total weight of the load that has to be determined. (This combination of in-situ volume and mass will then allow the in-situ density to be determined for these representative loads.)

Note: *A team of 12 labourers (plus support from TA supervisors) should be able to weigh at least 6 tons of waste for the density determinations and a further 3 tons of waste as part of the waste characterisation audit in a three day period.*

Equipment Required

- 3 x Plastic sheets, each at least 5 metres square – to put under audit waste piles
- 6 X 100 litre plastic rubbish bins or similar – for carrying waste to the scale. No lid needed but good handles or grips are necessary.
- Electronic weighing platform scales – for weighing waste when placed in plastic rubbish bins. Capacity of at least 100 kg
- Sieve – about 10mm for separating out the smaller particles and dirt
- Data recording sheets – to keep the results of weighing and note any issues (Included at the end of this guide)
- Personal Protective Equipment – gloves, masks, eye protectors and rubber boots for labourers.
- First aid kit – in case of cuts or abrasions
- Water – for drinking and washing

- 5 shovels and metal rakes, and some barrows – for mixing waste piles and/or loading waste for auditing. Borrow from Municipality
- 12 labourers (minimum). A budget of USD15 per labourer per day has been allowed previously to compensate for the hazardous nature of the work, as well as compensation for travel out of town to the dumpsite and purchasing meals in such remote locations.

Small Municipalities (Hauling Less Than 5 Truckloads A Day)

Waste Characterization

All collection trucks deliver waste to an agreed separate part of the site on the agreed day/s.

Waste being unloaded into a separate dumping area which is kept free from scavengers and animals until audit is finished

Waste piles from the loads being mixed together. Plastic buckets filled waste from one pile are mixed with the waste in other piles. Waste from the edges of various piles are collected and dumped onto the top of the pile. Aim is to make the overall waste pile one homogenous mixture of waste from the separate truck loads. (An excavator or end loader can be used instead if available of course)

Once the total waste pile is well mixed, separate out one quarter (Sector slice) of the overall waste pile for auditing. The quarter must extend from the edges of the pile to the middle of the pile and to very base of the waste pile.

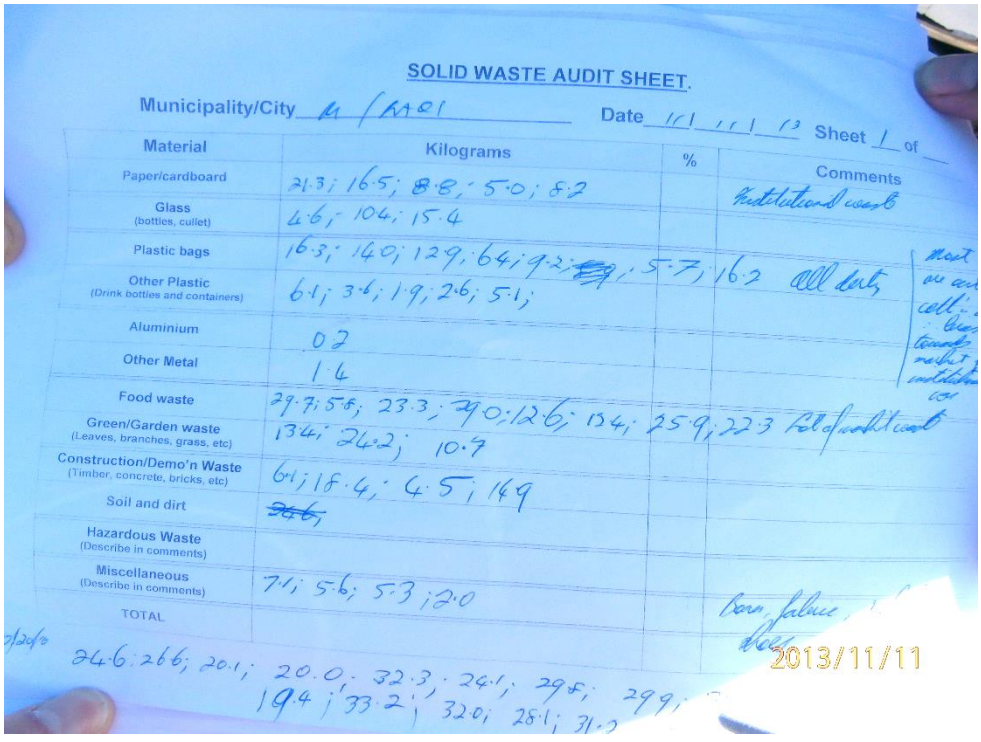
The quartered waste should then be further mixed. Then take waste from the mixed and quartered area (to the right of the pile here) to the audit area as required

Prepare the waste characterization area with signs and plastic sheet

Bring the waste from the preparation area to the audit sheet. Separate the waste into the 14 various components and place near the appropriate sign on the plastic sheet.

Note the plastic sheet under the waste audit pile to prevent contamination and losses. Note use of signs for each waste type. The waste in the audit area must be fully sorted, weighed and removed before any further waste is brought from the quartered pile. Whenever collecting waste from the quartered pile for auditing, take it from a different location with the quartered pile. This reduces sampling bias.

Weigh the various waste components progressively during the audit.



Continuously record the weights for each waste type and make copies of the record sheet in case it is lost or damaged during the day. Taking photos of the record sheet every hour during the audit is strongly recommended.

Waste Density Determination

Inspect and then measure with a tape measure **all** loads entering the disposal site to determine the total waste volume entering the site each day

Select a typical waste load and have the full load dumped after accurate measurement of waste volume in the truck. The waste will then be weighed (but not sorted) to determine waste density

For these density determinations, waste from a full load (the volume of which has been accurately measured in the truck body prior to dumping in a selected area) is being weighed bin by bin. No waste segregation into components is required as only total overall weight of the full truck load is recorded for this activity. The total weight of the truck load is to be determined and then used to calculate the truck waste density.

Midsize Municipalities (Hauling 5 To 20 Truckloads A Day)

Divert every truck to dump in a designated area but keep each individual pile as separate as possible. No scavenging allowed prior to auditing and keep animals away. The plastic sheets may be used to cover the waste piles until ready for auditing

Select two drums of waste randomly from each individual stockpile for taking to the audit area. Only 1 drum if a small load.

Waste from the individual stockpiles is then carried to the characterization audit area. Once the audit pile is fully sorted, weighed and removed, more waste is carried from the individual stockpiles by again taking drums of waste at random from every stockpile to the audit area. (There should be no residual waste in the actual audit area after every pile is audited, to avoid any sample bias, prior to getting more waste from the stockpiles ready to audit.) The 100L drums must be filled from a different part of the individual waste piles at each filling during the audit.

Note plastic sheet under audit pile to prevent contamination and losses. Note use of signs for waste type.

The actual waste characterisation and density determination processes, as well as measuring every truckloads entering the site, is then the same as for the Small Municipality procedures described above. It is only the waste sampling process that is different.

Still measure the volume of every truck entering the site and select a few trucks for weighing their entire load just for density determination.

The aim should still be 3 tons of waste for full audit characterisation and 6 tons of waste for just weighing (no segregation required) for density determinations.

Large Municipalities (Hauling More Than 20 Truckloads A Day)

- Collect two (2) plastic bin samples for each 3-5 cubic metres of waste in every truckload entering the site on the agreed day/s
- Stockpile the waste samples
- If the resulting sample stockpile is approximately equal to the volume that will be characterised by auditing, then just carry the waste to audit area as required during the actual characterisation.
- If the sample stockpile is too large to audit, then mix and quarter prior to auditing as described for Small Municipalities.
- Then just follow the actual characterisation audit and density determination procedures for Small Municipalities

Collecting a waste sample from **every** truck load on the agreed audit days

Must ensure that samples are representative. For example part of the large palm frond was included in the sample

Do the sampling from the trucks near where the audit is to be undertaken, to reduce having to carry the selected waste too far from every truck to the audit area.

Appendix C – Waste Audit Comparisons

Results of International Waste Audits

The Sialkot Solid Waste Management Strategy and Action Plan, Punjab, Pakistan (GHK, 2010) includes data on waste characterisation for three levels of household income as below.

- **Waste Composition of Sialkot, Pakistan**

Waste Type	High Income (Percentage)	Medium Income (Percentage)	Low Income (Percentage)
Paper/cardboard	13	11	12
Food/Organic Waste	40	40	35
Plastic	13	12	12
Glass	5	6	7
Rubber/leather	4	3	2
Metals	2	3	4
Wood	4	4	3
Miscellaneous	19	21	24

The tables below indicate the typical waste components in these countries.

- **Waste Composition of Philippine Cities**

Waste Type	Bamban (Percentage)	Magalang (Percentage)	Mabalacat (Percentage)	Angeles (Percentage)
Paper/cardboard	4.7	6.5	4.4	7.8
Food Waste	9.3	13.7	12.0	18.9
Plastic	16.9	15.3	17.2	17.4
Glass	1.4	2.6	2.4	1.8
Rubber/leather	0.6	1.4	2.0	0.9
Metals	3.1	2.9	1.9	2.1
Textile	0.6	3.2	1.2	3.4
Wood	0.1	1.0	1.9	0.9
Green Waste	54.4	41.7	52.2	40.3
Hazardous Waste	0.0	0.0	0.0	0.0
Miscellaneous	8.9	11.7	4.8	6.6

- **Waste Composition of Vietnam Cities**

Waste Type	Hanoi (Percentage)	Haiphong (Percentage)	Hue (Percentage)	Danang (Percentage)	BacNinh (Percentage)
Organics	60.7	57.5	77.1	68.4	56.9
Papers	5.3	5.4	1.9	5.0	3.7
Fabrics	1.7	5.1	2.8	1.5	1.0
Wood	6.6	3.7	0.5	2.7	-
Plastics	8.3	11.8	12.4	11.6	9.6
Rubber& Leather	0.2	1.9	0.2	0.2	0.2
Metals	0.2	0.2	0.4	1.4	-
Glass	5.0	1.3	0.3	0.1	0.5
Ceramics	1.2	0.4	0.7	0.7	-
Soil, sand	5.4	2.9	1.7	6.7	27.8
Ash	2.3	6.0	-	0.00	-
Hazardous	0.8	0.05	-	0.02	0.07
Sludge	1.6	2.7	1.4	1.3	-
Other	0.05	1.1	-	0.03	-
Total	100	100	100	100	100

Appendix D - Source Reduction Policy Options

Source reduction or waste minimisation is a necessary component of a waste management strategy. The benefits of waste minimisation include pollution prevention, reduced need for waste treatment and disposal facilities, and cost savings. The following sections review the major strategies employed to encourage waste minimisation, and are in compliance with the legal framework discussed in the previous chapter.

A primary step in determining the levels of source reduction strategies that can be implemented by generators is to get information on their current waste generation status and disposal practices. The Municipal Solid Waste Management Committee can pass an ordinance that will require high-volume generators, to provide this information for consolidation. This will determine the need for training and/or appropriate technology to promote in order to facilitate source reduction.

The following are examples of policy statements to facilitate source reduction of waste at household level, and are to be incorporated into waste management education and awareness campaigns:

Avoid Non-Recyclables

> Policy 1: Any item or product, which cannot be reused or recycled efficiently, must be avoided or not promoted.

A product, which cannot be ecologically processed or disposed of, becomes a burden to the environment and to the local government. As long as the technology or process to appropriately dispose of these products is not accessible or feasible, then the marketing and promotion of such products should be discouraged. Without infringing on the policies of free trade, the Municipality should make it clear to the public that these items, even if they are cheap, are wasting taxpayers' money.

Items like cellophane, composite materials like doy packs and polystyrene can be actually reused or recycled but the technology may not be economically viable at this time.

"One-time-use" products like disposable razors, utensils, plates, cups, toothbrush, wipes, etc. must be avoided, whenever possible, but obviously higher concerns, such as the potential impact on health, must be considered in deciding the use of these items.

Use Re-Useable Products

> Policy 2: Products that are packaged for longer use, as in litres, must be given preference over sachets or small packs. Products that are refillable must be given preference over those that are singly packed.

These preferences are related to the impact that these types of packaging have on the ecological manner of their disposal. The practice of packaging in sachets and smaller containers may mean better marketing results, but at greater cost to proper disposal. Using refillable containers may be better if the refills are also packaged in recyclable containers. More often than not, the refills are packed in composite materials, which are in themselves not recyclable.

Various programs can be implemented in order to facilitate source reduction for industries and commercial establishments as well.

The Preventive Principle.

> Policy 3: All industries must adopt the "preventive principle" of clean processing and production whereby the majority, if not all, of the components of the production process are recyclable or compostable.

It is cheaper and more effective to prevent environmental damage than to attempt to manage or "cure" it. Prevention requires examining the entire product life cycle, from raw material extraction to ultimate disposal. It encourages the exploration of safer alternatives and the development of cleaner products and technologies.

For example, prevention requires changes in processes and products – designing non-toxic products from materials that can be safely recycled and composted – in order to avoid the generation of waste that needs to be landfilled.

The Democratic Principle

> Policy 4: The public must be given access to information and be involved in the deliberations for the approval of industries to be permitted to operate within the Municipality, through the Municipal Solid Waste Management Committee.

Clean production involves all those affected by industrial activities, including workers, consumers, and communities. Access to information and involvement in decision-making, coupled with power and resources, will help to ensure democratic control. Clean production can only be implemented with the full involvement of workers and consumers within the product chain.

The Holistic Principle

> Policy 5: Decision on environmental resource use and consumption should not give way to new problems. An holistic approach should be used.

Society must adopt an integrated approach to environmental resource use and consumption. We need to think in terms of systems. For each product we buy, we need to have access to information about the materials, energy, and people involved in making it. Access to this information would help build alliances for sustainable production and consumption. We must also take a holistic approach so that we do not create new problems while addressing old one or shift the risk from one sector to another.

Adoption of Eco-technology

> Policy 6: Adoption of "Eco-technology" whenever possible to reduce the use of non-recyclables.

Ecotechnology is the concept of embedding technologies or manufacturing tin the natural cycles of the ecosphere, with its capacity to produce renewable materials. Ecotechnologies are biodegradable and may use a range of biological process in a holistic and non-invasive way, with the aid of efficient engineering.

Shifting Management Costs

Policy 7: The responsibility for disposal of used products should be shared with the producer.

Extended Producer Responsibility can be a way to shift waste management costs from the public sector to the private sector. Today, responsibility for the disposal of used products rests ultimately on local government and the general taxpayer, not on the producer. As solid waste burdens have increased and more stringent disposal regulations have made waste management more expensive, the budgets of local governments have been stretched thin, and local taxes have increased. The sitting of solid waste facilities has become a major issue. Local government have been saddled with the responsibility for a problem that is not of their own making and which they can do little to prevent.

Legislation

Policy 8: Legislate ordinances to apply “Extended Producer Responsibility”, like buy back mechanisms and avoidance of packaging waste.

Even since the Ordinance on Avoidance of Packaging Waste was enacted in Germany in 1991, product take-back and related forms of EPR have spread across industrialised countries, industry sectors, product categories, and waste streams. Although some of the applications of EPR may be new, the idea is not. After all, deposit refund systems on refillable glass bottled are some of the earliest forms of EPR.

The range of products and waste streams targeted under these emerging EPR policies includes packaging, paper goods, consumer electronics, office machinery, cars, tires, furniture, electric appliances, buildings and construction materials, mercury, batteries and household hazardous wastes.

In industrialised countries, product take-back programs have been enacted for the following product categories: packaging, batteries (particularly small consumer batteries), electric and electronic products, and end-of-life vehicles.

Appendix E – Waste Minimisation for Special Wastes

Tyres

The minimisation of tyres going for final disposal can be reduced by greater use of retreading, and reuse of tyres, but little else, as they are fundamental requirement in society.

The management of waste tyres has been highlighted as a major environmental problem over the last decades. When disposed of in landfills, tyres tend to 'float' up to the surface of the fill causing significant landfill closure problems. The adoption of shredding internationally as a prerequisite for landfill disposal of tyres has necessitated an increase in tyre disposal costs, creating an alternative market for disposal in tyre dumps. These dumps frequently catch fire, causing significant environmental damage. The creation of tyre dumps usually occurs in response to increased disposal charges at landfills, which have been raised in line with problems of dealing with tyres in landfill systems.

Clearly, there is a need to regulate discarded tyres as a prescribed waste and direct tyre disposal to either recyclable uses or at least require tyre shredding prior to landfill disposal. Those regulations must also prohibit the creation of tyre stockpiles for some undefined opportunity, without at least the provision of significant fire control systems.

A number of re-use and recycling technologies have been developed and implemented or proposed for waste tyres. Almost exclusively though, they require a significant gate charge to cover costs.

Potential recycling applications for tyres include:

- Incineration for energy recovery. A plant is currently being proposed for Perth and two operate in Manila.
- Chip rubber as a compost bulking agent, or use as a permeable layer for leachate or landfill gas collection.
- Sports field improvements (crumb rubber), which improves turf quality and uses about 12 000 tyres per football field.
- Road pavement: rubber modified asphaltic concrete uses about 10 000 tyres per kilometre of 10 m wide pavement.
- Road sub-base: whole and sliced tyre road mat system can be used similarly to geotextile membranes for stabilising poor ground.
- Finely milled rubber can be incorporated into a wide range of rubber or composite products.
- At a lower technology scale, old tyres are converted into sandals in Afghanistan.

- Alternatively they can be given back to households, stacked on edge to form a cylindrical container some 1.3 metres high, and used as an above-ground compost facility.

The discussion above illustrates that a number of solutions can be identified for the waste tyre problem, most of them offering commercial development opportunities. But these will only be viable if;

- tyres become a regulated waste, and (subsequently)
- co-operation between landfill operators and the commercial sector ensures landfills do not become a cheap legal dumping alternative.

Contaminated Soil

In general, landfills can accept any resulting low level contaminated soil if they;

- are clay lined or have an impervious base and walls
- have a leachate collection system and a leachate-monitoring program
- have a groundwater surveillance program.

Low level contaminated soil can generally be used as daily cover, provided that the contaminated soil is not used on any external batters. There is generally no need to mix the contaminated soil with general waste for co-disposal.

Acceptance criteria are available in international publications.

Asbestos

In most countries, asbestos is deemed a prescribed waste. As such it can only be disposed of at landfills according to the relevant national Standard or Act. These landfills should have designated areas marked by grid and depth references. The date and location of disposal is recorded for each load of asbestos.

Therefore there is no real opportunity for reducing the quantity disposed of without incurring a community health risk.

Food Processing Waste

The reduction of food processing waste is usually only successful where there is some financial benefit to the processor, and is therefore very much site specific.

Due to the putrescible nature of the waste, immediately transporting to the Landfill and then covering with other waste will reduce fly and rodent intrusion and odour problems.

Medical Wastes

Biomedical wastes include infectious substances and pharmaceutical substances. The onus is on the waste producer to ensure that wastes are segregated, packaged, labelled, stored, transported and disposed of in accordance with government regulations. Proper segregation of waste at the point of generation (using the internationally recommended colour coding and identification system) will substantially reduce the amount of waste that requires incineration or other approved treatment.

