Annex 5

Selection of the Best Technical System Scenario

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5 Selection of an Optimum Technical System Scenario

5.1 Selection of an Optimum Technical System

5.1.1 Selection Method

a. Criteria for Selection

Taking the current situation and background of SWM in the target area considerably into account, the policies for the selection of a technical system are as follows:

1) Technical system proposals have to contribute to the goal for the SWM master plan, "to create the closed loop society in solid waste".
2) The implementation of technical system proposals have to be afforded by the responsible municipalities in the target areas and to be justified in terms of national economy.
3) Technical system proposals have to be consistent with the institutional requirements which are outlined in the Chapter 6 to ensure their efficiency.
4) Systems and technologies to be adopted should be simple so that operation and maintenance would be easy and inexpensive.
5) The foreign currency requirements for the purchase, operation and maintenance of systems should be minimised. The use of locally available materials and services should be maximised.
6) Proposed technical system should be consistent with the existing conditions and existing practices, in order to easily cope with the system.

b. Selection Procedure of an Optimum Technical System

An SWM technical system consists of various technical subsystems such as discharge and storage system, collection and haulage system, street sweeping system, intermediate treatment system, final disposal system, etc. A number of alternatives can be formed from the combination of these various subsystems. Hence, selection of the optimum technical system was carried out according to the following procedures.

1) Examining preconditions for selection of subsystems
2) Identification of potential subsystem technologies for Adana and Mersin
3) Screening potential subsystem technologies
4) Selection of an optimum technical system

5.1.2 Preconditions for Selection of Subsystems

The important factors, such as preconditions, requirements, etc., to be kept in mind regarding the selection of an optimum technical system are summarised below.

a. Sites of Future SWM Facilities

The formulation of the optimum technical system was mainly influenced by the location and number of proposed SWM facilities' sites, especially disposal sites. Through site selection work conducted in the first study work in Turkey the future SWM facilities' sites were identified and agreed on the M/M (minutes of meeting) on the IT/R (Interim Report) as shown in the table below.

Table 5-1: Sites of Future SWM Facilities

GM / SWM Facility	Adana GM		Mersin GM	
	F/S Stage	M/P Stage	F/S Stage	M/P Stage
Final Disposal Site	Present Sofulu disposal site	Not identified	Cimsa site	Not identified
Resource Recovery Facility	Present Sofulu disposal site	Not identified	Cimsa site	Not identified
Transfer Station	Not identified	Not identified	Not identified	Not identified

b. Collection and Haulage System for Private Operators

At present most of district municipalities in the target area are contracting out their SW collection/transportation and public area cleansing services to the private enterprises. The privatisation of cleansing services is being encouraged by the central government. Private operators in principle independently choose the collection and haulage system they think is most suitable. Further, they usually have limited capacity and resources. Therefore, the collection and transportation systems of private operators are ordinary excluded from the SWM master plan. However, the collection and transportation systems adopted by these contractors is covered, in view of the needs that the public sector will promote recycling of SW and introduce separate collection system for it so that the governments will control/monitor and enforce the system to the private operators.

5.1.3 Identification of Potential Subsystems

The potential technical subsystems to be screened for Adana and Mersin are listed in Table 5-2.