The categories of biomedical waste include;

- infectious substances

- pharmaceutical substances
- laboratory chemical waste

Infectious substances include all waste which is known to be, or could potentially be contaminated with pathogenic micro-organisms (e.g. bacteria, viruses, parasites) and which presents a recognised infectious hazard to personnel handling it, to waste disposal workers and to the environment if appropriate precautions are not used.

Similarly, medications, sharps packages, containers and equipment are often included in their description of pharmaceutical wastes. Cytotoxic chemicals are the most hazardous of pharmaceutical wastes and are substances used in chemotherapy, capable of impairing, injuring or killing cells.

There is no real way to minimise these wastes, apart from careful segregation to reduce cross-contamination of less hazardous waste.

Wood and Agricultural Wastes

Wood wastes, which are too large to shred, should be placed in a designated area prior to pit burning or disposal into the landfill face. This allows scavenging of the stockpiled material in an effort to reduce the quantity to be further treated, burnt or landfilled. Open burning on the landfill should be prohibited as this could cause the landfill to catch fire. Landfill fires can burn continuously for many years causing smoke, heat and explosions.

In the event of a fire in the landfill the affected areas must be excavated and smouldering material saturated with water to ensure the fire has been stopped prior to reburial.

Hazardous Wastes

The study area does not currently have a formal management plan for hazardous wastes. This should be remedied by auditing premises using or generating hazardous waste.

Industrial Waste Minimisation

At present there is no industrial waste in the Municipality. However this may change and the following guideline may then be appropriate.

At the commercial and industrial level of waste production, which typically accounts for some 30% of all waste going to a landfill, the practice of waste minimisation can be assessed on a cost-benefit basis as well as on the basis of an environmental ethic for industry.

Industrial waste minimisation policy has traditionally been targeted at hazardous industrial waste streams. However, the principle can be extended to more than hazardous wastes, including such wastes as poultry processing residues and food processing effluent.

The most important prerequisite for an effective industrial waste minimisation policy is active enforcement of air and water pollution control and hazardous waste management regulations. Even without specific regulations requiring waste minimisation and utilisation of low waste technologies, increased charges for waste disposal and limitations on certain unacceptable disposal practices will provide some incentives for waste minimisation.

Planning controls could be considered for new industry, which make waste minimisation a development consent condition for new industry, or for expansion of existing industries. This would require a waste minimisation audit on the proposed process.

Appendix F–Minimising Plastic Bags and PET Drink Bottles

Plastic bags

Recycling

Plastic bags are only recycled in a few countries where:

- labour costs are very low
- plastic bags are not dirty with organic waste such as food scraps
- there are large quantities of such bags available, and
- where there is recycling facility very close by to overcome the high transport costs for such low density material.

Plastic bags which have not been cleaned can be sold internationally for USD0.07/kg whereas cleaned plastic bags attract a price of USD0.25/kg. Raw polyethylene pellets cost over USD 1.30/kg.

The option of recycling plastic bags, and in particular cleaning soiled bags, must be considered in the whole of life environmental context.

A somewhat similar scheme operates in Manila on laminated plastic and foil juice containers where these are recovered from the landfill and washed prior to being sewn into handbags and other carry bags.

Superficially the scheme is highly successful and has attracted international recycling markets and achieves a very high sale premium. However the washing processing is causing significant local water pollution as obviously the soiled containers are highly contaminated with organics.

So if a similar scheme to wash an ever higher percentage of the total mixed waste stream is proposed locally, then a recirculation system will have to be installed for the plastic bag wash-water with only the bleed off being directed into the leachate management system.

At this stage, recycling plastic bags will first require a waste segregation scheme where clean bags are kept separate from the dirty bags and other contaminants such as food waste. Alternatively the dirty bags need to be scraped and then washed. This will result in significant pollution and makes the whole-of-life considerations for recycling dirty plastic bags unattractive at this stage.

Locally there is very little opportunity for recycling plastic bags apart from burning as a fuel source or bringing in shredding equipment and moulds to make plastic items such as plastic seats. However given that most plastic bags are soiled in terms of either inorganic soil or organic material attachment, the overall environmental cost associated with having to clean and dry these bags, not to mention the higher transport content, would make such a scheme generally unattractive at the present time.

Burning plastic bags

In some countries plastic bags are burnt as a fuel source.

There are many technical papers investigating the health aspects of burning plastics and the general conclusion is that burning any plastic containing Chlorine atoms is dangerous. Burning these plastics, such as PVC (Poly-Vinyl Chloride)) can lead to the formation of carcinogenic compounds such as dioxins.

However almost all thin “grocery” bags are made from High Density Poly Ethylene (HDPE) or Low Density Poly Ethylene (LDPE) which do not produce toxic gases when burnt at normal temperatures. Therefore use of these bags as fuel is a valid recycling/reuse activity provide that the community is educated to only burn bags and not other plastics which may contain chlorine compounds, such as PVC.

Plastic bag ban

Some cities have taken the step of simply banning the use of plastic bags. An example would be Makati City with in Metro Manila. This ban applies to both the large supermarket outlets and also smaller corner stores where all purchases have to be placed within paper bags or cartons. This plastics ban has also been extended as far as drinking straws which have to be waxed paper rather than more traditional plastics straws.

This is not been universally supported and there is significant consumer resentment because in the often raining environment with in Manila, the paper bags become wet and grocery items can fall through the bags.

Superficially this is a very aggressive approach for the Municipality to take it this time and other alternatives described below would be preferable.

Plastic bag tax

As mentioned in the chapter above, some countries introduced a charge for the supplying of supermarket plastic bags. In Fiji for example, approximately 2¢ for each shopping bag was previously being charged at supermarkets to discourage people from taking excessive numbers of plastic bags and as a corollary, encouraging people to provide their own reusable fabric bags.

Such a scheme has recently been introduced into the European Union. However to make implementation more streamlined, only those supermarket chains employing more than 250 persons have to charge the tax. Therefore, a similar approach would be just that the larger supermarkets are required to pay the tax as opposed to the markets and the small stores.

Bio/Degradable bags

There a number of degradable plastic bags now available, generally termed:

- Degradable – where the matrix biodegrades leaving numerous small pieces of plastic
- Biodegradable (Oxodegradable) – special additives in the plastic allow the plastic to fully biodegrade over a specified period (Costs 7c to 10cents/bag approximately)
- Compostable – made of organic material such as corn-starch and are not really plastic as such and fully biodegrade (Costs about 21c/bag)

A normal grocery non-degradable bag costs about 3c/bag – range of 2 to 5 cents.

Degradable plastic bags break down primarily through the action of a chemical additive to oxygen, light or heat. The first generation involved just the degradation of the matrix holding the plastic molecules together such that the plastic bag merely broke down into a large number of very small pieces of plastic which then would take many decades to biodegrade. For plastics, degradability refers to change in chemical structure and loss in mechanical properties caused by a specific environment, resulting in the plastic breaking down into small fragments. Such bags are not really environmentally beneficial.

The second generation of biodegradable plastics are also known as 'oxodegradable' bags. These benefit from having chemical additives that can ensure that the entire bag breaks down over a specified time period into the base compounds (Carbon dioxide etc) and not just intermediate resins.

In the first stage, TDPA® accelerates the plastic degradation process by several orders of magnitude, whereby the long polymer molecules are reduced to shorter and shorter lengths and undergo oxidation (oxygen groups attach themselves to the polymer molecules). This process is triggered by heat (elevated temperatures found in landfills or composting), UV light (a component of sunlight) and mechanical stress (e.g. wind or compaction in a landfill). Oxidation causes the molecules to become hydrophilic (water- attracting) and small enough to be ingestible by micro-organisms, setting the stage for biodegradation to begin.

In the second stage, biodegradation occurs in the presence of moisture and micro-organisms typically found in the environment. The plastic material is completely broken down into the residual products of the biodegradation process. As micro-organisms consume the degraded plastic, carbon dioxide, water, and biomass are produced and returned to nature by way of the biocycle.

This time period can be set to vary from weeks up to a number of years as required by the purchaser. In the Pacific Island and many other nations, this has been the preferred approach and the consumer tax for purchasing non-biodegradable bags has been abandoned. The central government in Fiji for example has mandated that all plastic bags must be of the degradable type and this applies not only to shopping bags but also storage bags such as for hot bread, etc.

Compostable plastic bags are often made from farmed products like corn-starch, which, in the right conditions, will break down into elements like carbon dioxide, water and methane. These bags are generally best suited to composting and may contribute to methane emissions if sent to landfill. To meet international standards, bags need to compost within 12 weeks and fully biodegrade within 6 months. These bags are not suited to recycling and are only appropriate for large cities where the bag turnover is very high. However if the bags are stored for protracted periods due to slow sales or distribution issues, the bags will start to biodegrade prior to use. Therefore it is considered that the fully compostable “plastic” bags are inappropriate at this time

Summary

Therefore the recommended approach for plastic bag management is to legislate that all plastic bags have to be biodegradable using the second generation chemistry wherein the bags break down entirely into their prime elements, and not a multitude of small plastic remnants. This approach would also be supplemented through the information and education campaign which would encourage use of reusable fabric bags and the general minimisation the use of plastic bags, even though they would be degradable.

If this is not possible or practical, then a small tax will be applied at the point of sale to encourage people to reuse fabric bags instead of using plastic bags. In parallel, the public could be advised to use the plastic bags as fuel. This has the added benefit of reducing tree felling

Regardless of the option adopted, the community should be educated to minimise the use of plastic bags and encouraged to use reusable (multi-use) fabric bags wherever possible.

PET Bottles

Background

As noted above, these bottles only represent a small percentage of the total waste mass entering the dumpsite. However a large proportion of the bottles are not collected and represent a major component of the local litter concerns, especially given their propensity to be washed into local drain systems and ultimately be washed into the local rivers.

There are a number of options for waste minimisation/source reduction of these containers including taxes, charging policies, container deposit legislation and ultimately, extended producer responsibility.

Charging policies

These are alternatively termed pay as you throw schemes, meaning that any material sent for disposal attracts a specific charge. The idea is that a price signal is then sent to the waste generator to encourage waste Minimisation. However such schemes will only work within an institutional and enforcement environment where illegal dumping or littering is policed.

Therefore the basic charging policy should only be applied within a regime of close institutional control but is considered inappropriate at this time.

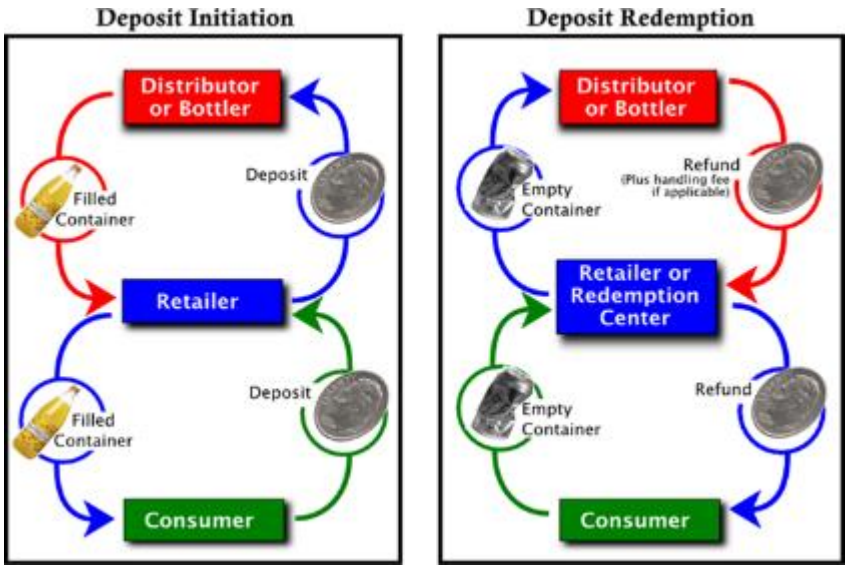
Container deposit legislation

It was first started in Germany over 35 years ago.

It works when a deposit is charged at the point-of-sale for the container. Traditionally this is mainly been for glass bottles to ensure their recovery and reuse and to a lesser extent aluminium cans. Given the very high recycle rates associated with aluminium globally, there is little merit in applying a container deposit to such a high value recyclable.

When the containers return to the shop, the deposit is then refunded to the person returning the item. This works well in larger shops where there is sufficient storage space to keep the containers awaiting collection by the beverage manufacturer. However for smaller shops, storage space will be at a premium and is particularly the case for small shops that have essentially no spare space for storage.

The other issue is that unless specific legislation is introduced to the contrary, any shop is obliged to refund deposits on an unlimited number of bottles. Some states within the USA have prescribed limits on the number of bottles that can be returned any one time or in fact the hours during which refunds will be paid out. There is no requirement to return the bottles to the same store from which the bottles were purchased for the refund.



The shopkeeper then claims back the deposit from the beverage manufacturer upon collection of the stockpiled containers.

Such a system works in an environment where the beverage manufacturers want the containers returned. However it would be far cheaper for the bottled water manufacturers to simply use new PET bottles rather than having to freight them back from the Municipality to their manufacturing hubs.

To make the return of used PET bottles financially viable, the bottles would either have to be pressed and baled or shredded prior to exporting. This negates the overall ideal of reusing the original container and morphs more into a recycling program rather than a reuse program which is the usual are aim of container deposit legislation. Furthermore traditionally the container deposit legislation was more focused on durable goods such as glass bottles.

Specialised chippers and granulators are available to reduce the volume required and therefore increase the attraction of recycling plastics, both bottles and bags.

There is always a percentage of unclaimed deposits that are usually retained just as profit by the various beverage companies. In some countries, such as the USA and parts of the European Union, the central government takes an active role in the management of the container deposit funds and actually retains the unclaimed deposits as part of government revenue. This is another level of complexity that is considered inappropriate at present.

There are real concerns with this approach because:

- Small shops will need to provide large secure storage areas.

- The storage areas must be secure as the bottles can be stolen and resubmitted for deposit funds again, or the bottles can be set on fire as they are highly flammable.
- There is no real incentive for the beverage manufacturer to pick up the returned bottles as they would be more expensive to collect, ship and return to their manufacturing bases internationally than simply using new bottles within the international bottling facilities. This is particularly the case with the current slump in oil prices where reprocessed plastic has become far more expensive than virgin plastic leading to the closure a number of very large plastics recycling companies in Europe.
- Therefore there is a real risk of large stockpiles will be generated without any market forces dictating that they would be reused or recycled.

In summary, container deposit legislation for PET bottles may achieve good collection but not necessarily facilitate a sustainable recycling protocol at the current PET prices and export costs.

Extended producer responsibility

This is the next possible step after container deposit legislation which makes the manufacturer of products responsible for the material's entire life cycle. This means the manufacturers are responsible for the take-back, recycling and final reuse for disposal of the products manufactured.

This responsibility is normally applied for larger items and lately particularly for materials such as eWaste internationally.

For items such as PET water bottles, it would be very costly to have international companies responsible for shipping back all the bottles since most PET bottles are not refilled but rather are chipped and recycled. If extended producer responsibility was applied to these bottles, a very significant cost impact could be expected in the product sale price to the consumer.

Overall it is considered an inappropriate mechanism at this time for PET bottles.

PET tax

Another option is to apply a tax to either the PET bottles or the pellets used for bottle making. A notional charge equivalent to say a few cents a bottle could be applied.

The tax would work in the following manner:

- Government collects the tax on either PET bottles or virgin pellets from the manufacturers;
- The private sector or NGOs could then offer to pay a reasonable amount for used PET bottles for recycling. Such an amount would need to make it attractive for people to collect bottles for sale, especially those from the lower Socio-Economic groups;
- The bottles would then be cleaned, sorted and chipped and perhaps baled to maximize the quantity that could be transported efficiently;
- Once the recycling company has processed the material, the company would present their manifest to the government and receive payment for each ton of PET recycled.

There are approximately 18,000 two (2) litre PET water bottles per tonne making $360 a tonne tax revenue at a notional 2¢ a bottle. Assuming 75% tax processing efficiency within the government, this translates to approximately $270 a tonne available to support PET

recycling. This would be more than sufficient to make the recycling economically feasible even for remote Municipalities.

Such a tax needs to be considered in terms of whether it is progressive or regressive, and whether it has significant impacts on the less advantaged communities. In fact such a tax would be pro-poor too as usually only about 50% of low to middle income earners buy bottled water. It is generally the middle to upper income bands that purchase bottled water. So the tax would not impact upon the less advantaged communities in terms of access to water.

However the significant increase in recycling would be beneficial to the disadvantaged community groups who would most likely become more involved in bottle collection and sale.

Implementing the scheme will obviously require government support and appropriate legislation.

Overall the purpose of the tax is to make the recycling scheme financially viable for such light material as PET. At the present time, it is at best marginal. Payment of the collected tax money back to the recyclers would greatly encourage both collection and recycling of this material, leading to a significant reduction in the amount of PET litter and general material waste at present.

Also if haulage costs still remain a constraint, the Municipality could consider providing a small chipper to reduce the volume of the plastic and make transport more economical.

This tax will require the drafting and approval of National legislation.

Appendix G – Larger Scale Composting

Neighbourhood Schemes

The Social Action Centre of Tarlac (SACOT) operates a composting scheme in Dapdap, Philippines.

The scheme uses a hammermill and four motorised compost drums from Happy Soil. Raw product is essentially dry cow manure, mixed with additives such as odour suppressants, Happy Soil enzymes, coco-dust, burnt rice hulls and a small amount of composted municipal solid waste to act as a drying agent in the mix. Each drum is operated for 5 to 7 days, and produces 300 to 500 kg of compost or 12 to 15 bags.

The compost is sold for P150 (US$4) /sack to farmers operating organically-grown rice fields, endorsed and sponsored by SACOT.

The facility tried composting municipal solid waste previously, but the fertiliser content (NPK) was too low for rice agriculture, without needing artificial fertiliser supplements. This caused the permanent changeover to cow manure as the primary input, which provides compost with higher NPK content that is more suitable as a fertiliser replacement than composted solid waste.

During the inspection, the compost drums were observed to be acting only as a mixing and aging facility. The material within the drums was only tumbling at ambient temperate, and was not composting in terms of waste stabilisation and pathogen destruction. The cow manure is essentially just dried out a little further, and diluted by the additives, but is not a true composting scheme.

The NGO may be suitable as a vehicle for energising the Bamban public in terms of solid waste management issues generally. However, the NGO is more focused on assisting farmers with their natural farming methods, rather than solid waste management.

Other issues to be addressed include;

- Vector control: There are existing non-pesticide fly catchers that can be used (i.e. trap-a-fly technology, where flies are attracted by natural means to a trap)
- Odour Control: There are many local deodorisers available that can be utilised by the facility. However, deodorisers are not necessary if the carbon-nitrogen ratio in the compost is maintained, such that no methane is produced beyond tolerable levels. Regular turning and aeration of compost heaps will reduce foul odour. (The composting process will definitely emit a specific earthy odour.)
- Dust control: When compost facility is set-up in windy area, a way of enclosing the area, such as roofing and boundaries, is necessary to control litter and dust.

Another operating compost scheme near the old Smoky Mountain dumpsite has a 1000kg/day capacity, and treats only hand-selected kitchen waste. It is mixed with equal parts of sawdust, plus some thermophilic aerobic bacteria. These bacteria are added every 2 weeks or so and cost P10/kg. The bacteria are added to equal about 10% of the daily throughput of compost. The compost is sold for P3/kg, about 5 cents a kilogram. Because it is partially funded by University research funds, and the equipment costs are not being annualised, the economics of the system cannot be determined.

It had not operated for many weeks prior to inspection.

The Sun Valley composting system has been developed over a number of years to the present system of basic composting. The previous use of mechanised equipment especially motorised composters has now declined because of the costs involved. The present scheme theoretically operates as follows;

- Waste segregation is mandatory into wet and dry waste.
- Wet waste is collected daily by eco-aides from the households. It is mixed with coco dust in the field to assist in drying the waste.
- The impoverished areas do not enjoy a door-to-door collection service for wet waste, because they cannot afford to pay for this. These households deposit their waste into a centralised bin that contains coco dust to limit wetness and the associated odour. The central bins are then collected weekly.
- The bio-waste is then mixed in an old concrete mixer, and blended with chipped greenwaste to provide the carbon rich material and drier material to provide the correct carbon to nitrogen ratio and the optimum moisture content.
- The waste is then placed in open weave bags for 2 to 3 weeks.
- It is then sieved and milled, and re-bagged for another 1 to 2 weeks for maturation prior to marketing.

The compost is not selling that well, apart from some small scale purchases by locals and some visitors. The application of this compost on purpose-built vegetable gardens has also reduced recently. In essence, it is not operating.

Centralised Schemes

Battambang, Cambodia. This small plant accepts only selected wet market waste which is hand sorted twice prior to composting. It is no longer hammer-milled prior to composting because of glass injuries. Hammer-mill not used as injuries from glass shattering kept occurring, even after 2 lots of hand sorting on selected market waste. This confirms the great difficulty in keeping compost feed pure, even when starting with selected and having two lots of hand sorting. The facility only survives because of ongoing equipment updates and daily operating funds provided by a local NGO. It is far from self-funding.

Baguio in the Philippines only runs their plant intermittently and has some old compost on display for demonstration but no new compost is being produced regularly.

Another example of the centralised composting scheme in San Fernando, Northern Luzon, Philippines. It reportedly sells compost at about P3 per kilogram, to the value of P12,000 per month, with production costs estimated at P34,000. The production costs include all labour costs. The scheme is located near to lahar affected areas which would be a prime candidate for using compost on lahar affected soil. Sales are questionable as during three separate visits to the site, the plant was never working and there were no piles of partially aged compost to see, only some very aged product which seemed very dry and possible many month sold.

Aceh, Indonesia has a central plant wh9ich reportedly keeps blocking with coconut husks. It appears to only run very intermittently, mainly for demonstrations. One operator confirmed that the plantis only run intermittently when visitors arrive. Compost is just used for planting a few demonstration seedlings as there is no market for selling outside.

Figure 7 Application of unutilized compost as regular cover in Gampong Jawa Landfill, Banda Aceh, Indonesia.

The large Ha Tinh facility in Viet Nam is designed for 200t/d and is highly mechanised with bag breakers, elevating belts, primary trommel, hammer mill, aerator, secondary trommel, motorised screens and then finally bagging. It has never operated sustainable and also is just started for demonstration. Note the impurities in compost after trommels.

Phot shows the second trommel and screening system after composting

The Lahore compost scheme is 1,000 t/d scheme and is as a result of a PPP with a local farmer who takes all the compost.

– Compost quality is potentially poor and unsafe (glass, sharps) at times

– Private component is a local farmer who accepts poor compost quality and unconcerned about worker safety issues

Risks

One issue to be considered is the risk management required. For example, Municipalities have been sued for damages due to poor compost causing crop damage due to excessive microbial activity, or personal injury from sharps accidentally included in the compost product in some countries. Even if the compost is given away, there is an inferred warranty that the material is fit for purpose.

Waste must be fully segregated at source to make this option sustainable as centralised waste segregation of mixed waste is unreliable and costly. This means that centralised schemes are possible only for long term consideration locally, not for immediate introduction.

If there was a larger fraction of greenwaste that could be separated out at source, then that may be viable to compost as it is many other countries, provided that there is a sustainable market and that there is a supplementary source of Nitrogen such as dried sewage sludge (biosolids) from a sewage treatment plant.

Appendix H- Background to Waste Containers, Segregation and Collection Systems

Introduction

The chapters on waste minimisation, reduction and recycling provide an overview of contemporary schemes worldwide. Some are more aligned with developed countries but are presented as an aspirational guide to the long term options.

This is critical so any medium to long term approaches preferred by the Municipalities are not restricted or prevented by the decisions taken for the short term approaches.

Present Waste Receptacles

At present there is little no formal door to door collection so Municipal governments have not specified the container type required.

Some people use plastic bags or other flexible containers such as woven bags, and others just throw the waste unpackaged into the formal or informal primary dumping locations or fly dump their waste onto the nearest local vacant land, drain or river.

Present Waste Segregation

There is no waste segregation at present in a structured sense, apart from the following:

- recovery of high value recyclables by householders and primary waste bin scavengers, such as aluminium cans and bottles
- some households separating out food scraps to either feed their domestic animals or make compost in their own compounds
- some market waste is often segregated informally, and farmers then collect the fruit and vegetable scraps for animal feed. However this is not undertaken in a structured or formal manner, and is opportunistic at best.

Relationship between Receptacles and Waste Segregation Approach

To decide what containers are required, waste segregation and collection must be addressed in parallel.

If waste is required to be sustainably segregated, there must be some downstream benefit realised and supported by the community. Segregation takes time and costs money for the householder, as additional bags or bins are required. Many schemes have subsequently failed because the community does not see any benefit in waste segregation, such as a result of witnessing:

- the segregated waste just being remixed in the haulage truck or at the landfill
- no decrease in their waste management charges/taxes although this may be expected as a result of waste being recovered because of their segregation efforts
- no environmental improvement with demonstrably less litter or uncollected waste apparent in the community

A common starting point for waste segregation is having one colour for wet biodegradables (essentially kitchen waste plus any dirt-free greenwaste) and one for all dry matter including all recyclables and other non-biodegradables.

Usually waste is segregated differentiating biodegradable from non-biodegradable waste to allow mechanised sorting of the recyclables centrally. Based on the waste audits, the high value recyclables are already being adequately recovered and could benefit just from some fine tuning. Therefore the amount of high-value recyclables entering the local waste stream for final disposal is minimal, and would not justify a highly mechanised MRF and therefore traditional biodegradable/non-biodegradable segregation.

However the separation of organics to facilitate animal feeding and composting at a communal or central installation supports this segregation option. Therefore this will require the use of two bins and a commitment to undertake composting at one or more of the institutional levels such as a householder, local commune/neighbourhood or a centralised scheme based at the landfill. The schemes could be located on other municipal land or on private land if a local farmer commits to productively using the compost produced.

The only waste streams of significant mass are the dirt/soil and the organics (green waste and food scraps).

Therefore the appropriate segregation option initially may be to adopt a two-bag approach to segregation of the organics (clean greenwaste and putrescibles) from other waste, and include waste segregation training into the IEC. The greenwaste is only small branches, roots plus leaves suitable for direct composting, and does not generally contain branches large enough to warrant chipping and then composting or direct reuse as erosion or dust protection.

Also the local greenwaste mainly comes directly from sweepings and is full of dirt. This percentage of dirt cannot be composted as the dirt will limit oxygen transfer into the compost windrows severely limiting the aerobic composting process. If there is sufficient dirt, then the compost process will become anaerobic which is much slower and odorous. Given that the dirt is often comingled with the greenwaste during the collection (sweeping) process, the greenwaste/dirt mix would require separation either at the household/street sweeper level or centrally. It is extremely unlikely that householders will be willing, on a sustained basis, to screen their greenwaste using a mesh sieve to separate the dirt from the organics. However householders with suitable large compounds could, as an alternative, simply bury the greenwaste /dirt mixture or place it around plants.

This allows greenwaste to eventually be chipped and reused at the landfill site but this unlikely to be appropriate for many years until the Municipality has extensive parklands and gardens and residents have house compounds with extensive greenery. This may of course never happen and as such segregation for these products may never be warranted.

The ultimate ISWM approach must consider what the waste stream will look like after household wealth increases over time. Ultimately with additional parks and gardens there will be significant quantities of greenwaste that will not be used for fuel. This greenwaste and construction and demolition waste could be separately chipped/crushed and reused as landfill access road cover in wet weather, erosion protection on external mound batters. Alternatively the greenwaste can be used as a compost feed if some future composting scheme is adopted, such as with animal manure or biological sludges from treatment plants.

Waste Containers

Waste containers need to be selected to satisfy segregation needs as well as sensibly integrate with the proposed collection system, either community bins or door to door based.

If waste is to be segregated, there must be some downstream benefit realised and recognised by the community. Segregation usually involves having one container for wet biodegradables (essentially kitchen waste) and one for dry matter including all non-biodegradables. Usually waste is segregated differentiating biodegradable from non-biodegradable waste to allow mechanised sorting of the recyclables centrally. No

mechanised sorting such as a Materials Recovery Facility (MRF) is being proposed at this time.

Developed countries have up to 5 separate containers, but three is more common for recyclables, green waste and residuals (both organic and inorganic).

Depending upon any move towards composting, the more traditional waste segregation of organics and non-putrescibles may be more appropriate.

If it is eventually proposed to segregate organics (food scraps and possibly clean greenwaste) from comingled inorganics, the appropriate approach would be to initially continue with using bags with different colours or coloured ties if being collected door to door or just dump segregated waste in the appropriate bins of a community collection scheme still applied.

One additional perspective for this option to reduce plastic bag content in the final waste is to use reusable woven plastic bags for carrying the waste to the appropriate primary dumping location.

The next step would be to have householders use hard plastic or metal bins so that the waste is deposited at the primary dumping location and the bins reused. This will require consideration of methods to manage vermin and flies such as:

- having informal primary dumping locations phased out to avoid putrescible waste simply being dumped in open areas
- moving towards enclosed bins (not the open sided concrete bins) to limit vermin and animal access
- ultimately having skip or hook-lift bins at all primary dumping locations

The next evolution would be to then eventually require hard bins (plastic or metal) to be collected from the household door to door where practicable. Generally door to door collection is only offered for houses along readily accessible streets. The more difficult to access areas often have a community based collection service using hand carts or barrows to bring the individual householders' waste to a primary dumping location, preferably a skip or hook-lift bin. Door to door collection is usually roughly twice the operating cost of community systems.

Daily house to house collection is resource intensive and therefore expensive, and should not be the initial aim of the Municipalities. If waste is to be segregated for commune-based or centralized composting, then a separate collection run will be required for the organics in a different container.

If considered beneficial and sustainable, waste segregation will be encouraged through the IEC campaign. One possibility being for children to establish resource centres at schools recycling household primary recyclables to aid in school project funding, for the households that presently do not segregate and recycle.

Enforcement

If waste segregation is to be adopted, use of the correct containers needs to be enforced in parallel with an overall anti-littering and illegal dumping campaign. It is common in other countries for the waste collectors not to collect waste unless it is in the prescribed bin. Whilst this seems appropriate, care must be taken to ensure that this does not result in uncontrolled littering as a result of non-collection.

Alternatively the waste which is wrongly binned is still collected and the householder fined.

Adopting either of these options will need to be supported by an anti-littering campaign. Such campaigns in developing countries need to be implemented in parallel with an information and education campaign on the environmental and social impact of uncontrolled

littering. There also needs to be a punitive component where a small fine can be issued by Municipality or agency officials for repeated littering offences.

These improvements are best considered as long term issues at this stage of community development.

Collection Fleet Options

The existing fleets are barely adequate to collect waste and dispose of it within the Municipality precinct at the secondary disposal locations.

There will be a general aim in the future, particularly as community wealth increases over time, to increase mechanisation in the collection system by way of garbage compaction trucks and skip or hooklift bins. The options are presented in decreasing order of collection and haulage efficiency and reducing capital cost for system establishment.

Waste Compactor Trucks

Ultimately two sizes of compactor trucks would be required. The larger trucks will be appropriate for the larger roads within the Municipality. The method of operation will involve the driver proceeding slowly down the street with staff walking to each house to collect their rubbish (if door to door collection is eventually adopted) and place it directly in the compaction trough at the rear of the vehicle.

The compactors can also be fitted with arms to lift pushcarts or small skip bins into the rear trough, if those systems are proposed for primary dumping locations in some areas of the municipality rather than door to door collection.

The compactor truck will continue collection in this manner until the vehicle is full when it will proceed directly to the landfill for emptying.

This means that the compaction vehicles do not need secondary dumping locations as the waste is compacted and it is efficient to haul the waste directly to the landfill. These trucks would be expected to make at least two return trips to the landfill each day.

To navigate the narrower streets and alleyways within the Municipality, a larger number of five cubic metre compacting trucks will be utilised. These vehicles will also continue to navigate the local narrower streets and alleyways until full when they will directly haul the compacted waste to the landfill. These trucks would be expected to make at least two return trips to the landfill each day.

Waste compactor trucks have a number of rams, hoses and hydraulic pumps that require maintenance. In some environments, such maintenance can be lacking and the vehicles can become unserviceable.

However this must be considered in the light of the option of not using compactor vehicles. A compactor truck typically can carry 2 to 3 times the mass of waste compared with an open

tipping truck are therefore achieve significant costs and environmental benefits. The basic tipping truck also has the need for an hydraulic pump, ram and hoses but admittedly not as many in a waste compactor vehicle.

It possible that the vehicles purchased will be operated by a private sector group hired through a performance based contract. Therefore there will be financial as well as contractual responsibilities on the private sector operator to ensure the ongoing maintenance and therefore correct operation of the compactor vehicle fleet.

Finally there are different options for a waste compactor vehicle that do not utilize a ram system. A rotating trommel design as shown in the adjacent photographs is equipped with a spiral steel plate welded to the external shell. The entire cylinder rotates in a system similar to that of a concrete agitator truck. Therefore the only moving parts are the roller bearings and one motor to drive the cylinder. When the waste has to be emptied from the cylinder, the motor is merely reversed and this spiral plate forces the waste from the vehicle. Such systems are becoming more popular throughout Europe and require far less maintenance than a typical waste compactor vehicles using the traditional ram system.

Skip Bins

Skip bins can also be used for community based collection systems and have the advantage of optional wheels so they can be more easily moved to the truck for emptying rather than Hook-lift bins.

However the main advantage compared with hook lift bins is that the waste is compacted prior to hauling. The main disadvantage is that they must be limited in size to about 4 or 5 cubic metres because of bin weight lifting limits. It is common to have multiple bins in one location if a lot of waste is generated locally.

If there are only a few of the bins in one area, then the large compactor trucks can be fitted with lifting arms to empty the skips into the compactor truck rear, along with general loose waste.

Hooklift Bins

The hooklift bins can vary between a minimum of 5 cubic metres to 30 cubic metres. These can be low side bins equipped with rear entry donors to allow walk-in and drive in access to the bin.

Unless these bins have easy access, experience confirms that people will merely dump the waste by the side rather than either reach over the low side to place waste within the bin or a pushcart or Riksaaf trucks can drive into the bin to empty their load without having to shovel it out.

The large bins up to 30 cubic metres capacity are available and will be effective provided that they are of the “walk in” design where people can access the bin through the opening rear doors. The actual size mix and location of the bins will be determined after a detailed public consultation campaign.

The hook lift trucks are able to cart all these bin sizes.

The hooklift bins will be placed at strategic locations based on the following criteria;

- Bins will be need to be near areas where pushcarts and Riksaafs are used to minimise hauling distances for these small vehicles

- Bins will also be placed near institutions such as schools and commercial precincts, especially markets, where door to door collection is inappropriate
- Preference given to using exiting sites where possible as the local community is familiar with the location
- The final location of the primary dumping areas (hooklift bins) will be determined at the time of detail investigation when the final specification of other haulage equipment is determined and will be based on a series of community consultation meetings and council discussions.
- However the number of bins will be kept to a minimum as the waste in bins is not compacted and therefore represents a less efficient haulage model than garbage compactors or skips bins.
- There will not be any open secondary dumping areas where waste is merely placed on vacant land or into drainage easements.

Tip Trucks

A number of body tipping trucks will also be required for the collection of general litter throughout the Municipality. The trucks can be either 10 wheeler vehicles for larger loads and wider streets or 6 wheeler for narrower streets.

Alternatively additional hooklift trucks and bins could be used for this purpose.

Tractor – Trailer combinations

These are common in smaller and rural municipalities because of the mechanical familiarity with the tractor by the municipal staff. They are also relatively manoeuvrable in narrow streets. The tractor and trailer combination with lifting rams have essentially the same mechanical complexity as a tip truck.

Some tractors are equipped with a front bucket that can lift the waste from the primary dumping locations into the trailer which is a significant labour saving benefit. Adding the loader element to the tractor adds more hydraulics and is now comparable to a skip bin truck excluding the body compaction elements.

However the tractors are obviously slow when hauling to the landfill and even with the option of hauling more than one trailer, is still relatively inefficient. A hybrid combination could be to use the tractor-trailer for collection from the primary dumping locations hauling to a transfer station using large articulated tipper-trailers or 30m^3 hook lift bins.

They do not provide any compaction either, similar to hook lift bins and tip trucks.

Riksaaf Vehicles or equivalent

There are usually a number of small streets and alleyways that are too narrow and uneven to allow access by even small compactor trucks.

Therefore a number of the Riksaaf three wheel vehicles, or equivalent, capable of carrying 200 kg of waste could be utilised.

These vehicles would collect waste door to door from households and then carry the full load to hooklift bins acting as a limited number of secondary dumping areas.

These will only be used where small compactor trucks cannot reach.

Pushcarts

For the very difficult to access areas, additional pushcarts will be purchased.

The modern pushcarts can have capacities up to 600 litres and are fitted with a tipping mechanism to facilitate easy emptying into the hooklift bins.

Alternatively some larger compactor trucks can be fitted with lifting arms to lift the pushcarts directly into the compactor and so primary dumping location can be avoided for these areas.

There are also versions of pushcarts connected to a bicycle to facilitate quicker turnaround if the collection area is somewhat remote from the primary dumping location.

Determining Vehicle Numbers

In determining the number of new vehicles required in the future, it should be assumed a percentage of the existing haulage fleet in reasonable condition would still be used to haul waste. Obviously over time as the Municipality becomes familiar with utilising the new equipment, the existing system can either be renewed for specific duties or replaced with some other more traditional equipment as listed above.

Three other factors should be used in determining the amount of collection equipment required:

- In some cases the bins (both skip and hook type) and also the compactor trucks will not be full when hauling to the landfill. It has been assumed that on average the loads are only 80 percent of capacity
- With an increased number of mechanised items in the fleet, an allowance must be made for both breakdowns and programmed maintenance. It should be assumed that only 80% to 90% of the mechanical fleet would be available at any one time
- Finally is collection every day or only some days a week. The overall fleet capacity has to be increased if not collecting waste every day of the week.

Need for Transfer Stations

Given that there may eventually be a number of hookliftor skip bins acting as replacements for the old primary dumping locations, another option is to consolidate the number of bins and install a small number of transfer stations instead.