Table 5-2: Potential Subsystems for SWM in Adana and Mersin

Technical Systems	Technical Sub-systems	Sub-system Components
Discharge and Storage	• Type of Storage Equipment	• Minor containers • Disposable containers • Medium containers • Large-bulk containers
	• Source Separation	• Mixed discharge • Separate discharge • Delivery by home-owner to drop-off centres
Collection and Haulage	• Collection Frequency	
	• Collection Method	• Mixed collection • Separate collection
	• Type of Collection Service	• Communal container • Block (Bell) collection • Curbside collection • Door-to-door collection
	• Collection Schedule	• Day collection • Night collection
	• Type of Collection Vehicle • Transfer Station	
Street Sweeping	• Cleaning Method	• Manual street sweeping • Mechanical cleaning • Vacuum cleaning • Flushing
Recycling	• Government Related • Private Sector Centred	
Intermediate treatment	• Incineration • Refuse Derived Fuel (RDF)	
	• Composting	• Centralised windrow composting • Centralised digester/windrow composting • Decentralised windrow composting
	• Biogas Production • Pyrolysis • Size Reduction • Mechanical and Manual Sorting	
Final Disposal	• Location of final disposal sites • Final disposal methods • Landfill structure • Level of sanitary landfill development and operation	• Cavities in a mining quarry site, flat land or valley • Sanitary or open dumping • Anaerobic, Semi-aerobic or aerobic • 4 sanitary landfill level
Maintenance of Vehicles and Equipment	• Preventive Service Workshop • Full Service Workshop	

5.1.4 Screening Potential Technologies

a. Collection and Haulage System

The storage, collection and transportation of solid wastes account for more than 60 to 80 percent of the total solid waste management system. Therefore, an understanding of the fundamental elements, which lead to an efficient and cost-saving option by decision-makers on solid wastes planning and management, is deemed to be indispensable. Nevertheless, the co-operation of the public, particularly in onsite separation is essential if environmental standards are to be maintained within the limited resources. It is important at this stage to examine the technical alternatives of onsite handling of wastes, collection and haulage systems.

a.1 Discharge and Storage

Waste is generated on a somewhat continuous basis. However, collection occurs intermittently, a few times a week or perhaps daily, depending on the quantity generated at a specific location and climatic conditions. Therefore, it is necessary to provide proper on-site storage for waste until it is collected.

Storage is quite important because it can have a significant effect on:

- Public health and aesthetic conditions.
- Subsequent functional elements such as collection.
- Public attitudes concerning the operation of the system.

In order to make collection easy and efficient, on-site storage of the solid wastes should be facilitated. Without proper temporary storage facilities, a substantial proportion of waste produced in the vicinity of cities is never being collected, and therefore; uncollected wastes are accumulated on open ground and on streets, and are thrown into water courses or blown away by wind, causing aesthetic problems.

Generally, on-site storage facilities or containers should basically fulfil the following requirements:

- They should be strong and durable.
- Easy to put in and take out solid waste.
- They should be moderate in size, light in weight and easy to carry.
- Secured from flies, rats and wild animals like cat and dogs.
- Preventive diffusion of odour.
- Preventive leakage of leachate.
- Easy to keep clean

Applications and limitations of containers used for the on-site storage of solid wastes are given in Table 5-3.

Table 5-3: Application and Limitations of Containers for On-site Storage

Container Type	Capacity (lit.)	Application	Limitation
Minor Containers (Plastic or metal containers, litter bins, etc.)	50 -150	Low-volume waste sources, houses, street litter, and parks.	Containers are not large enough to hold bulky waste, damages over time.
Disposable Containers (Plastic bags, paper bags)	50 -150	Households, institutions, commercial areas	Bag storage is more costly as it has to be leak-proof, if they are located on streets or curb-side torn and teased by animals
Medium Containers (Plastic or metal wheeled containers, drums)	150 -1000	Medium volume waste sources, commercial and residential areas	Initial cost are high as they require mechanical handling
Large-Bulk Containers (Skip containers, trailers, etc.)	1000 -5000 or up	Commercial and industrial areas, residential areas	Initial costs are high, requires smooth level surfaces.

The following are the 3 types of solid waste on-site storage methods commonly adopted in the study area:

- Household storage
- Communal storage
- Curb-side storage

a.2 Source Separation of Municipal Solid Waste:

Municipal refuse contains inherent values mainly; paper, glass, plastic, metal and putrescible materials. Recycling of these materials provides an opportunity to recover some of the inherent values in municipal solid wastes, particularly in the form of long-term energy and resource savings.

A material becomes a waste when the owner or the generator discards it without expecting to be compensated for its inherent value. Most of the local administrations consider wastes to be their responsibility and within their domain of ownership only after they have been placed on the curb or street for municipal collection and disposal.