Typically, small to medium transfer stations are direct-discharge stations that provide no intermediate waste storage area. These stations usually have drop-off areas for use by the general public to

accompany the principal operating areas dedicated to municipal and private waste collection trucks. Depending on weather, site aesthetics, and environmental concerns, transfer operations of this size may be located either indoors or outdoors.

There are many “rules of thumb” for when a transfer station is more efficient than direct haul. Many suggest that the minimum distance is in the order of 20km each way before a transfer station is required.

More complex small transfer stations are usually attended during hours of operation and may include some simple waste and materials processing facilities. For example, the station might include a recyclable materials separation and processing centre.

Usually, direct-discharge stations have two operating floors. On the lower level, a compactor or open-top container is located. Station users dump wastes into hoppers connected to these containers from the top level, or even directly into large open containers such as 20 cubic metre hook-lift bins or 40 foot long high side tipping trailers.

For longer transfer haul distances, the 40ft tipping articulated trailers are the most efficient and can contain the usual road transport limit of about 20 tonnes net without needing any compaction system. There are two basic types, namely end tipping and side tipping. End tipping can be dangerous at dumpsites where elevated trailers have toppled on their sides because of the unstable ground condition sunder the trailer wheels.

The side tipping option is safer if less common.

The required overall station capacity (i.e., number and size of containers) depends on the size and population density of the area served and the frequency of collection. For ease of loading, a simple retaining wall will allow containers to be at a lower level so that the tops of the containers are at or slightly above ground level in the loading area.

Several different designs for larger transfer operations are common, depending on the transfer distance and vehicle type. Most designs fall into one of the following three categories: (1) direct-discharge no compaction stations, (2) platform/pit non-compaction stations, which are very common and simple, or (3) compaction stations, including the sealed vertical silo systems.

The key factor in determining if a transfer station is required is the haul distance from the collection area to the drop off location. Determining the economic point where a transfer station is less costly than using the collection compactors requires a detailed financial analysis and collection of real travel time data.

Staff Training

OHS training will be essential for collection staff as well as environmental concepts and the need for improved ISWM management approaches and litter avoidance specifically.

Options for primary waste collection process

There are a number of approaches to collection of waste from residences and commercial producers. Together these are described in detail as follows. Presented here are some of the possibilities.

- Householder separates the organics and fines, composts them at the house, and then places residuals in a small household bin. Door-to-door collection of home bins with manually operated handcart by community worker.
- Door-to-door collection of home bins with manually operated handcart by community worker.
- Door-to-door collection of waste piles by community worker.
- Householder takes waste to community bins as it is produced.
- Householder places waste in indiscriminate piles, to be collected by community worker.

Separation of wastes for household composting

Since between 30% and 40% of the waste has been measured as organics and fines, it means that composting at the household level has the potential to have beneficial impacts on ISWM management from primary collection to final disposal. Removing roughly 1/3 of the waste reduces that which needs to be handled at all three levels – storage at the house, secondary storage and landfill space. It also means that it is much easier to separate out other recyclable materials like metal and plastics. Secondly, it means that an extremely valuable soil amendment can be produced and used at virtually no cost to the household.

▪ **Single bin for household composting.**

Depending upon space available, there may not be enough room to compost on-site.

However, a mini enterprise for private company could be developed, that could get paid a small amount to take the waste away, than can sell the final product to farmers.

Excellent guidance for backyard composting is available from numerous internet sites. (See the Compost Chapter later for more details) Un-enclosed compost piles are not recommended in an urban setting since these kinds of piles tend to spread out and become

unsightly. Home composters are relatively easy to make. However, there are important considerations, such as flies, animals (rats) and odours. A good home compost system will usually have a restriction so that animals cannot get into it. It is usually recommended that meats are not included in the composter.

Alternatively composting can be done even more simply (but less speedily) in ground. Shallow trenches are dug 300mm deep, half filled with organic waste and then covered with soil. The organics remain in situ until sufficiently biodegraded. The compost can then be recovered and used around the compound.

Since this option diverts up to an absolute maximum of 30% of the waste produced, the containers at the residences can be smaller, or transport to secondary waste sites can happen less frequently.

Diversion of the organic waste also reduces the odour and vector attraction of waste stored at the household.

Positives	Negatives
• Cheapest whole-system option as up to 1/3 of the waste stream could be diverted. • Results in a soil amendment but does not replace fertilisers for any crops requiring overall nutrient dosing. • Requires smaller household bins, or less frequent transport to secondary collection. • Encourages communities to take responsibility and ownership of environment and keep community clean. • Citizens are free to choose how they live and operate. • Does not require every household/ commercial enterprise to participate.	• Relies heavily on individual responsibilities; therefore if citizens donot participate, there will be less beneficial impact. • Households would be required to purchase or build their own composters or trenches. Used tyres can be supplied to HHs for use as compost bins. • An aggressive community education campaign would be required, however, this could have far-reaching impacts beyond ISWM. • A demonstration program would likely be required.

Door-to-door collection of home bins

This alternative is very similar to the first alternative, with the exception that there is no composting component. Although it is a far simpler option, it is not as sustainable, and requires potentially much more SW handling.

▪ **Door-to-door collection of home bins.**

In this option, all the household and commercial waste is placed in containers. These containers must be bigger than in the prior option, or emptied more frequently. On a weekly basis, the containers are collected with a manually operated handcart and emptied into a community bin, ortaken directly to a truck for transport to the landfill.

Given the highly variable long-term sustainability of compost schemes internationally, bins and haulage systems should be sized on the basis of no household based composting to be conservative.

Positives	Negatives
• Can be conducted by a number of entities, including individual stand-alone operator, community based organization arranged operator, Municipality operated staff, or a combination. • Waste producers (householders) don't have to be physically present to take waste out, bin is left at door for operator to collect. • Community groups can take ownership of local environment to keep it clean. • Requires less community education or reliance upon individual.	• The cost of bins. • Relies on worker being available with equipment to collect waste, requires management and routing designation as well as equipment procurement/ maintenance. • Requires coordination and payment of workers and a system that ensures if a worker is absent, an alternate is available and in place to ensure the system continues without failing. • If collection workers do not conduct primary waste collection for over more than 2 programmed collection cycles, then entire system would likely collapse.

Some typical options for household/commercial bins are presented below.

	Metal Bins (60ltr)	Plastic Bin (60Ltr)	Wheelie Bin (120ltr)
			
Price/unit	US $ 30	US $ 20	US $ 70-100
Positives	• Heavy duty/robust – can withstand heavy handling and heavy/dense waste loads. Repairable if damaged; U.V. resistant • Fabricated locally/cheap	• Cheapest option • Lightweight and therefore easily emptied by collection crews.	• Relatively heavy duty and robust body. • Larger capacity while remaining maneuverable. • Fixed lid
Negatives	• Heavier than plastic therefore can be more difficult for collection worker to empty. • Lid likely to be damaged or lost resulting in open container	• Not U.V. resistant • Not robust (especially given composition and density of waste stream) and easily broken • Un-repairable if damaged • Bought in from abroad • Susceptible to vandalism by burning or theft	• Most effective when collected by vehicle with hydraulic bin lift which are not common in • Heavy when full, awkward to manually empty. • Bought in from abroad • Comparatively expensive. • Susceptible to vandalism by burning or theft

This door to door option has the advantage of allowing the waste collector to charge the household or institution directly for removing their waste, especially if collection is to be privatised.

Door-to-door collection of waste piles by community worker

- **Door-to-door collection of waste piles by community worker.**

Waste can also be removed from small piles outside of houses/ commercial establishments with a manually operated handcart operated by a community crew like Alternative 2.

The obvious primary difference is the lack of a container, and the subsequent potential for indiscriminate dumping.

Secondly open piles are attractive to animals and other vectors, who can spread the waste and break open bags. This greatly reducing the environmental attractiveness of this option, and has associated health issues.

Positives	Negatives
• Can be conducted by a number of entities, including individual stand-alone operator, community based organization arranged operator, Municipality operated staff, or a combination. • Waste producers (householders) don't have to be physically present to take waste out, waste is left in a pile for operator to collect. • Community groups can take ownership of local environment to keep it clean. • Requires less community education or reliance upon individual. • Requires little expense at household level to establish practice (no bins).	• Relies on worker being available with equipment to collect waste, requires management and routing designation as well as equipment procurement/ maintenance. • Requires coordination and payment of workers and a system that ensures if a worker is ill, an alternate is available and in place to ensure the system continues without failing. • If system fails and collection workers don't conduct primary waste collection, then entire system would likely collapse. • Increases the potential for indiscriminate dumping. • Can often be spread by animals • Has environmental and health considerations.

Householder takes waste to community bins

A clean and cost effective option is for the household/ commercial enterprise to carry and place their waste in a secondary collection bin as it is generated on a daily basis. If properly implemented, this would be cost effective and environmentally friendly. Secondly, virtually no coordination is necessary between the household and the collector as the capacity of the community bin provides the temporal buffering required.

The community bin could be a concrete bunker, trailer, hooklift bin or skip bin, or in some cases, a transfer station.

Positives	Negatives
• Cheapest option for the household or commercial enterprise. • Least labor requirements for organized crew, as it relies on individual participation alone to get waste to collection spot. • Encourages communities to take ownership of local environment to keep it clean. • Citizens are free to choose how they live and operate.	• Relies heavily on individual responsibilities and therefore if citizens don't participate and take their own waste to the community bin, it will end up irresponsibly discarded on streets. • Transport to community bins is not easily achieved by households and therefore is not often practiced. • An extensive educational program would be required to institute this to a successful level. • Unorganized and un-managed, it increases the potential for indiscriminate dumping. • May require drop bins to be established at a closer interval.

Waste taken by household to open waste piles

This option is a combination of other options, with potentially the least control. Households and commercial establishments dump their wastes in relatively uncontrolled piles that may or may not be formally designated.

- **Householder takes waste to open waste piles to be collected by community workers.**

This option is what is happening currently in some locations in the Municipality.

Piles are subject to animal scavenging and scattering of the waste. Although virtually no coordination is necessary between the household and the collector is required, uncontainerised waste requires collection crews to hand-collect loose waste from the street, which is a hazardous and time-consuming practice.

Positives	Negatives
• Existing practice in many places. • Allows haphazard scavenging to occur, and access to animals. • Least labor requirements for organized crew, as it relies on individual participation alone to get waste to collection spot. • Encourages communities to take ownership of local environment to keep it clean. • Citizens are free to choose how they live and operate.	• Alternative that most results in waste being irresponsibly discarded on streets. • Requires collection crews to hand collect loose waste from the street, which is a hazardous and time-consuming practice. • An extensive educational program would be required to institute this to a successful level. • Unorganized and un-managed primary waste collection system; most difficult for the citizens to see a benefit. • Subject to animal attack and waste spreading with greater vermin concerns.

Secondary collection, ditch and street cleaning

Community bins

A number of both formal and informal drop sites exist for community-level solid waste collection at present. This confirms that a certain level of flow from primary to secondary to final deposit already takes place and is accepted by the community.

With most of the options, the waste is collected through the primary collection system and temporarily stored at community collection drop points – "trash dams," bins, or skips - prior to being transported in bulk to the waste treatment or disposal site, or possibly a transfer station. The function of this component is solely to provide an interim storage site to make operations more efficient. As such, it is very important that they are:

- capable of holding the entire amount of waste brought to them during a set period (for instance, to be able to hold a week's worth of contributions from primary collection if that is adopted as the collection frequency),
- emptied prior to new cycle of waste being brought to them – that is they are synchronized with primary collection, and
- easily emptied and accessible for transport vehicles.

There are a number of alternatives for drop points (primary dumping locations), including

- not using formal drop points – just allowing uncontrolled open dumping
- uncontainerised, open piles in agreed locations
- trash dams (permanent concrete or steel bunkers)
- hook-lift bins matched to the collection truck.
- skip bins matched to the collection truck

The open pile alternative is by far the least desirable; the hook-lift bins or skips are the most efficient and clean, but are by far the most expensive initial cost requiringspecialized matched equipment.

Hook lift bin systems do not provide any compaction and even partially full hook-lift bins will sometimes need to be transported. Bins cannot be added to one another to fill one bin (to maximise haulage efficiencies) unless waste is manually shovelled from one to the other.

Skip bins are loaded into a compactor truck where not only is the partially full bin issue then overcome, but the compactor truck can then double or treble the waste density making haulage far more efficient.

Locating any of these containers is an important decision. It is important to consider:

- Containers are located strategically, taking into account where community workers or households have established past drop practices.
- There is adequate space to place one or more containers, and access by the collection vehicle.
- They do not obstruct the entrance of any building, or hinder traffic.
- Neighbours will not vandalise them if the waste become odorous or if feral animals spread the waste

- The walking distance from the edge of the bin catchment is sufficiently short so that residents will take waste to the primary dumping location and not fly dump or litter instead. Anything less than 250 metres is usually considered sufficiently close, but reducing this to a 100 metre maximum walk if possible has been found to reduce illegal dumping to very low levels.

The value of locating at existing informal waste disposal sites is that the community is used to these drop locations, and the change in appearance (when a bin, skip or trash dam is placed) is a noticeable visual improvement. Thus objections from the community should be minimal in that case.

- **Selected alternatives for community trash collection.**

	Open piles	Trash dams/Bunkers	Hook-lift Bins	Skip bins
				
Price/unit	- 0 -	US$400 to $600	US$600 to $1500	US$400 to $1200
Vehicle required	Non-specific	Non-specific	Hook-lift truck matched to bin	Forklift-type compactor truck matched to bin
Positives	• Low cost • Disposal points presumably established by community needs	• Static so residents have defined disposal point • Relatively inexpensive • Requires no special equipment • Fabricated locally	• Bins easier to relocate as they are not fixed • In an emergency, small bins can be lifted by crane trucks which are relatively abundant, known by mechanics & operators • Fabricated locally • Easily removed, cleaned, repaired and replaced • Bins replaced immediately by empty bin	• Bins easier to locate as they are not fixed • In an emergency, skip bins can be lifted by crane trucks which are relatively abundant, known by mechanics & operators • Fabricated locally • Easily removed, cleaned, repaired and replaced • Skip bins recycled immediately and waste is compacted in truck
Negatives	• Alternative that most results in waste being irresponsibly discarded on streets. • Requires collection crews to hand collect loose waste from the street, which is a hazardous and time-consuming practice.	• Difficult and slow to access & awkward to empty • Manual labor required to empty exposing workers to health hazards • Difficult to locate as residents don't like them beside house	• Requires specific hook-lift truck matched to bin • Lifting and unloading can cause damage to containers. • Very low risk of container being stolen • Does not allow compaction in transit to landfill	• Works best with specific fork truck matched to bin • Lifting and unloading can cause damage to containers. • Low risk of container being stolen • Does allow compaction during transit to landfill

Collection points should be located at a distance not exceeding 250 metres from the primary collection points. That suggests the distance between two bins should not exceed 500 metres. The size of the trash dam or number of bins can be determined on the basis of the volume of waste likely to be received from the area concerned. That requires a count of the households (to get a number of people) and number of commercial establishments, and the estimated waste contribution from each. For households, the data above can be used to make estimates. Waste generated form commercial enterprises will have to be estimated from inspection or interviews of the business.

Secondary Collection

Depending upon the particular system and configuration, the number of trucks required can be determined. This also depends upon how long it takes to load the waste and how far it is to a landfill/disposal site. For instance, shovelling out a concrete trash dam or a scattered pile takes much longer than it takes to pick up a skip or bin. But it is also possible that a dump truck can hold more than the amount of waste in two trash dams, whereas it may be that the flatbed associated with a crane can only transport two skips/bins. A typical calculation might be:

Skip-crane combination

- 2 skips/truck @ 2 trips/truck/day = 4 skips/truck/day
- 6 days/week = 24 skips/week/truck
- 4.5 m^3/ skip * 24 = 108 m^3/truck/week (assuming that the skip is full when collected)

Trash dam (or informal dump site)-dump truck combination

- a standard truck has a capacity of 5 m^3
- one truck load per day at 6 days/week = 30 m^3/week/truck

It is entirely possible that a combination of systems is put in place in any one city. Some possibilities are show and described as follows.

- **Secondary collection of piles by tractor/trailer**

Secondary collection of piles by tractor/trailer	
Cost of vehicle = US $25,000	
Positives	Negatives
• Equipment is relatively cheap with good availability. • Has a good short turning radius, so it is fairly easy to access tight spots, such as within communities. • Still has maintenance issues with hydraulics associated with the trailer lifting ram and the front bucket system	• Fairly labor intensive to fill trailer by hand. • Shoveling waste is a hazardous and time-consuming practice. • A tractor is very slow on the way to the landfill. • Consider using a transfer station to overcome the tractor's slow speed

- **Secondary collection of containers by tractor/trailer.**

Secondary collection of containers by tractor/trailer	
Cost of vehicle = US $25,000	
Positives	Negatives
• This system by-passes the need to have secondary collection stations, as the household/commercial bins are emptied directly into the trailer. • Equipment is relatively cheap with good availability. • Has a good short turning radius, so it is fairly easy to access tight spots, such as within communities. • Still has maintenance issues with hydraulics associated with the trailer lifting ram and the front bucket system	• Fairly labor intensive to collect bins from households and businesses, though it may be less expensive than shoveling out trash dams or open piles. • Some bins may be fairly heavy due to the majority being fines (earth and ask) and food waste. • A tractor is relatively slow on the way to the landfill. • Consider using a transfer station to overcome the tractor's slow speed

- **Secondary collection of waste in trash dams by dump truck.**

Secondary collection of waste in trash dams by dump truck	
Cost of vehicle = US $90,000	
Positives	Negatives
• This system is very similar to the first alternative, but uses a truck with potentially much greater haulage capacity than a trailer pulled by tractor. • Dump trucks are moderately priced with good availability and mechanical support. • Is capable of good road speed when going to the landfill. • Can access replacement trucks easily as these vehicles are used for many other haulage purposes	• Fairly labor intensive to clean out trash dams. • Shoveling waste is a hazardous and time-consuming practice. • A large truck has poor turning radius, so may not be able to negotiate some narrow roads, or turns. But can use a variety of truck sizes to suit road widths in the city • Truck has hydraulic systems for tipping requiring maintenance (same as tractor-trailer systems)

The next step is to the ultimate system of compactor trucks.

- **Secondary collection of waste in bins by SW compactor truck.**

Secondary collection of waste in bins by SW truck	
Cost of vehicle = US $180,000	
Positives	Negatives
• This system is a very quick and clean way to collect containerized waste. • Low labor requirements and costs. • Relatively high weekly waste capacity. • Provides compaction • Good road speed to landfill	• The most expensive in terms of capital investment, and not generally available locally. • Requires significant room to turn, and bin must be aligned with truck. Smaller rear lift vehicles are available for narrow street areas • May require advanced training for mechanics.

One of the key factors that requires a concerted effort and buy-in on the part of the community is proper use of waste drop sites. In many instances, a trash dam is not properly used, so the result is not dissimilar to having an uncontainerized open trash dump site with similar visual, odour and health concerns. This may require an aggressive education effort.