Municipal solid waste recycling activities contend with mixture of materials. The more a waste mixed with others from various sources of generation, the more difficult it is to recover for reuse. There are a number of points in the waste management system, between initial waste discharge and ultimate waste disposal, where recycling can occur. Generally, the nearer to the origin of the waste that recovery occurs, therefore less sorting and processing will be needed before the material can be recycled.

Separation is a necessary operation in the recovery of reusable and recyclable materials from municipal solid waste. Separation can be accomplished either at the source of the generator or at waste recovery facilities. Depending on the separation objectives, a variety of waste recovery facilities can be developed.

Source separation of waste should be given importance when organic waste recycling schemes, such as composting and biogas production, are under planning. Composting and biogas production is a method to achieve microbial degradation of organic matter (kitchen waste, garden wastes, etc.), to produce a recycled organic product for use in agriculture, gardens, parks, etc. and methane gas in case of biogas production. Essential measure for achieving success organic waste recycling is that the waste is sorted into a “green fraction” (i.e., organic waste) and in a fraction that is not appropriate for organic waste recycling (plastics, glass, metals, etc.). Sorting may be conducted at a central composting or biogas production plant (which would require mechanical equipment as well as manual sorting with due consideration of workers’ hygienic conditions) and/or **at the source** (i.e., at the residences).

Waste separation at the source is usually accomplished by manual means. It is mainly not a technical but an organisational way of resource recovery. The number and types of components separated depend on the waste diversion goals established for the program. Even though waste materials have been separated at the source, additional separation and processing will usually be required before the materials can be reused or recycled.

Source separation can be accomplished mainly in two methods:

- Source separation by plastic bags
- Source separation by containers

The most accurate and economical method for source separation of recyclables is to separate the waste in plastic bags. For storage purposes single bag or multi-bag systems can be used. It is important not to mix the organic matter with the recyclables to avoid contamination of recyclable materials during source separating process.

Collection of source separated materials can be achieved by three ways:

- Separate collection
- Mixed collection
- Delivery by home-owners to drop-off centres

Separate collection and mixed collection can be achieved by conventional or specially designed collection vehicles from curbside where source separated recyclables are stored.

a.3 Collection and Haulage

The term “collection” is to provide a means of regulatory gathering or collecting all those solid wastes generated by the society. It is also to provide the means hauling all those wastes to the location where the contents of the collection vehicles are emptied for further transfer or for treatment or disposal.

In solid waste planning and management, equipment selection and crew size determination should not be made until decision have been reached on level of service, e.g., type and frequency of collection, means used for onsite storage, etc. Based on these decisions, preliminary selection of vehicle and crew size can be made. However, other local factors will also effect the final choice, e.g., round trip time to the disposal site/ processing facility, street width, housing density, amount of waste collected, payload regulations, etc.

a.3.1 Collection Methods

There are four basic types of collection methods employed in the waste management system:

- Communal container collection
- Block (bell) collection
- Curbside collection
- House-to-house collection

i. Communal Container Collection

The organisation of refuse collection is greatly simplified by the use of large communal storage units. Communal containers are provided where communities deposit their wastes. The collectors just collect the refuse from these locations.

Communal collection is suitable for market areas, commercial centres and apartment blocks and flats. It is also employed in the residential areas, where the waste amount is essentially high. In such areas there is a disadvantage of using communal container collection system of which the containers are widely spaced and the residents are unwilling and too lazy to carry the waste to the communal storage point.

ii. Block (Bell) Collection

A collection vehicle serves definite routes and stops at every street intersection where a bell is rung to inform the residents of the entire street leading to the intersection. Residents bring their waste bins, bags or containers to the vehicle and hand them to the crew to be emptied.

It is not easy to synchronise the collection due to the delays caused by the residents. If the collection frequency is not daily (i.e., 2 day intervals), this system can be applicable due to the minimisation of operational costs. It can also be advantageous due to the minimal crew size of not more than 2-man crew.

iii. Curbside Collection

Under the curbside collection system, residents are advised to place the bins/drums/containers on the verge outside the house only during the period when curbside collection is expected. Standard containers are encouraged for the ease and efficiency of the collection.

The disadvantage of the system is, scavengers often sort through the containers and scatter the contents around, bins are found stolen too.

iv. House to House Collection

Under this system, the householder does not work. The collector enters to the garden or courtyard, carries the bin to the vehicles, empties it and returns it to the usual place.

This system is costly in terms of labour because of the high proportion of working time spent walking in and out of premises and from one dwelling to the next.

Storage and collection are separate operations but must be closely co-ordinated. The type, size and location of containers are very important factors in determining the most efficient collection system. Large public containers are favourable in terms of maintaining public health and aesthetic conditions but difficult to load manually. Small containers are quite convenient for loading waste but reduce waste collection efficiency because they require more frequent stops for loading.

a.3.2 Frequency of Collection

The frequency of collection is a very important factor to be considered in solid waste management as it determines the overall cost. The factors influencing the frequency of collection are:

- **Waste Characteristics :** For non-putrescible waste a once a week collection is sufficient if there is enough storage possibilities. This is very much appropriate for source separated materials. More frequent collection is desirable for vegetable-putrescible (compostable) matters.
- **Climate :** Hot, moist conditions may accelerate decomposition of wastes, so under these conditions daily collection should be preferable, by using covered receptacles. Separated wrapped putrescible (compostable) wastes in plastic bags may permit less frequent collection. Cool climates usually permit less frequent collection.
- **Public Activities :** The activity of human-beings, consumerism greatly affect the waste generation rates. During holidays it is anticipated that more wastes are generated and more frequent of collection or bigger container capacities are required.
- **The Weight of Container Contents:** Large containers (heavy wastes) may reduce the frequency of collection as an additional crew member is needed to help to lift the container or full mechanised lifting devices are needed.
- **Storage Capacity:** Limitations in storage capacity may require more frequent collections, frequent than may be justified by other factors. In general, the aim should be for the storage capacity to be sufficient to accumulate the waste between collections without overspill or congestion.

a.3.3 Collection Routes

The collection routes form an integral part of solid waste collection system. Once equipment and labour requirements have been determined, collection routes must be laid out so that both workforce and equipment are used effectively.

In general, the layout of collection routes is a trial-and-error process. There are no fixed rules that can be applied to all situations.

However, the following factors could be taken into consideration when laying out collection routes:

- Wherever possible, route should be laid out so that they begin and end near arterial streets, using topographical and physical barriers as route boundaries.
- In hilly areas, routes should start at the top of the grade and proceed downhill as the vehicle becomes loaded.
- Routes should be laid out so that the last container to be collected on the route is located nearest the disposal site.
- Wastes generated at traffic-congested locations should be collected as early in the day as possible.
- Sources at which extremely large quantities of wastes are generated should be serviced during the first part of the day.
- Scattered pickup points where small quantities of solid wastes are generated that receive the same collection frequency should, if possible, be received during one trip or on the same day.

The general steps involved in establishing collection routes include:

- Preparation of local maps showing pertinent data and information concerning the waste generation sources.
- Data analysis and, as required preparation of information summary tables.
- Preliminary lay-outs of routes have to be prepared.
- Comparison of preliminary routes and the development of balanced routes by trial and error method.

a.3.4 Transfer and Haulage of Solid Wastes

Because frequent collection appears to imply high costs, unconventional systems and transport method may have to be employed to bring the expenditures within local capacity.