Changing to waste bins (Hook-lift or skip bins) also require some community engagement to ensure that the waste is placed in the bin by the householder or commercial institution, and not just dumped near the bin.

Appendix I - Difficult Waste

Difficult wastes are those wastes that are always allowed to be tipped at the Controlled Landfill but require special treatment to ensure that the best compaction/disposal is achieved. This class does not include hazardous or dangerous wastes, or Special Wastes.

Tyres

Tyres can be a real problem at Controlled Landfills, they are impossible to compact and provide homes for rats. After several weeks or months, tyres "float" to the top of the Controlled Landfill and pierce through the cover. Tyres should be collected in a special area and shredded before they are tipped. Alternatively, the tyres may be useful in remediating the old Dump, or used as scour protection around the external base of the waste mound to prevent erosion from flood flows.

Alternatively tyres can recycled into sandals which is common in Afghanistan.

Mattresses

Mattresses are also hard to compact and are difficult to break up. When found in loads, they should be pushed to the toe of the face and covered.

Whitegoods

When a fridge, freezer or stove is tipped on the working face, it should be carefully crushed to ensure that it is as small as possible. Preferably, these larger items should be stored in the recycling compound and sold to a metal recycler after degassing.

Car Bodies

Car bodies should be collected for sale to metal recyclers. If car parts or bodies are to be tipped, they must be carefully crushed. Operators must take extra care, as there may be petrol left in the tank which could catch fire. If car bodies are collected, they must not be stacked more than 3 high.

Drums

Drums of any material must not be accepted if they are sealed or if they contain any liquid. If a sealed drum is found on the tipping face it must be removed and the Site Foreman notified. He will arrange for the contents to be tested and disposed safely.

Opened drums or large containers of any sort must be crushed before being covered, but should always be recycled if at all possible.

Whitegoods, cars bodies and drums can trap landfill gas and be an explosion danger unless well compacted. In any case, they should always preferentially be recycled.

Appendix J - Special Wastes

These wastes include material that may be accepted into the Controlled Landfill but require special consideration on a case-by-case basis.

Local legislation and ordinances would cover the management of this collective of wastes, when developed, or the national standards and codes as appropriate. These wastes are allowed into the Controlled Landfill on a case-by-case basis only.

Asbestos

Generally the requirement is for all forms (solid sheet and fibrous) of asbestos to be bagged before disposal. Any building (e.g. house) or site where asbestos (even in a sheet form) is being removed, must be:

- removed by a licensed contractor
- site covered with a tent
- all asbestos bagged
- workmen adequately protected in fully enclosed suits and masks, and
- all waste, clothes and tent placed in a shipping container and buried in a defined trench in an approved landfill.

It is proposed that the following procedures be undertaken for the disposal of such waste;

- solid form (fibro-board) - disposal in designated area and covered immediately with night cover
- fibrous/dust form - must be bagged prior to receival at the landfill, disposal in designated area and covered with night cover.

The date and location (grid and depth references) is recorded for each load.

The area where asbestos is deposited is to be identified with date of deposition, quantity, fibrous or bonded, origin, name of contractor and accurate location. It is safe provided that the material bagged and not allowed to escape from the bags in a dry state. It is always safer to keep the asbestos material wet as an added safety precaution.

The asbestos will be managed under any local new legislation, or suitable international standards, such as the Australian Code of Practice for Asbestos Removal and Management NOHSC 2002.

Dead Animals and Obnoxious Waste

Animals and obnoxious wastes will be tipped in front of the Controlled Landfill face and covered immediately. Obnoxious waste would include rotting food produce or other condemned foodstuffs.

The animals and obnoxious wastes should not be placed on the base/liner of the Controlled Landfill.

Non-toxic Liquid Waste

Disposal of large quantities of any liquid wastes and soluble chemical wastes will not be permitted. This may encourage the generation of excessive leachate.

It is common to allow up to five percent (5%) of the total Controlled Landfill waste stream to be liquid. This is because waste usually has a moisture content of 15% to 30%, and is not saturated until the moisture content reaches more than 70%. Leachate will not flow until the waste reaches saturation.

However, because of the moderately high rainfall conditions experienced in the Municipality, liquid waste should not be accepted in large quantities until the Controlled Landfill mound is well established and factual data is derived on leachate generation rates and waste moisture content. Limiting the liquid waste to a maximum of 5% of the waste volume would be appropriate for low toxicity waste, such as grease trap pump-outs.

Preferably, grease trap wastes should be tankered to a sewage treatment plant and discharged to an unmixed, unheated tank. Grease will rise to the surface and form a crust. Solids, such as peelings and scraps, will settle to the tank bottom. The water fraction, which will be the largest volume of the three components, will be drained to the sewage treatment plant inlet works. When the sludge and grease layers build up to excessive levels, the sludge and grease should be pumped out and taken to the Controlled Landfill for co-disposal with the waste. The grease/sludge mixture will be covered as quickly as possible.

Toxic Liquid Waste

These wastes must be recorded for type, source and quantity at the front end of the Controlled Landfill operation. If there is any doubt about the actual content of the load, it should be emptied into a separate trench for subsequent inspection, and if deemed necessary, chemical testing.

The general approach is to pre-treat toxic waste prior to placing in trenches cut into the clay. The waste will then be covered and entombed in the dedicated trench.

An alternative is to store the waste for eventual export to countries, which can provide higher technology solutions. The disadvantages to accessing this higher treatment standard is cost and violation of the general aim that people who produce the waste should manage it themselves and not export their potential problem. Another issue is that the style of treatment proposed for the Controlled Landfill is essentially what happens to most cities' waste in many developed countries in any case.

The possible waste streams and treatment methods are as follows:

Oily Waste Water

The best option is to recycle the oil from the emulsions and suspension. A recovery plant may be available in the future.

These waste waters generally have a high Biochemical Oxygen Demand, high salinity, a waste oil or oil emulsion fraction and potential contaminants such as radiator anti-rust fluids. These wastes usually come from ship bilges and service stations. Because of the potential toxicity, the volume should be limited to 1% of the waste volume. (This is compared with the general non-toxic liquid waste such as grease trap wastes that can be up to 5% of the waste stream)

For quantities exceeding the 1% limit, the waste should be lagooned for separation purposes. The oil film and bottom sludges should be tested for toxins. If below acceptable limits, the solids can be directed into the Controlled Landfill. If the toxin content is considered excessive, solids should be blended with kiln dust, cement, fly ash or clay mixtures to fix the toxins in a cement matrix, and encapsulate any mobile fractions. The resulting solid blocks should be land filled.

Phenolic and Emulsified/Concentrated Oil Waste

This includes wastewaters contaminated with degreasers and decarbonisers, emulsified oils such as machine and cutting oils and other products from light industry and tanker washouts.

Where possible, the phenolics should be oxidised using potassium permanganate. The treatment and disposal method is then the same as for oily wastes.

Acid/Alkali/Metal Wastes

These wastes are derived from metal plating works, metal finishers and the paint manufacturing industry.

Wastes should be neutralised where possible by blending acidic and alkaline wastes. This may require the construction of holding lagoons for the various waste stream components.

The blended product is then treated as for the oily waste by Controlled Landfilling or chemical fixation using cement products. The disposal method is also the same, involving Controlled Landfilling the solidified waste capsules and evaporating where possible the remaining liquid waste fraction.

If evaporation is unsuccessful, the liquid can be added to the Controlled Landfill mound provided that the 1% rule is observed.

Paint/Pesticide/Solvent (PPS) Wastes

This includes all pesticide, fungicide and herbicide wastes, plus solvents such as halogenated cleaners and Methyl Ethyl Ketone derivatives. Sources would include manufacturing processes for the nominated waste types, laboratories and other heavy industry.

This is generally regarded as the most toxic waste stream and requires fixation with cement material, unless the total load can be restricted to less than 1% of the total waste volume. Because the organics do not fix strongly into the cement matrix (unlike metals, which are strongly fixed and become effectively immobile), the resulting cement capsules should be placed in a dedicated disposal trench as monofill. The trench into clay would then be sealed prior to the entry of any stormwater. At least 600 millimetres of low permeability clay should be underneath and around the trench.

The trenches should be located in clay at least 600mm thick below the base of the trench, and at the head of the Controlled Landfill mound to maximise the distance to the creek and any groundwater. Locating the trenches upslope of the Controlled Landfill also allows the surface and groundwater monitoring programs to assess any leakage from the trenches.

The size of the trenches cannot be determined at this time as there is no reliable data on waste generation volumes. They should be sized to accept up to 6 months production of the component waste streams. This will allow the liquid to isolate from surface scums and bottom sludges, and allow evaporation to occur.

The one exception is the Paint/Pesticide/Solvent (PPS) waste, which should be stored for only one month prior to solidifying.

Pathogenic and Medical Waste

Various local medical facilities, such a hospitals and medical clinics, have inadequate facilities to correctly handle all their special waste. This was confirmed by medical wastes appearing in some of the Dumps in the region.

The best solution is to provide a regional medical waste incinerator at the Controlled Landfill. It would be remote from the public, and ash residual could be safely co-disposed with the waste. The incinerator could also treat some of the liquid wastes, such as PPS that has calorific value, provided that the incinerator and anti-pollution equipment is appropriate for these wastes.

The general requirements for an incinerator are that the temperature should be over 1 200^{o} Celsius and a residence time of 2 seconds.

The only residual concern is that the collection and handling of the medical waste must be dedicated and safe, and mediwaste is not co-mingled with other domestic or commercial waste.

Contaminated Soil

This soil can be derived from contaminated sites or dredge spoil. The soil should be tested to ascertain the health and environmental risk profiles, such as using the ASTM Standard Methods for Toxicity Characteristic Leaching Procedure.

There are three options for managing contaminated soil coming to the site, namely;

- Non-acceptance based on laboratory testing, because it is too contaminated for the standard of Controlled Landfill.
- Acceptable into the site but still too contaminated (or unsuitable for some other reason such as too wet) for use as cover material but suitable for incorporation into the waste mound as waste
- Acceptable into the site for use as daily, but not final, cover material

If the soil is determined as being too hazardous for the environmental capabilities of Controlled Landfill, it must not be allowed onto the site and should be directed to a hazardous waste facility. This would apply to highly contaminated soil from an old pesticide factory for example.

However if the soil is not an occupational or health risk, it may be used as daily cover. It must not be used as final cover.

If unsafe to use as cover for whatever reason such as being too wet, it should be incorporated into the Controlled Landfill as normal waste.

Biological Sludge

This material is recyclable, provided that it has been stockpiled or otherwise treated to control pathogens. It should only be Controlled Landfilled if the material is not recyclable, due to excessive heavy metals or biocides or lack of market demand.

The sludge would not require any special treatment prior to Controlled Landfilling with other waste.

Batteries

Lead-acid batteries are recyclable and should not be allowed into the Controlled Landfill.

If the market fails, then batteries should be drained of the acid prior to placing in the mound. However this is a waste of the lead contained in the plates and should only be used as a last resort.

Dry cell batteries, such as torch batteries, should be accepted without any special precautions being required, unless the quantities become significant. This is unlikely however as there is a trend to using rechargeable rather than disposable lead type.

Appendix K - Privatisation

Overview

The options for privatisation are somewhat limited in this case where the operation is just for a single local authority. In cases where a facility is shared between Municipalities in a regional approach, then there is greater scope for private involvement for reasons such as the following;

- The scale of operation is larger, and therefore more attractive for a private company to commit Capex funds and mobilise.
- The regional context means that at least one of the Municipality's cannot be directly involved in the operation of the facility. This can result in some friction between the member Municipalities. Using a third party, possibly the private sector, to operate the facility gets around this issue.
- A further disincentive to involving the private sector is that the work required is relatively low technology, and therefore has low possible margins. The recycling systems for example will most likely be basic Neighbourhood level systems using lower cost civil society or possibly NGO staff. The collection system is unlikely to be mechanised in the foreseeable future to equipment such as side-lift trucks for Mobile Garbage Bins (MGBs) of say 240-litre capacity. Similarly the disposal facility is only a Controlled Landfill which has only basic operational requirements compared with a Sanitary Landfill.

For these relatively simple operations, the private sector may not be attracted because of the low potential for innovative solutions or management that will make the private sector price cheaper than the cost that the Municipality themselves can operate the facility. Once the Controlled Landfills have to be converted to Sanitary Landfills, or perhaps enlarged to become a regional facility, then there may be more scope to involve the private sector.

However if the Municipality is interested in seeking private sector involvement, it can be sought on non-commitment basis. This means that the Municipality can seek tenders for one or more components of their waste management services and compare the offers with their internal records of costs under Municipality operation. If the Municipality appears to be less expensive for the same level of service, then the Municipality would not be obligated to award the tender. In any case, it is likely that the collection, recycling, composting and Controlled Landfill aspects will be undertaken under different arrangements, contractual or otherwise.

It is also critical to consider the length of contracts for privatisation success. Short contracts of a year or two are insufficient to allow the investor to recover his Capex exposure on equipment or site development if a landfilling operation. Any privatisation contracts requiring extensive capital injection by the operator must be at least 5 years in duration, but preferably a minimum of 10 years, to allow amortisation of the capital cost.

The following sub-sections address the most common options for the various levels of private sector participation in the ISWM requirements of the Municipality. The seven (7) generic options are listed below and discussed. The Municipality should just be aware of the privatisation spectrum available to them, and the various pros and cons associated with the options.

Private Sector Involvement Options

The options are described below.

Service Contracts

These delegate particular operations and maintenance (O&M) functions to a private operator for a short period of time (one or two years) in return for a specified fee. These could be appropriate for operating a Controlled Landfill or collection services if the scale of the operation is sufficient.

Management contracts

These allocate responsibility to a private operator for the full range of O&M decisions, typically for three to five years, or longer. The private operator is paid a fee, which may sometimes be linked to performance. It could be appropriate for operating a small Controlled Landfill if the scale of the operation is sufficient.

Lease contracts

These are where a private company is granted the right to the revenue stream from the operation in return for full O&M responsibilities. Ownership of the asset remains in the public sector. These are also known as “contracts d’affermage” or service concessions.

The private operator collects revenues directly from the customer, and pays a percentage as a rental fee (or redevance) to cover the administrative and investment costs of the public entity, which exercises residual ownership of the assets. The responsibility of the public entity typically includes regulating the contract and managing the investment program. The leasee does not therefore invest in fixed assets, but does bear the full commercial risk of running the service. This option would only apply if the Municipality owns the land or collection vehicles.

Concession contracts

These grant a private operator the right to exploit a given service for a fixed period of time (ranging from 15 to 30 years), assuming full commercial risks and responsibility for a specified program of new fixed investments. A formula is set for tariffs to be collected by the operator, to cover the full cost of running the service and capital expenditure.

As with lease contracts, provision is made to renegotiate the tariff formula to reflect changing circumstances throughout the long life of the contract.

These contracts are only appropriate for large Sanitary Landfill operations, a major collection service or perhaps for a very large mechanised MRF.

Build Operate Transfer (BOT) contracts

BOT contracts give the responsibility to a private operator (or consortium) both to finance and construct an infrastructure facility and to operate and maintain it for a specified period of time. At the end of an agreed period, ownership of the facility is transferred to the government at a symbolic cost.

The private operator retains all the revenue from operating the facility for the period of the contract, to pay for the capital and operating expenditure. This revenue stream typically consists of fees paid by the public sector user and commercial operators.

Such a scheme would only be suitable for a very large landfill or major collection service.

Private Sale

This involves selling existing public facilities to a private operator, usually by means of an auction. Private sales may involve majority or minority stakes in the state owned enterprise, and certain restrictions on purchasers. The decision whether or not to participate can only be made on a return on investment basis.

Sale is usually only an option for very large facilities. At present, the Municipality facilities are too small to be an attractive sale option.

Flotation

This involves floating state assets on domestic or foreign stock markets, perhaps with restrictions on share purchase. In particular, governments retain “golden shares” in the Privatised Company, which confer special voting rights and powers of veto.

Flotation is too complex unless a major regional scheme is adopted, and the risks associated with such a private-public sector participation model is accepted by the national government.

At present, the Municipality facilities are too small to be an attractive flotation option.

Criteria for Privatisation Method Decision

The decision on whether to consider privatisation of some sort must be based on suitable criteria, such as those listed below for both the public and private sector perspectives.

Public Sector Perspective

Four groups of criteria can be considered when choosing between privatisation options:

Financial criteria.

State owned utilities can place a variety of financial pressures on the public purse, which governments may wish to reduce:

- Subsidies to loss making utilities to finance existing operations
- Funding of substantial new investment to increase capacity and improve service quality.

The greater the public sector deficit, the more important financial considerations are likely to be as a motivating factor towards privatisation. Privatisation options may relieve some of the pressure by:

- Reducing or gradually eliminating subsides and cross-subsidies, through greater efficiencies of private sector operation, and the phasing of tariff increases up to cost recovery levels. Such increases may prove politically easier to implement under private rather than public operations.
- Attracting finance to meet new investment needs, thereby avoiding the need to incur additional public expenditure.
- Generating cash revenues through the private sale or flotation of public assets. The funds can be used to create a reduction in public sector debt or to fund alternative projects.

Efficiency of service criteria.

Public owned utilities may have relatively low levels of efficiency, since there are poor incentives for cost reduction. Introducing private expertise and management methods can improve efficiency in a number of different ways:

- Increasing productive efficiency linked to reductions in operating costs even without substantial new investment.
- Stimulating innovation driven by the adoption of new technologies in the context of an investment program.
- Improving the quality of service, as long as targets are clearly set by the public sector.
- Raising accountability to customers, brought about by the market context.
- Increasing tariff/fee collection efficiency, as a result of the profit motive of the private operator.

Ideological criteria.

Where governments are undertaking a wide range of policies involving deregulation and pro-market reforms, privatisation will be enthusiastically embraced. In this context, it is viewed as a means of increasing private participation in the economy and may be used to encourage wider share ownership. Where governments do not espouse to a free market political philosophy, privatisation may be undertaken more reluctantly primarily as a means of funding new investments or improving the efficiency of public services. In these cases privatisation is likely to be accompanied by special measures to ensure continued public control.

A desire to retain maximum public control may lead governments to adopt contractual forms of privatisation as opposed to asset sales. However, asset sales need not entail a loss of public sector control. The government can retain a controlling stake and use the proceeds of privatisation to achieve wider social goals.

Administrative criteria.

Two aspects of the privatisation process will create a significant administrative burden:

- Preparation. Assembling information on the state of the existing infrastructure assets, assessing the quality of the competing bids, providing reliable revenue and cost forecasts for the operation of the contracted services.
- Regulation. Ongoing costs of regulating the activities of the private operator, on both price and non-price performance parameters.

Private Sector Perspective

Private operators will consider the balance between risk and return when selecting between possible investment opportunities.

Potential risks may include:

- Commercial risk from the operation and maintenance of the service, subject to demand, cost and revenue volatility.
- Project risk from uncertainties in forecasting costs and revenues attached to investment responsibilities.
- Country risk from exchange rate volatility, which may affect profitability for foreign operators.