Where a site suitable for the final disposal of solid waste is available within or close to the main collection area, then the cheapest method of transporting and disposing of the waste is to haul it in the collection vehicle for direct dumping of waste. However, many urban areas face acute shortage of land in close proximity to the main collection area and the waste has to be hauled to remote disposal sites or waste processing facilities. In these circumstances, transporting the waste directly in the collection vehicle can result in many man-hours being spent on hauling solid wastes from the collection zone to the disposal site. In other words, it is more expensive to haul a large amount of waste in small vehicles over a long distance than it is to haul a large volume of waste in a large vehicles over along distance. This situation may be alleviated by using a transfer station, which refers to the means, facilities, and appurtenances used to effect the transfer of waste from relatively small collection vehicles to larger vehicles and transport them over long distances to either disposal sites or processing facilities. This is illustrated in Table 5-4, which summarises the anticipated costs of the transport modes to the disposal function. It should be noted that the compactor trucks are used are 15 m^3 vehicles with 3 man crews and that all per tonne costs include pre-processing, use of transfer stations, transportation, and both vehicle loading and unloading costs.

Table 5-4: Comparison of Transport Modes (Round Trips)

US $/Ton

Mode	One way mileage to site									
	10	20	30	40	50	60	70	80	90	100
Compactor truck at 10 mph	7.3	-	-	-	-	-	-	-	-	-
Compactor truck at 20 mph	3.8	7.4	-	-	-	-	-	-	-	-
Compactor truck at 40 mph	2.2	4.4	6.6	-	-	-	-	-	-	-
Rail-hauling	-	-	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7
17 tonne semi-trailer	1.9	2.6	3.2	3.7	4.1	4.5	5.0	5.4	5.8	6.0

b. Street Sweeping System

Street sweeping is one of the most visible of all municipal services. Consciously or not, residents allow their opinions on the effectiveness of street sweeping program influence their assessment of the credibility of their municipal leaders and local officials. Visitors instinctively rate municipalities based on their external conditions, i.e., cleanliness. Dirty cities cannot attract foreign investors. These opinions should be positively used to stimulate the residents to build a better city.

Street sweeping programs were conducted mainly to remove litter and dirt so that streets appear presentable, and traffic will not create dust. Specifically, in some areas, regular street sweeping is necessary to prevent sewers from becoming clogged. It is also recognised that dust is a potential pollutant.

Municipalities must balance the costs for adequate street sweeping and effective litter control programs, sewer improvement operations, projects to ensure safety of pedestrians and vehicle occupants, air and water pollution countermeasures, and economic development. Public education programs alone, however, will not help eliminate street litter. Debris also accumulates from air pollution fallout, animal excreta, oil drippings, parts dropped from vehicles, spillage from solid waste collection, construction debris, as well as mud tracked onto pavements.

b.1 Street Sweeping Methods

As practised today, street-sweeping methods in Adana and Mersin may be grouped conveniently under these general headings:

- manual sweeping
- mechanical sweeping
- vacuum sweeping
- flushing

b.2 Manual Street Sweeping

Manual street sweeping is by far the oldest method. However, it still retains certain advantages as follows:

Advantages

- low capital
- great flexibility of operation
- applicable to cleansing of areas where debris accumulation is most frequent
- makes cleaning beneath parked vehicles possible
- makes cleaning rough cobble stone pavements possible
- produces less noise
- creates more job opportunities
- requires minimum equipment, repair and maintenance costs

Disadvantages

- difficulty in supervision
- dangerous under heavy traffic conditions

The equipment required for manual sweeping is simple and inexpensive. Sweepers use stiff bristled brooms, wheelbarrows, shovels, and few other tools for special tasks.

b.3 Mechanical Sweeping

Mechanical sweeping entails the use of as many machines as possible, usually of various sorts. Three or four-wheel sweepers are mainly used for wide main roads. Self-propelled sweepers and water sprinkling-trucks are also used for mechanical sweeping.

Advantages

- great productivity
- low manpower requirement
- ensures safe operation

Disadvantages

- huge capital
- high maintenance cost
- low flexibility of operation
- difficult to conduct in narrow areas
- produces lots of noise
- difficult to conduct under heavy traffic

Mechanical sweeping is generally the cheapest sweeping method for wide roads. This method is generally suitable for roads exceeding 6 m in width.

b.4 Vacuum Sweeping

Vacuum street sweeping is becoming increasingly popular in developed countries because it removes fine materials as well as larger debris without using water, thereby curtailing water-use expenses. The flicking action of the broom is not as effective on fine materials as is the vacuum.

Vacuum units can also pick up larger debris, ranging from cigarette butts to beer bottles at operating speeds of 20 km per hour. With the help of gutter brooms, this unit is able to loosen and deflect debris so it can be picked up. It is also equipped with an additional broom, which may or may not be used in picking up debris, to windrow dirt. This second broom loosens the street dirt and pushes it toward the vacuum nozzles where it is drawn into the storage compartment. A filter system traps the dust and confines it to the sweeper hopper.

Advantages

- high sweeping capability
- no harm to sewage pipes by dust
- produces only a very small amount of dust

Disadvantages

- requires huge capital
- requires high maintenance cost
- low flexibility of operation
- difficult to conduct in narrow areas
- produces lots of noise
- difficult to conduct under heavy traffic

b.5 Flushing

Street flushers hydraulically remove debris from the street surface to the gutter. Since the disposal of street dirt in sewers and catch basins is regarded with increasing disfavour because it pollutes the environment, several municipalities now flush only to aid sweeping and not as the sole method of sweeping.

Flushing before sweeping washes street dirt to the curb for collection by motorised sweepers. This type of flushing ordinarily employs smaller quantities of water and lower nozzle pressures to keep the dirt from flowing into the inlets as well as minimise the risk of getting pedestrians and vehicles wet. The benefits of flushing after sweeping are: cleaner pavements and the discharge of only small quantities of dirt into inlets and catch basins.

Advantage

- produces no dust

Disadvantages

- needs a large amount of water
- may clog sewage pipes
- requires high maintenance cost
- low flexibility of operation
- difficult to conduct in narrow areas
- difficult to conduct under heavy traffic

c. Recycling System

c.1 Introduction

Most developed countries started taking various actions in the mid-1980s directed toward recycling of solid waste. The commonly accepted definition of solid waste recycling would be to utilise one or more waste components in such a way that they are not deposited in a landfill. Materials commonly recycled or recyclable wastes are paper, cardboard, glass, bottle, aluminium, ferrous metal, and plastic.

The primary benefits of recycling are conservation of natural resources and landfill space; however, the collection and transport of materials requires substantial amounts of energy and labour, and historically, most recycling programs are subsidised economically[1]. The requirements for a successful program are that a strong demand exist for recovered materials and that the market value of the materials be sufficient to pay for collection and transportation costs.

c.2 Important Issues on Current Recycling in Adana and Mersin

c.2.1 Composition of Recyclable Waste

Table 5-5 shows the surveyed waste composition of Adana and Mersin, the standard waste composition of industrialised countries and the United States. This comparison clearly shows that the present composition of recyclable waste in ADANA AND MERSIN is far less than that of industrialised countries: 29.62%for Adana, 30.03 % for Mersin, 27-80 % for industrialised countries, and 67.5 % for the United States.

Table 5-5 shows that the ratio of commonly recyclable waste, composing of mainly non-putrescible wastes, in whole waste is very low. It implies that to promote recycling non-recyclable wastes, composing of mainly organic/putrescible (compostable) wastes, is required in order to increase the overall recycling rate.

Table 5-5: Comparison of Waste Composition

	Adana in 1998*1	Mersin in 1998*1	Industrialised Countries*2	United States in 1990*3
Kitchen	66.45 %	67.87 %	20-50 %	9.0 %
Paper	17.17 %	18.64 %	15-50 %	40.0 %
Textile	2.43 %	2.15 %	2-10 %	2.0 %
Plastic	6.17 %	5.81 %	2-10 %	7.0 %
Grass/Wood	2.48 %	0.88 %	-	20.5 %
Leather/Rubber	0.32 %	0.18 %	-	1.0 %
Metal	1.00 %	0.78 %	3-13 %	9.5 %
Glass	2.53 %	2.47 %	4-12 %	8.0 %
Ceramic/Stone	0.96 %	1.08 %	1-20 % (including others)	3.0 % (including others)
Others	0.49 %	0.14 %	-	-
Total	100.00 %	100.00 %	100.0 %	100.0 %

Note: Screened items are recyclable wastes.
*1: MSW excluding public area cleansing waste.