- Regulatory risk from unexpected alterations in the regulatory conditions, such as political interference.
- Force majeure risk from damage to assets owned by the private operator, as a result of natural disasters.
- Potential factors affecting the return on investment include;
- Bidding costs. Preparing the bid and participating in the selection procedure, compared to the probability of winning the contract and the resulting revenue stream.
- Cost reduction potential for efficiency gains, and whether the resulting profits can be retained by the operator.
- Revenue expansion through increasing the size of the market and the associated flow of revenues.
- In general for private operators:
- Service and management contracts lie at the low level risk, low reward end of the spectrum.
- Lease contracts and concessions offer a somewhat higher level of risk, but offer the opportunity to increase revenues through demand growth.
- BOT and BOO contracts are high risk, with limited scope for demand growth.
- Private sales and flotations also carry significant risk, but may allow high returns depending on the terms of the regulatory regime.

Service Contracts and Management Contracts

Service and management contracts have the lowest degree of private sector involvement. These options give financial relief to governments, and some scope for efficiency improvements by the private operator.

Circumstances in which governments tend to consider service and management contracts are:

- Modest public sector deficit
- Inefficient public services
- High risk environment for private operator
- Desire to experiment with small scale privatisation
- Ideological ambivalence towards privatisation
- Low availability of regulatory capacity

These conditions generally apply to the current Municipality environment, and as such, Service Contracts and Management Contracts are the most likely options for privatisation locally, from both the public sector and private sector perspective.

Public Sector Perspective:

The key differences between service and management contracts is that management contracts offer somewhat greater scope and incentive for efficiency improvements, and create a slightly greater administrative burden if there is performance based remuneration.

Advantages.

The advantages of service and management contracts are:

- Minimal ideological implications given the limited responsibilities transferred to the private sector.
- Comparative light administrative and regulatory burden.
- Possible efficiency improvements through skilled private management, which may reduce subsidies or lower customer tariffs, see also disadvantages.
- Possible quality of service improvements through performance related bonuses.
- Opportunity for private operators to acquire experience and knowledge of the local infrastructure, necessary to operate a more comprehensive and demanding contract in the future.

Disadvantages

The disadvantages of service and management contracts are:

- Limited scope for service improvements, with little incentive for cost cutting measures because of the short period over which benefits can be retained by the private sector.
- Efficiency gains are likely to be significantly smaller than they might be under a more complete form of privatisation.
- Improvements may not be transferable to the public sector at the end of the contract -especially if the benefits are largely attributable to the management skills of the private operator. These will be entirely lost unless adequate training measures are incorporated into the contractual structure.
- The separation of responsibility for the operational and investment decisions between private contractors and the public body introduces the danger of coordination problems between these two areas of decisions making.

Private Sector Perceptions

For the private operator, the key difference is that management contracts offer greater autonomy, but also additional risk if the contract is structured to include performance based remuneration.

Advantages.

Such contracts are low risk given that:

- The operator’s compensation generally takes the form of a fixed fee.
- The relatively short duration of the contract reduces exposure to political risk.
- The operator is not required to make any irreversible financial commitment in the form of large investments.

Disadvantages

The rewards are limited, given the:

- Low degree of managerial autonomy
- Relatively small scope and little incentive for cost cutting
- Limited opportunity for expanding revenues.

Lease contracts and concessions

These types of contracts allow governments to obtain substantial relief from expenditure commitments, while preserving ultimate asset ownership. This is an issue with Municipality for large commitments such as sanitary landfill development or for renewing the entire garbage collection fleet.

Both the scope and incentives for efficiency improvements by the private operator are far greater than with service and management contracts.

Circumstances in which governments tend to consider lease contracts and concessions are:

- Public sector deficit
- Inefficient public services
- Public sector desire to retain control over investment
- Unattractive environment for private investment
- Ideological ambivalence towards privatisation
- Medium availability of regulatory capacity

Additional circumstances in which governments tend to prefer concessions over lease contracts are:

- Major infrastructure needs
- Public sector willingness to relinquish investment activities
- Relatively attractive environment for private investment

Public Sector Perspective:

The key differences between lease contracts and concessions are that concessions:

- Provide additional relief from public expenditure commitments associated with infrastructure development, given that the public sector is able to transfer the financing of investment to the private operator.
- May lead to more effective utilisation of resources, since they partially eliminate the coordination problems often present in lease contracts between public authority in charge of investment and the operator responsible for the operation of the system.
- Require additional non-price regulation to monitor and assess the investment decisions of the operator, especially toward the end of the concession period as the date for rebidding the contract approaches. Given the uncertainty of winning a contract renewal, the investment incentives are likely to be weakened towards the end of the contract period.

Advantages.

Lease contracts and concessions offer the following advantages:

- Significant fiscal relief, as they may permit the gradual elimination of public sector subsidies by providing a framework for a phased increase of tariffs/rates/gate fees to actual cost recovery levels. These levels are too low in the Municipality at present for all facets of waste management, from collection and disposal costs, and includes the domestic and commercial/industrial users.
- Significant potential improvements in service efficiency as the private sector enjoys a considerable degree of autonomy and has a much greater incentive to cut costs,

given the longer duration of contracts and the ability to retain sufficient efficiency savings as profits.

- Greater degree of private sector participation without transferring asset ownership to the private sector.

Disadvantages.

Lease contracts and concessions require:

- Considerable preparatory work to organise the bidding procedure, provide adequate information to prospective bidders on the state of the assets, and to preselect the bidders on the basis of their technical competence.
- A comprehensive regulatory apparatus to establish and implement a satisfactory tariff formula and to monitor the standards of service provided by the operator. Non-price regulation is particularly important given the operators possible incentive to cut costs at the quality of service.
- A favourable political environment, given the length and scope of private sector involvement, and the magnitude of tariff increases which may follow the granting of the contract.
- Incentives for the operator to carry out proper maintenance of assets, particularly towards the end of the contract period given that asset ownership will revert to the public sector.

Private Sector Perceptions

For the private operator, the key difference is that concessions incur additional investment risk. However, compensating factors are the greater degree of managerial autonomy and the avoidance of coordination problems with agencies responsible for government funded investments.

Advantages.

They provide the operator with the opportunity for relatively high returns given that:

- There will often be significant potential for efficiency improvements over the duration of the contract.
- The operator will benefit from growth in demand for the service, as well as creation of additional network connections.

Disadvantages.

A higher level of risk accompanies the potential for increased return;

- Commercial risk becomes considerable since the operator relies directly on consumer tariffs as a revenue stream. The private operator is directly exposed to the risks of demand volatility, and to the potential difficulties associated with tariff collection, especially where prices may be rising steeply to meet real costs.
- Exchange rate risk can arise since the operator is generally remunerated in local currency. However the contract may periodically allow exchange rate fluctuations to be passed on to the customers through a change in the tariff.
- Regulatory risk is likely to be substantial, given the long-term duration of such contracts.

Evaluation Criteria	Lease	Concession
Commercial risk	Risk due to cost volatility: present Risk due to demand volatility: present, as all of the Operators return comes from tariff revenue. Risk due to bad debtor: present, but may be reduced if the operator has the ability to disconnect customers.	Risk due to cost volatility: as for lease Risk due to demand volatility: as for lease Risk due to bad debtor: as for lease.
Project risk	Minimal	Exists, given the introduction of responsibility for investment financing.
Regulatory risk	Present, given the possibility of unexpected changes in tariff and quality regulation.	As for lease
Country risk	Risk due to exchange rate volatility: present, unless the tariff formula encompasses a pass through term for currency changes. Risk due to political instability: possibility of premature termination of lease contract owing to a change in government.	Risk due to exchange rate volatility: slightly greater than for lease contracts owing to the longer contract duration. Risk to political instability: greater than for lease contracts given the longer contract duration and the profiling of returns (initial outlay, followed by tariff revenue later in the contract.
Force majeure risk	Minimal given that the Operator does not own any infrastructure assets and has no rehabilitation responsibilities.	Limited, connected to the possibility of dangers to fixed assets built by the Operator during the concession.
Bidding costs	Potentially high, relative to the probability of success given the need to technically prequalify and the length of the selection process.	As for lease.
Cost reductions	Significant, given that the operator retains most of the tariff revenue and has a significant time horizon to benefit from cost cutting measures.	As for lease contracts, but with additional scope for efficiency improvements arising from more control over the investment program.
Revenue expansion	Significant, given the possibility of benefiting from demand growth, and service additional customers.	As for lease contracts

BOT and BOO contracts

These contracts are of greatest relevance where governments need to harness private capital to finance rapid expansion in the capacity of infrastructure services. They can be seen as a variant of contracting public works, where the remuneration for the operator is not a lump sum paid up front, but a risk bearing compensation scheme spread over a period of time.

Circumstances in which governments tend to consider BOT and BOO contracts are:

- Public sector deficit
- Major infrastructure needs
- Attractive environment for private investment
- Ideological ambivalence towards privatisation
- Medium availability of regulatory capacity

BOTs and BOOs have been used mainly in power generation, transport infrastructure and water treatment services.

The only real difference between BOT and BOO contracts is the ultimate asset ownership, which may make the BOT option more attractive for governments reluctant to relinquish ownership in the long term. A potential complication with the BOT contract is the loss of incentives for asset maintenance as the transfer date approaches, so additional regulatory effort may be required towards the end of the contract period.

Public Sector Perspective:

Advantages.

The principal advantages of these privatisation options are;

- They enable governments to exploit private sector finance, technology and expertise in the expansion of infrastructure.
- They are relatively uncontroversial from a political standpoint, as private sector involvement is generally limited to a specific infrastructure project.

Disadvantages.

The main problem with BOT and BOO contracts are:

- They can be relatively unattractive to the private sector, given the level of capital expenditure and the degree of risk, resulting in the need to provide revenue guarantees.
- They may require considerable preparatory work prior to the award of the contract to select bidders and provide them with adequate revenue forecasts.

Private Sector Perceptions

Advantages.

The main advantages of these options from a private sector perspective are:

- Where the plants are designed to meet demand peaks, and the revenues are consequently likely to be volatile in nature, it is not unusual for the operator to secure some form of “take or pay” arrangement with the downstream user to provide a minimum guaranteed revenue. This has the advantage of insulating the operator from demand-side risk.

- Such contracts represent a relatively small scale and self-contained involvement, compared with the operation of a complete infrastructure network. They can therefore be used to gain experience of working in a particular country or area with a view to developing further business in that country or area.

Disadvantages:

- Potentially high risk with relatively modest returns. The main risk, given the capital-intensive nature of such contracts, is the potential for construction cost over-runs.
- The financial assessment of such projects depends crucially on the quality of the demand forecasts used to project the revenue stream. Where such forecast are inaccurate, or ill conceived, the commercial viability of the project might be seriously jeopardised.
- The maximum revenue is clearly defined by the capacity limits of the plant, so any upside for the operator must come from capital and operating cost reductions.

Private Sales and Flotations

These are the ultimate forms of privatisation, with the permanent transfer of ownership of infrastructure assets along with full responsibility for management and investment.

Such privatisations have been extremely rare, probably owing to the very limited scope for competition and the social charter of the service, both of which have made governments unwilling to relinquish ownership of assets.

Circumstances in which governments tend to consider private sales are:

- Substantial public sector deficit
- Inefficient public services
- Small scale of enterprise
- Major infrastructure investment needs
- Attractive environment for private investment
- Strong ideological support for privatisation
- High availability of regulatory capacity
- Additional circumstances in which governments tend to prefer flotations to private sales are;
- Large scale of enterprise
- Desire to develop capital markets and promote share ownership

Public Sector Perceptions

The principal differences between private sales and flotations are:

- Private sales may not be feasible for enterprises above a certain size. Where a single state owned monopoly is being privatised, flotation may be the only way to go.
- It may be possible in a private sale to obtain greater control over the identity of the purchaser, selected by the government. In flotations, the government's choice is restricted to whether to undertake a domestic or international public offer.
- Domestic flotations of public utilities can have positive side effects, such as the development of stock markets and broadening share ownership.

Advantages

The advantages associated with private sales and flotations are:

- Considerable fiscal relief, by reducing current expenditure on service subsidies and avoiding additional investment expenditure. In addition significant revenues are generated from the privatisation.
- Full scope for service efficiency improvements through the introduction of the profit motive and reliance on private sector managerial expertise. The extent to which such improvements come about depends critically on the nature of the regulatory regime that is put in place at the time of privatisation.

Disadvantages.

The disadvantages associated with private sales and flotations are:

- A heavy administrative burden in the preparation of the sale. The most difficult issue is the valuation of the existing assets as a basis for an appropriate sale price for the infrastructure.
- The regulatory burden is potentially greater than for any other privatisation mechanism. Success depends to a large degree on the effectiveness of the regulatory system that is put in place.
- A possible negative political reaction, depending on the ideological climate of the country or area. This can potentially be reduced by retaining a controlling government stake, although this will also reduce the proceeds of the sale. Other mechanisms to improve political acceptability are restrictions on foreign ownership, and sales of shares to employees.
- Revenue generation as a motivation for privatisation may conflict with other objectives, such as pro-competitive restructuring of the privatised industry.

Private Sector Perceptions

The key differences between private sales and flotations are:

- Where the flotation entails the complete sale of a private enterprise with no trading restrictions, capital market competition may come in to play, whether by means of mergers or hostile takeovers.
- For the international investor, private sales provide the opportunity to acquire some degree of permanent ownership and managerial control over the utility. Flotations may only offer financial investment opportunities, with only limited scope for exercising control over the privatised enterprise.

Advantages.

The main advantages are;

- Asset ownership by the private operator gives a high degree of decision-making autonomy.
- The prospect of high rewards, given the ability to develop the infrastructure market and the scope for efficiency improvements typically present in formerly state-owned enterprises.

Disadvantages.

The two privatisation options both share the same disadvantage, from a private sector perspective, of being characterised by a relatively high degree of risk associated with:

- Regulation, a primary determinant of the operation’s profitability.

- Political interference, which may arise with a change in the prevailing political ideology, and could take a variety of forms ranging from an unanticipated tightening of the regulatory regime to full scale asset appropriation.

Performance Monitoring Measures for Solid Waste Collection Operations

There are numerous criteria for performance monitoring of collection and landfill operations, depending upon the complexity of the privatisation option adopted.

The following tables present typical measures that may be incorporated, wither fully or partially, into any such future contracts.

Performance measures	*What is measured ?*	*How is it measured ?*	*Where is it measured ?*	*How often is it measured ?*	*By whom is it measured ?*	*Basis for sanction ?*
Cleanliness of service areas	Existence of litter Existence of ***clandestine*** waste piles Waste in drains Improperly placed waste bins Regularity and frequency of collection service Cleanliness around ***communal*** containers Weekly washing of communal containers Completeness of collection service – number of collection points unserved False loading of vehicle with water, stone, etc. to increase payments	Zone inspection reports Customer complaints register	Service zones	Daily	Assemblies Districts[1]	Yes
Safe disposal of collected wastes	Waste quantity delivered at official site Clandestine dumping	City-wide inspections Records at disposal site Complaints by witnesses of clandestine dumping	City-wide Disposal sites	Daily	Assemblies Districts	Yes
Customer satisfaction	Perception about cleanliness of zone Willingness to pay Willingness to participate with collection requirements	Surveys of customer satisfaction Surveys of willingness to pay	Service zones	Semi-annually	Assemblies Districts	No
Customer dissatis-faction	Complaints about improperly placed waste bins, damage of waste bins, uncollected wastes, rude behavior by collectors, poor appearance of collection vehicle and collection crew.	Zone inspection reports Records of complaints Records of follow-up of complaints Records on attainment of service frequency targets	Service zones	Weekly	Assemblies Districts	Yes
Worker productivity	Number of workers in service Waste quantity per worker each shift Absenteeism	Zone inspection reports Records at disposal sites Vehicle log books	Service zones Disposal sites	Weekly	Assemblies	No
Vehicle productivity	Number of vehicles in service Waste quantity per vehicle each shift Waste quantity per vehicle each day Vehicle ***downtime***	Records at disposal sites Vehicle log books Zone inspection reports Load inspections at landfill	Service zones Disposal sites	Weekly	Assemblies	No

[1] Each Local Government, whether it be a city, municipality, metropolitan area, or council, has its own terminology for its sub-areas. Assemblies and districts are among the terms most often used for such sub-areas.

Performance measures	*What is measured ?*	*How is it measured ?*	*Where is it measured ?*	*How often is it measured ?*	*By whom is it measured ?*	*Basis for sanction ?*
Recycling achievements	Types of ***secondary*** materials recycled Quantity of secondary materials recycled	Zone inspection reports Records from sales of ***recyclables***	Service zones Records from service provider	Monthly	Assemblies	No
Environmental controls	Exhaust emission control of vehicles ***Sump tank*** control of leakage from wastes in vehicles Control of litter from vehicles Washing of vehicles	Vehicle emission inspection reports Zone inspection reports Complaints about vehicle emissions and litter	Service zones Records from service provider	Weekly	Assemblies Districts	Yes
Occupational health and safety controls	Use of gloves Use of respiratory masks Use of uniforms Tools on vehicle to load loose waste Annual medical checks Provision of vaccinations Control over size and weight of lifted loads Operational status of vehicle lights (night lights, brake lights, and reversing lights) Number of accidents Adequate accident liability coverage (insurance)	Zone inspection reports Survey of workers Medical records Accident records Insurance policies	Service zones Records from service provider	Weekly	Assemblies	Yes
Fair labor practices	Wages paid - minimum or above Payment for overtime Medical expenses coverage Vacation and holiday allowances Adequacy of work breaks Proper hiring and justifiable termination procedures	Zone inspection reports	Service zones Records from service provider	Monthly	Assemblies	Yes
Hazardous waste segregation	Refusal to collect ***hazardous*** waste Provision of special collection for household hazardous waste	Zone inspection reports Inspection of loads at disposal sites	Service zones Disposal sites Records from service Provider	Monthly	Assemblies Districts	Yes
Fuel consumption	Fuel records showing consumption – per kilometer and per tonne Maintenance records on engine calibration Route rationalization	Vehicle log books Workshop vehicle records Zone inspection reports Route plans	Service zones Records from service provider	Monthly	Assemblies	No

Performance measures	*What is measured ?*	*How is it measured ?*	*Where is it measured ?*	*How often is it measured ?*	*By whom is it measured ?*	*Basis for sanction ?*
Reliability	Downtime of vehicles Number of accidents Worker strikes Absenteeism, illness and accidents of workers	Vehicle log books Workshop's vehicle records Medical records	Service zones Records from service provider	Monthly	Assemblies	No
Communi-cation	Notification of service problems Continuous radio accessibility Use of designated routes so vehicles can be located	Correspondence files Zone inspection reports Radio functioning between all trucks and central offices Adherence to route plans	Letters from service provider	Monthly	Assemblies	No
Finance	Payment of government property, income, VAT, and corporate taxes, etc., as required Regular payment of fair wages and benefits to workers	Financial records Reports of independent auditor	Records from service provider	Yearly	Assemblies	Yes

Performance Monitoring Measures for Solid Waste Landfill Operations

Performance measures	*What is measured ?*	*How is it measured ?*	*Where is it measured ?*	*How often is it measured ?*	*By whom is it measured ?*	*Basis for sanction ?*
Quantity of waste received for landfill	Waste quantity per shift Waste quantity per day	Landfill inspection reports Landfill records Vehicle log books Zone inspection reports	Landfill	Daily	Assemblies Districts	No
Construction of landfill base according to design	Compaction of base soils at optimum moisture Slope of base soils Placement and sealing of impermeable ***liners*** Placement and slope of ***leachate*** collection system	Survey instruments observed to be used during construction Construction inspection reports	Landfill	During construction	Assemblies	Yes
Construction of landfill cell according to design	Daily delineation of ***working face*** boundaries Survey of coordinates and elevations of daily ***cell*** construction, including slope of working face Continuous on-site availability of design drawings and O&M manual Closure of cell when final design elevation is reached Respect of maximum angle for side slopes Respect of minimum requirement for base slopes	Survey instruments observed to be used daily Marking up of daily progress in cell construction on design drawings Topographic survey map of completed cell area when final design elevation is reached	Landfill	Daily	Assemblies	Yes

Performance measures	*What is measured ?*	*How is it measured ?*	*Where is it measured ?*	*How often is it measured ?*	*By whom is it measured ?*	*Basis for sanction ?*
Adequacy of internal access roads	Roads free of waste Roads usable in all weathers Adequate drainage to keep roads free of flooding	Vehicle log books (Operational delays of collection vehicles at landfill) Landfill inspection reports	Landfill	Daily	Assemblies Districts	No
Cleanliness of access routes to landfill	Litter Clandestine waste piles Waste in drains Improperly placed waste bins	Zone inspection reports	Service Zones	Daily	Assemblies Districts	Yes
Residents' and private haulers' satisfaction with landfill	Perception about environmental acceptability of landfill operation Willingness to pay Willingness to participate with service requirements	Surveys of customer satisfaction Surveys of willingness to pay	Area around landfill All haulers	Semi-annually	Assemblies Districts	No
Residents' dissatisfaction with landfill	Complaints about landfill noise, dust, odor, traffic, appearance and increase in ***vectors***	Inspection reports Records of complaints	Area around landfill	Monthly	Districts	Yes
Private haulers' dissatisfaction with landfill	Complaints about landfill noise, dust, odor, traffic, appearance Complaints about delays suffered by collection vehicles at landfill, damage to vehicles and tires, inappropriate tipping fee charges, operation of ***weighbridge***, difficulty in driving to working face	Inspection reports Records of complaints Records of follow-up to complaints	All haulers	Monthly	Assemblies	Yes
Worker productivity	Number of workers in service Waste quantity per worker and shift Absenteeism	Landfill inspection reports Records at landfill	Landfill	Weekly	Assemblies	No
Equipment productivity	Number of equipment units in service Waste quantity per equipment unit each shift Waste quantity per equipment unit each day Equipment downtime	Landfill inspection reports Records at landfill	Landfill	Weekly	Assemblies	No
Recycling achievements	Types of ***secondary*** materials recycled Quantity of secondary materials recycled	Landfill inspection reports Records from sales of recyclables	Landfill	Monthly	Assemblies	No

Performance measures	*What is measured ?*	*How is it measured ?*	*Where is it measured ?*	*How often is it measured ?*	*By whom is it measured ?*	*Basis for sanction ?*
Environmental controls	Control of equipment exhaust emissions Windblown litter Dust Noise Control of area of ***working face*** Daily compaction of deposited waste Use of adequate daily cover at the end of each day's work Washing of equipment Flies, rodents, birds Leachate treatment and discharges Control of landfill gas Drainage of surface water – adequacy and maintenance Presence of unauthorized people or animals Presence of ***hazardous*** wastes Recording of all collected waste loads Provision and maintenance of an attractive vegetative ***buffer*** around operational areas	Equipment emission inspection reports Landfill and area inspection reports Complaints about emissions, noise, dust and litter Fly count, rodent count, bird count Pesticide application records Size of daily refuse cell Monitoring of ***leachate*** treatment plant discharges Groundwater and surface water monitoring Monitoring of landfill gases Records of incoming waste loads	Landfill and surrounding area	Weekly	Assemblies Districts	Yes
Hazardous waste segregation	Refusal to accept industrial or commercial hazardous waste Provision of special collection and storage area for household hazardous waste	Landfill inspection reports Inspection of loads at disposal sites	Landfill Disposal sites Records from service provider	Monthly	Assemblies	Yes
Fair labor practices	Wages paid - minimum or above Payment for overtime Medical expenses coverage Vacation and holiday allowances Adequacy of work breaks Proper hiring and justifiable ***termination*** procedures	Landfill inspection reports Survey of workers	Landfill Records from service provider	Monthly	Assemblies	Yes

Performance measures	*What is measured ?*	*How is it measured ?*	*Where is it measured ?*	*How often is it measured ?*	*By whom is it measured ?*	*Basis for sanction ?*
Occupa-tional health and safety controls	Use of gloves and boots Use of respiratory masks Functioning air conditioning on all equipment units Adequacy of roll-bars Replacement of filters on air conditioners Use of uniforms Annual medical checks Provision of vaccinations Control over size and weight of lifted loads Number of accidents Health and safety training of all landfill personnel Practice of emergency and evacuation procedures Continuous presence and function-ality of fire protection and other emergency equipment Continuous on-site presence of health & safety manual Posting of health & safety telephone numbers Adequate accident liability coverage Operational night-time illumination Reversing lights and audio signals on all equipment	Landfill inspection reports Survey of workers Medical records Accident records Inspection of equipment units Insurance policies	Landfill Records from service provider	Weekly	Assemblies	Yes
Fuel consumption	Fuel records on consumption – per hour and per tonne Maintenance records on engine calibration	Equipment log books Equipment maintenance reports	Landfill Records from service provider	Monthly	Assemblies	No
Reliability	***Downtime*** of equipment Number of accidents Number of slides, erosion events Worker strikes Worker illness and accidents	Equipment log books Landfill inspection reports	Landfill Records from service provider	Monthly	Assemblies	No
Communica-tion	Notification of service problems Continuous accessibility by radio	Correspondence files Landfill inspection reports Radio functioning between landfill and central offices	Letters from service provider	Monthly	Assemblies	No
Finance	Payment of government property, income, VAT, and corporate taxes, etc., as required Regular payment of fair wages and benefits to workers	Financial records Independent auditor reports	Records from service provider	Yearly	Assemblies	Yes

Appendix L- Evaluation and Diagnosis

Background

The monitoring and evaluation of the solid waste management program include detailed recording and assessments of the day-to-day operations. It is important to consider all costs incurred, and what category they fall in to. This is important to assess where resources need to be allocated, or conversely, where program changes might be able to reduce costs.

Secondly, both qualitative and quantitative evaluations of the working of the system need to be made. The assessment of the success of the ISWMP depends upon records of the amount of solid waste collected, frequency of collections of both secondary and primary secondary waste points, cleanliness of the various parts of the systems, and general effectiveness of the program.

Monitoring and Evaluation spreadsheets required would include as a minimum:

- Monthly Landfill Operations: Costs and Evaluation
- Monthly Secondary System: Costs and Evaluation
- Monthly Primary Collection: Costs and Evaluation
- Monthly Primary Storage: Costs and Evaluation

The costs and evaluations information needs to be recorded on a daily basis and turned in to the MSW manager on a weekly basis. The manager should summarize the monthly information and prepare a report to the Mayor on a monthly basis.

Steps in Implementation

A ISWM Plan needs to be flexible and capable of modification and adjustment. Over time, plans need to take into account external influences such as availability of funding and resources and interaction with other areas of Municipality activity and policy. The plan must also be strongly managed to ensure successful implementation.

The action plan should focus a short-term action plan and a longer ten year action plan period. The short-term action plan could be based on a 12-month period with two streams of activity.

- Immediate actions which are required to ensure progress could be made during the first year of the strategy;
- Building for the strategy which will involve a period of consensus building with the aim to bring to politicians firm proposals for implementation of the long term strategy;

Implementation of the ISWM plan is likely to require the responsible authority to adapt its structure and resources to suit changing managerial requirements as ISWM projects are developed. Having developed the plan, the process of practical implementation must begin and it is important that the Municipality follows through a logical sequence of steps to ensure successful implementation.

There are a number of examples of good practice that will aid implementation of ISWM plans, particularly for municipal solid waste agencies in low-income countries where comprehensive technical and institutional approaches have not previously been implemented. These include:

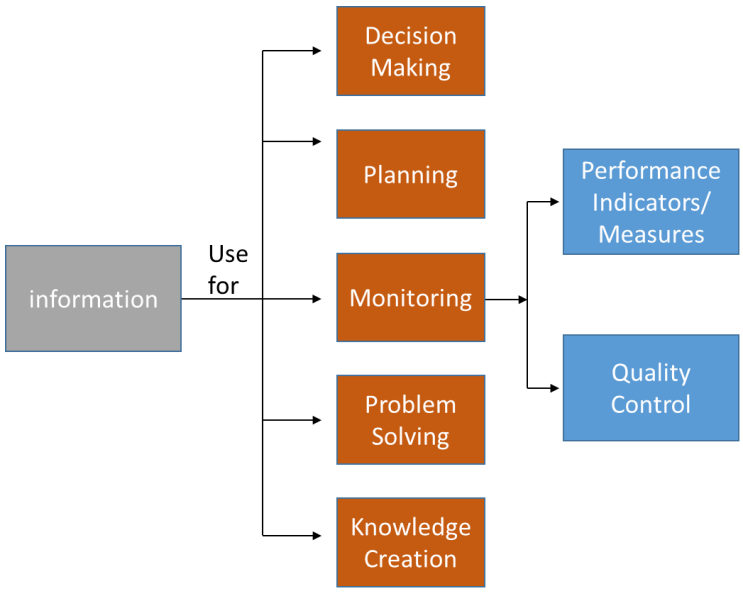
- Communication and evaluation is vital between the Municipality and donor agencies, supervising consultants and among on-the-ground parties in the project are. In many cases inadequate communication and consultation cause project delays.

- Particular attention needs to be paid to the writing of procurement specifications for vehicles and equipment. The need to select appropriate MSW collection vehicles and other equipment has previously been reviewed.
- It is important a solid waste management expert or Working Group (Reporting to the ISWM Committee) is assigned to the implementation stage of the plan. Where the plan involves implementation of a number of technical projects (e.g. development of transfer stations and landfill sites) it may be appropriate for an expert to be on hand at each project location. The expert (or project officer) may well be assigned to the project area for periods of up to several years. In this way continuity is guaranteed between the project planning and project implementation stages.

The process of ISWM action plan implementation must be monitored and regularly reviewed in order to identify weaknesses in the program and to identify actions to update the process. The following sections discusses this aspect of plan evaluation using indicators and measures of ISWM performance and with reference to specific worked examples of implementation monitoring.

Performance Monitoring For Solid Waste Management Services

Throughout this Plan the need for collecting and utilising information has been stressed. Large amounts of data are being collected and processed into useable information. But it has to be kept in mind that information *per se* is only valuable when it is focused and being used to a specific end. The diagram below shows the various possible uses of information.



- **Figure Use of Information**

Why Improve Performance Monitoring?

The monitoring tools frequently used to assess performance of the ISWM system are, among others,

- visual observations;
- general feed-back from the work force; or
- customer complaints.

Such observations can lead to inaccurate and unquantifiable results and present an insufficient basis for making planning decision for system improvement. Additionally, at first sight seemingly obvious reasons for an unsatisfactory performance of a ISWM function, may, through a more detailed and formal analysis, turn out to not be the reasons at all for the problems.

Lack of funds, for example, is often seen as the reason for low performance of components of the ISWM system in a Municipality. A detailed analysis might reveal that performance could be much improved through improved routing, staffing, more effective management or use of alternative vehicles. An improved planning process, also, will most likely lead to increases in effectiveness and efficiency of the service.

Monitoring the performance of a municipal ISWM system has a number of goals:

- To closely observe the quality of the ISWM service provided in order to maintain or improve service quality;
- To encourage the efficient use of available resources;
- To relate the outputs of a service to inputs (and ultimately their cost);
- To improve service quality overall and relative to cost;
- To enforce accountability of service providers;
- To put downward pressure on cost of service provision;
- To compare and assess services provided against the targets set out in municipal ISWM plan;
- To provide information on which management can make policy and management decision about the service;
- To compare the service provided between two or more sub-municipalities or municipalities in a regional association;
- To compare the quality of service provision in a Municipality with a previous month or year;
- To monitor and evaluate the quality of services provided by private service contractors.

Performance analysis is a key element in the process of providing good quality, value-for-money services. It is a process by which the efficiency of a service can be monitored and compared with similar services offered elsewhere or at an earlier time. Performance review needs to be an integral part of any ISWM process.

The two central questions of ISWM performance monitoring are:

- How effective is the ISWM service that is being provided? Meaning: To what extend does the system presently in place satisfy the need for a ISWM service and where is improvement required?
- How efficient is the ISWM service provided? Meaning: Are we using the available resources in the best possible way and how can we improve their use?

Effectiveness and efficiency are closely related, increases in efficiency lead in most scenarios to increases in effectiveness, provided resources are not cut simultaneously.

In summary,

- we need to know whether we use our money, people and equipment in the best possible way to serve the greatest amount of customers at the highest possible standards, and
- we need to know where the weak points in our present system are to enable us to take steps for implementing improvement.

Definitions of Performance Indicators and Measures

In order to determine the performance of a municipal solid waste management system in general, and its individual components in specific, data and information called “performance indicators” and “performance measures” of ISWM are used.

Performance Indicators– are quantitative data related to ISWM services such as:

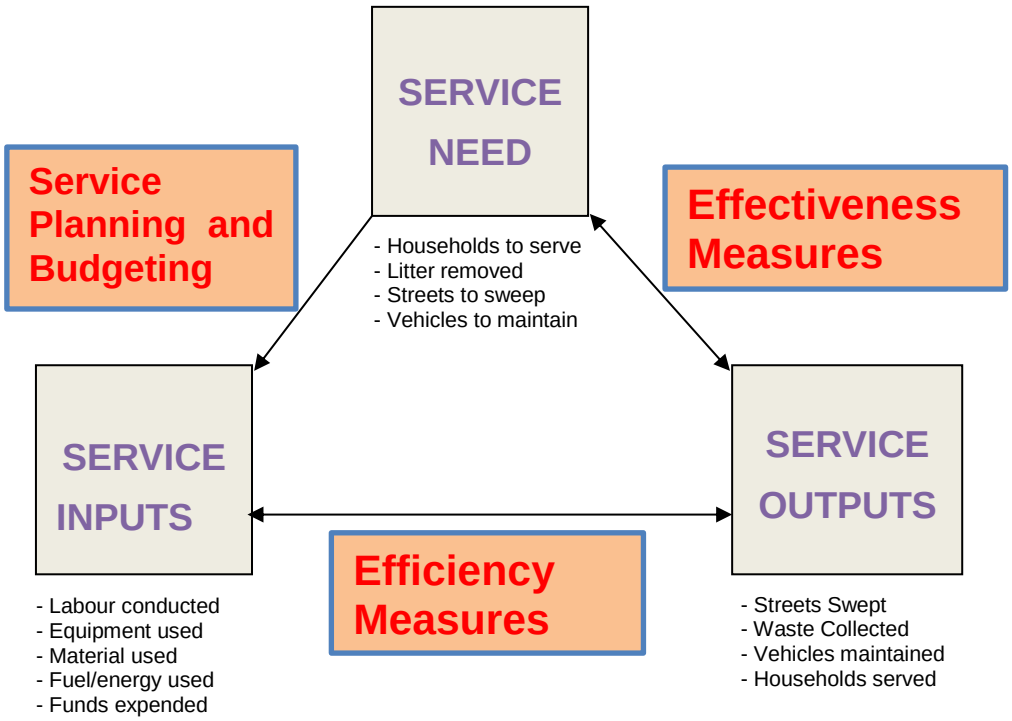
- Number of businesses to be served,
- Kilometres of streets to collect from, or
- Number of employees in service.

Performance Measures– are the result of processing indicators, by relating them to either time or cost, and are the principle tool for assessing the performance of the system under review. For example:

- Cost per ton disposed;
- Number of streets swept per hour etc.

In order to obtain reliable performance measures, the following is needed:

- Accurate, reliable and regular data collection;
- Accurate and reliable cost accounting procedures;
- Weighing of wastes;
- Availability of service operating detail;
- Units to which the performance indicators can be related (e.g. costs per 1000 of population served, costs per household served, time per tonne of waste collected etc.)



- **Indicators and Performance Measures**

Performance Indicators and Measures for ISWM System Analysis

While there are a number of specific performance measures that can be used to assess the individual functional elements or any ISWM system, there are also measures that help gauge the overall performance of the ISWM sector.

As with the performance measures especially focusing on particular functional elements of the system, these general sector performance measures have to be compiled at regular intervals and then be compared over time to enable planners to monitor and detect positive and negative trends in the sector. If for example the billing index (Billing index (%): Number of commercial premises that receive bills divided by number of premises served multiplied by 100) goes down steadily over time, this could be the signal for the ISWM department to revisit the existing billing system for commercial/industrial waste and find ways of improving it.

The following is a summary overview of performance, management and general measures related to ISWM.

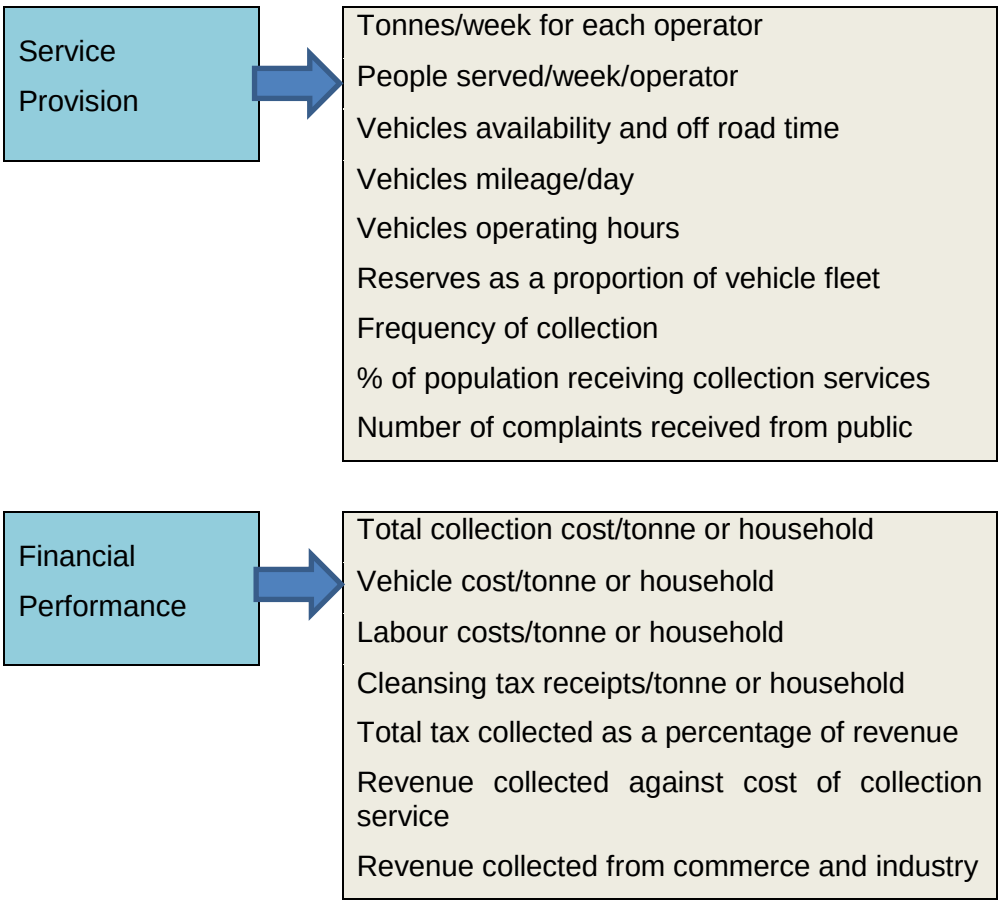
- Overview **of performance, management and general measures related to ISWM**

Issues	Indicator
Health	Morbidity and mortality rates due to illnesses related directly or indirectly, with solid wastes, such as, cholera, tetanus, dengue fever, teniasis, hepatitis etc., by urban and peri-urban zones.
Economy	Number of workers employed in the solid wastes sector.
	Number of large, middle, and small companies involved in urban sanitation (fabrication of mechanical equipment, contracting firms of urban sanitation, recycling industries, consulting agencies, maintenance shops, and others)
	Weight percentage of solid wastes recovered over the total of solid wastes generated.
	Increase in the number of tourists relative to the previous year.
Environmental Conditions	Weight percentage of SW collected over SW generated.
	Weight percentage of SW properly disposed over SW collected.
Social Conditions	Percentage of peri-urban population provided with collection services over total peri-urban population.
	Annual increase/decrease in separators in final disposal (last 5 years).
	Number of community health education programs.
Solid Wastes Generation	Per capita production (kg/person/day): Total tonnage of solid wastes collected per day divided per thousand served.
Recovery	Tonnage of solid wastes recovered per day divided by tonnage of solid wastes generated per day multiplied by 100.
Coverage and Access to Urban Sanitation Services	Urban collection: Urban population served divided by total urban population multiplied by 100.
	Peri-urban collection: Peri-urban population served divided by total peri-urban population multiplied by 100.
	Urban composition: Peri-urban population divided by total urban population multiplied by 100.
Management, Operation and finance:	Number of employees of sanitation service per thousand persons served.
	Rate or tariff of urban sanitation monthly average per home, in Afghs.
	Payment capacity: minimum monthly rate or tariff of urban sanitation versus income or monthly minimum salary (%).
	Budget of sanitation service versus total municipal budget (%).
	Capital investments versus total budget of urban sanitation service (%).
	Income generation through tariffs and rates versus total cost of the service (%).
	Efficiency of collection (%): Value collected divided by value billed multiplied by 100.
	Unit cost of sanitation service (Pesos/ton): Sum of all direct annual costs, indirect costs, social benefits, contract payments, financial costs, depreciation and others divided by tonnage received bat site of final disposal per year.
Other Recommended Indicators:	Coverage of street sweeping (%): length of paved streets swept divided by the total length of paved streets multiplied by 100.
	Efficiency of collection equipment maintenance (%): Total equipment divided by number of equipment in operation + reserve equipment + equipment in maintenance multiplied by 100.
	Number of bills paid per month versus total number of bills issued per month multiplied by 100.
	Billing index (%):

Performance Measures for SW Collection

Examples of performance measures for collection services are shown below. A comprehensive listing is also provided of the basic data that any Municipality department wanting to measure the performance of its collection service can use, and the recommended frequency of data collection for each specific item.

All of the indicators highlighted can be used to compare performance on a year-by-year basis within the Municipality and with other similar municipalities. However, the validity of any of these approaches depends on the availability and accuracy of the authority's information management system, and its ability to provide reliable cost and revenue information, and basic data on waste tonnage, or other measures of service provided. Also, comparisons of performance must take into account local geographic or industrial conditions and the standards of service provided.



- **Main Performance Measures for the ISWM Collection Service**

- **Data Collection Requirements for Municipalities to Compile and Report Performance of the Solid Waste Collection Services**

		Recommended Frequency of Data Collection
	Overall Service Provision	
1.	Tonnage collected – weighed or estimated vehicle loads	daily
2.	Population or number of households in area of Municipality waste collection responsibility	yearly
3.	Population or number of households actually collected from	yearly
4.	Frequency of collection services by type, domestic, commercial, clinical etc.	yearly
5.	Number of vehicles in Municipality fleet by type, size, age, make, registration number	monthly
6.	Name of person responsible for solid waste collection service	yearly
7.	Management structure and numbers of persons involved in collection service designated: collection: administration: maintenance	yearly
8.	Number of complaints received from public; nature of complaint and action taken	weekly
	Operational Information	
1.	Number of collection vehicles operating and total vehicle hours worked	daily
2.	Number of persons operating collection service designated: collection administration; maintenance	daily
3.	Vehicle operational records by daily driver worksheet: • Identification of vehicle and driver • Vehicle hours working • Vehicle mileage covered • Vehicle fuel used • Number of vehicle trips to disposal sites • Number of operating personnel in vehicle crew.	daily
4.	Vehicle operating costs by maintenance log for each vehicle: • Identification of vehicle • fuel and oil • tires • routine servicing • maintenance and repairs, recording description, cost and time to complete: • engine and transmission and brakes, hydraulic systems chassis and suspension, body work and glass, other	weekly
	Financial Information	
1.	Vehicle operating costs by vehicle and by fleet	monthly

2.	Labour costs: payroll plus overheads, consumables etc.	monthly
3.	All other solid waste collection department costs	monthly
4.	Total costs presented as full cost of the collection operation: • per ton of waste collected • per person/household served • per number of persons employed in solid waste collection	yearly
5.	Revenues collected from Tax	Twice yearly
6.	Revenues collected from commercial and industrial waste producers • As a total sum • As a revenue per ton collected	Twice yearly

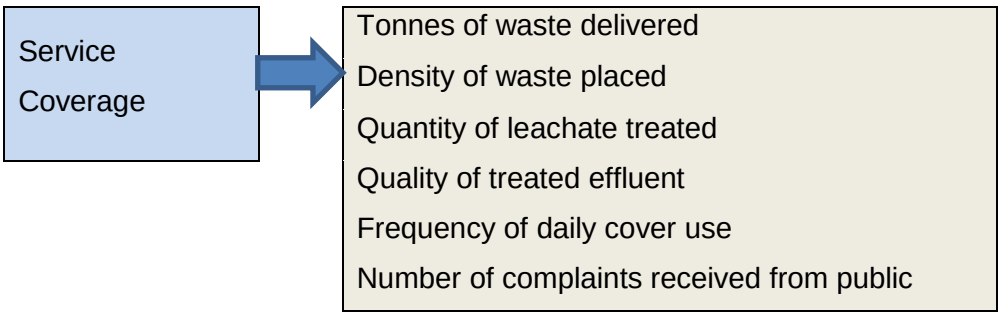
Assessment of Solid Waste Disposal Services

Disposal operations should also be monitored to ensure that manpower and other resources are efficiently and effectively managed at all sites.

Efficiency is again measured by computing unit costs for each operation. However, as with all performance measures, care must be taken to ensure that comparisons are made on a consistent basis. As with collection, the reliability of all performance measures depends on the quality of the information on which they are based: for example, weighing of wastes is essential. Comparisons must be made on a consistent basis, taking into account any geographical or other differences between sites.

It must be remembered that in many countries, current disposal costs are negligible due to the prevalence of open dumping practices. As such, higher operating costs are essential if services are to improve.

The main performance measures for assessing disposal services are highlighted below.



- **Main Performance Measures for the ISWM Disposal Service**

The following Table provides more detail on this issue.

- **Data Collection Requirements for ISWM Disposal Services**

		Recommended Frequency of Data Collection
	Overall Service Provision	
1.	Disposal site locations and type of operations; landfill, incineration, recycling plant etc.	yearly
2.	Tonnage received-weighed or estimated vehicle loads and by waste type and by collection authority: • Domestic • Domestic and commercial • Commercial only • Clinical • Industrial – what type of waste and origin	daily
3.	Vehicles equipment and plant utilised in disposal operations by type, size, age, make, registration number	monthly
4.	Name of person responsible for solid waste collection services	yearly
5.	Management structure and numbers of persons involved in disposal service designated	yearly
6.	Number of complaints received from public: nature of complaint and action taken	weekly
7.	Environmental management at landfill and transfer station sites: pollution incidents, breaches of license conditions, remediation actions, frequency of environmental monitoring	weekly
	Operational Information	
1.	Number of vehicles or equipment operating and total vehicle or equipment hours worked	daily
2.	Number of persons operating disposal or MRF services designated operational administration maintenance	daily
3.	Vehicle or equipment operational records by daily driver worksheet: • Identification of vehicle or equipment and driver • Vehicle or equipment hours working • Vehicle or equipment hours in-operational for maintenance • Vehicle or equipment fuel used	daily
4.	Vehicle or equipment operating costs by maintenance long for each vehicle: • Identification of vehicle or equipment • fuel and oil • tires or tracks • routine servicing	weekly

	• maintenance and repairs, recording description, costs and time to complete: engine, transmission, brakes, hydraulic systems, chassis, suspensions, bodywork, glass, other.	
5.	Leachate management installed on site: • Quantity produced per day – estimated or measures • Type of treatment or disposal • Costs of operation	yearly monthly
6.	Cover material used on site: • how often spread over waste • estimated volume of material used	yearly
7.	Recycling and resource recovery systems and programs in operation by Municipality or private sector materials recovered and method of recovery	yearly
8.	Transfer stations and bulk transportation operations Type, number of vehicles, tonnage transported and mileage covered	yearly
9.	Is there a weighbridge in consistent use at the landfill sites: Records kept of tonnage of waste being disposed.	yearly
	Financial Information	
1.	Plant operation costs for each site	monthly
2.	Labour costs: payroll plus overheads, consumables, etc.	monthly
3.	All other solid waste disposal departmental costs	monthly
4.	Total costs presented as full cost of the disposal operation: • per ton of waste received • per person/household served • per number of persons employed in solid waste disposal	yearly
5.	Revenues from municipalities using disposal service (proportion of Cleansing Tax)	twice yearly
6.	Revenues from receipt of commercial and industrial wastes	monthly
7.	Revenues or grants from any other sources	twice yearly
8.	Revenues from recycling and resource recovery operations	monthly
9.	Transfer and bulk haulage costs if applicable	monthly
10.	Capital repayments on loans for solid waste management projects specify	monthly

Dealing with Information: Management Information System (MIS)

As discussed above, in order to move a waste management system to better performance by increasing its efficiency and effectiveness, the system currently in place has to be assessed and then be continually improved through planning and operational management processes.

A significant part of the resources problem that confronts local government stems from a lack of concern and knowledge about costs, quality and accountability. These problems

stem, in part, from the inefficient use of existing resources, and used more efficiently, the same resources could provide better and more comprehensive services. With more, or better-used, information on the ISWM system, its inefficiencies can be removed or diminished. The tool to use to this end is called a Management Information System.

A Management Information System (MIS) is defined as a system in which information is collected, stored, organised, processed, utilised and disseminated.

A MIS is an on-going process, requiring a regular stream of data to be collected and fed into it. It also requires a medium for storage and processing data.

Benefits of a functioning MIS include:

- Though the provision of accurate, relevant, comparable and up-to-date management information, resources can be costed and matched against outputs delivered;
- Annual budget proposals can be made on the basis of actual needs, taking account of changes in service characteristics, costs and revenues;
- Overall revenue requirements can be better established and politically and socially acceptable charging schemes be devised;
- Revenue collections can be improve through better mobilisation of resources;
- Financial performance can be monitored against objectives;
- Investment planning and decision making procedures can be improved; and
- Information about the total cost and cost effectiveness of service provision give the ISWM department a basis to judge performance on a comparative basis against specified criteria, and gives a guide to future investment requirements.

The collection of management information is not an end in itself. Performance indicators must provide signals for action. Data gathering is a costly and time consuming exercise and if the following basic points are not considered in detail before the data gathering begins, it is possible to end up with large amounts of data, that are either unnecessary or cannot be interpreted.

There are different reports needed that summarise the result of performance measuring. For general planning purposes, and as a basis for updates of the ISWM plan, annual or bi-annual summary reports will be sufficient.

At the other end of the scale, routine management reports will be needed for upper level ISWM managers on a weekly or monthly basis, while operational managers will need daily indication of the progress of general operations.

In summary, as the Municipal support systems improve, the ISWM data should be placed on the MIS.

Revising and Updating the ISWM Plan

The process of ISWM plan review should be regularly undertaken in a planned and scheduled fashion. A regular review of the progress with implementation of the action program is necessary to ensure that targets are being met in terms of service delivery, financial performance et.

The action plan needs to be flexible and there may be a need for the implementation program to adapt to changing circumstances and conditions, such as, for example, changes

in the waste stream (e.g. through increased affluence), development of new technologies to treat and dispose of waste, or institutional changes.

A program of regular review can help to increase the Municipality's knowledge and understanding of the ISWM system through a process of interactive review, problem diagnosis and development of remedial action programs.

Appendix M – Local Legislation Summary

MCDC
Environmental Conservation and Cleansing
Regulations

Sept, 24, 2009

Chapter One
Name and Definition

1. This regulation shall be called MCDC Environment Conservation and Cleansing Regulation.

2. The following words shall have the meaning as follow.
(a) Environmental conservation means
- carrying out conservations, in order not to occur contamination and pollution in the **watershed areas** of MCDC owned ponds and lakes and all the spheres of land, air and water of the city's natural environment and not to occur noise pollution.

(b) to (t) definitions of ecological system, garbage, kitchen waste/ rubbish, garden waste, industrial waste, construction material waste, commercial activities waste, ordinary garbage, ditch and drain, nauseous things, hospital waste, corpse, burial, cemetery, crematorium, tomb, funeral shed, deportment, head of department.

Chapter Two
Environmental Conservation
3. MCDC shall require anyone (individual, organizations, communities) to make free from the risks of chemical materials, toxic materials and radioactive materials and designate disposal sites and disposal means (ways and means), in consultation with the concerned person, government departments and organizations.
4. MCDC shall require factories and industries to make arrangements, not to pollute the air by emissions of smoke, smell and any other thing, and not to make noise pollution.

5. MCDC shall instruct responsible persons from business activities, factories and industries, and hospitals and clinics, not to dump, dispose, scatter and flow hazardous fluids, nauseous things and hospital wastes.

6. MCDC shall instruct the user or the owner of dumping materials from business activities, factories and industries, to move to suitable places, should their materials pose environmental pollution, in some way.

7. MCDC shall instruct the owner or the user of any vehicle, not to emit so much fumes and exhausts, and not to make so much noise, which are unbearable to nearby residents.

8. Anyone who wants to dispose hazardous chemical materials, medicinal fluids and parts of human body, shall observe rules, ways and means, set by the MCDC, to do such disposal.

9. MCDC shall make arrangements and plans not to occur environmental contamination in wells, ponds, tube wells, ditch, drain and streams and rivers, by flowing into or infiltration or seepage, by wastes from economic activities, factories and industries and hospitals and clinics.

10. MCDC shall take action against anyone/ anything that cause environmental damage/ degradation/ and destruction.

11. MCDC, in the city limit,

(a) shall lay down plans and programmes that will lead to meeting the basic needs in qualified management, formation of technological associations, giving technical assistance and human resource development

(b) shall lay down plans and programme to construct and operate waste treatment centres, and waste disposal infrastructure

12. M.C.D.C -

(a) shall submit and report to respective ministry about the sanctioning to keep watershed areas, special ecological system and hazardous and fragile ecological system area, as environmental conservation zone

(b) shall keep and maintain invaluable areas or regions, for being importance in terms of culture and history, as environmental conservation zone

(c) can claim any area as environmental control and conservation zone, whenever any contamination or pollution led to environmental destruction, that poses threat and danger to the health of the people

(d) shall make announcements on the sanctioning of environmental conservations zones in order to make the people known.

Chapter Three
Cleansing of Garbage and Nauseous Things

15 – 18, cover responsibilities of MCDC for garbage collection and location of dump sites for different forms of waste and arrangements for collection and taking the garbage to the final disposal site.

19. Covers power to charge for service.

20. Covers responsibility of MCDC to protect health of citizens, including cleaning up dangerous substance occurring from natural hazards.
21. Residents in the city limit
(a) shall dispose garbage and nauseous things at the designated places by prescribed means.

(b) ordinary garbage shall dispose at the designated garbage cans, garbage tank and garbage dumping places.

(c) garden wastes, industry and factory wastes, construction wastes, business activities wastes, hospital wastes and nauseous things are to dispose at the designated places.

22 – 23. MCDC has to manage solid waste in such a way that it is in accord with environmental conservation.

24. MCDC can give permission to an individual or organization, the work of garbage collection, transportation, disposing, destruction and recycling and other sanitary works, as of contract or agent by means of bidding auction or tender system.

Chapter Four
Cleansing of Drains and Roads

25. MCDC can dispose water from its drains into **Ayeyawaddy river and Dotthawaddy river**, after the treatment of them, according to the set standard of treatment, in addition to disposal in the city and if dispose outside the city, prior coordination shall be done with the respective government departments and organizations.

26. Covers ensuring drainage work properly and can be filled if no longer required.

27. Gives permission to developers to change the flow of drainage so long as it has been evaluated beforehand and found satisfactory

28. Covers powers of MCDC to require drainage system to be constructed for storm water drainage and domestic water.

29. For the good drainage and flow, MCDC have the right to construct drains and ditches, that pass through the private property of someone. **If necessary, it can go to acquire and confiscate it, in accordance with the existing law**.

30-33. Covers responsibility of MCDC with regards to cleansing of roads and vegetation growing in road ways, including spittoons.

Chapter Five
Collection of Cleansing Dues and Fees
33-37 Covers the right of people to dispose on condition of making a payment to the MCDC

Chapter Six
Burial at the Cemeteries
38-43. Controls the burial of people, in designated areas but can follow their religion and beliefs.

Chapter Seven
Prohibitions and Taking Action

47. No one in the city limit
(a) shall dispose wastes of garden, factory and industry, construction, business activities, hospitals and nauseous things, except at the designated places.

(b) shall row, swim, fish, wash, bath, dig earth, wash vehicles and bath animals in the moat, water carrying canal to the moat, tanks connected to the moat water, and tanks owned by the MCDC.

(c) shall block and obstruct the flow, fill earth or divert the flow of canals, underground canals, naturally running flows, and canals.

(d) – (k) Restriction on removal of solid waste, restriction on disposal of industrial and other waste into rivers and water bodies, exhumation, cremation, morgues etc.

48. General application of all rules

49. Breach of rules will be punished by law.

Chapter Eight
Miscellaneous

50, Covers charitable status of funeral service work.

51. In implementing Mandalay City's environmental conservation and cleansing work, MCDC may lay down projects and plans to participate with government departments, organizations and NGOs and the people

52-54 Covers who can issue rules and regulations and how rules and regulations can be implemented and identifies responsibilities of head of department and power to delegate