Source: *2: “Integrated Resource Recovery, Recycling form Municipal Refuse: A state-of-the-art Review and Annotated Bibliography”, UNDP Project Management Report Number 1, S. Cointreau, et. al. 1985
*3: Integrated Solid Waste Management, Engineering Principles and Management Issues, G. Tchobanoglous, et al, McGraw-Hill, 1993

c.2.2 Present Recycling Conditions

As for the commonly recyclable wastes, a recycling system formed by the private sector, which consists of a lot of informal individuals, is well established and very

[1] Integrated Solid Waste Management, Engineering Principles and Management Issues, G. Tchobanoglous, et al, McGraw-Hill, 1993

active. However, the recycling activities of public institutions are considerably limited.

As for the non-recyclable wastes (putrescible wastes, although there is a compost plant (since 1985) in Mersin, the plant has not been satisfactorily operated. The potential demand for compost seems to be very high according to the preliminary compost marketability. However, the quality of the compost presently produced by the plant is extremely poor. Coarse compost contains a lot of impurities that the farmers tend not to use the product again.

c.3 Alternatives

Recycling systems may be divided into two types in terms of the magnitude of involvement of governmental organisations: government related recycling system and private sector centred recycling system.

c.3.1 Government Related Recycling System

Government related recycling system are carried out as a means of economically controlling solid waste generation. This system obliges dischargers to conduct waste segregation and sorting, as well as separate discharge, collection and transportation. These activities incur additional costs and their success is heavily dependent on public co-operation. The government related recycling system is considered to be more productive and they reduce the amount of waste for final disposal.

Many industrialised countries suffer from landfill site scarcity problems. In Japan, wastes are sometimes transported to disposal sites more than 500 km away from the weighted centres of collection points. Therefore, this system has become particularly common in industrialised countries as it generates considerable financial benefits by saving landfill space and reducing transportation costs.

c.3.2 Private Sector Centred Recycling System

The government has an indirect and limited role in the promotion of this recycling system, that is the conduct of public education programmes on recycling. This system does not impose separate collection and any risk encountered is solely the responsibility of the private entities involved.

This alternative is almost the same system as the present one.

d. Intermediate Treatment System

This section considers the possible options for:

- The treatment of wastes by improving or removing some of its undesirable characteristics (e.g., to reduce waste volume, to render waste inert)
- The recovery of some of the wastes either as energy (gas, steam or electricity) or as reusable materials (e.g., waste paper, ferrous scrap, compost)

Several criteria of prime importance in assessing the suitability and viability of any system of waste handling, treatment or recovery are as follows.

- **Technical feasibility**
- **The degree to which the technology of the system is proven,** i.e., "are these plants actually in operation elsewhere?".
- **The reliability of the system and similar issues.** (These questions are particularly important when considering latest technologies since, for example, many recovery systems are of relatively recent development).
- **Its financial and economic implications**: how much will the system cost to construct and operate; what are the potential benefits from savings in transport and disposal costs and from the sale of recovered products; what other economic benefits does the system offer in terms of foreign exchange savings, employment, etc. Of special importance here is the scope for actual selling and using any recovered products as this can frequently be less than is estimated.
- **Its management requirements**: how much qualified management and skilled labour will the system require to operate properly; how much co-operat will be obtained from the public, etc. Unless the necessary resources and skills are available, the system may be much less attractive than it initially appears.

Our assessment of the various operations below takes into account the prevailing conditions and problems in the target area, evaluating in broad terms the technical suitability and economic implications of different systems for handling, treatment and recovering solid wastes in Adana and Mersin.

The following intermediate technologies are discussed in this section:

- Incineration
- Production of Refuse-Derived Fuel (RDF)
- Composting
- Biogas Production
- Pyrolysis
- Size Reduction
- Mechanical and Manual Sorting

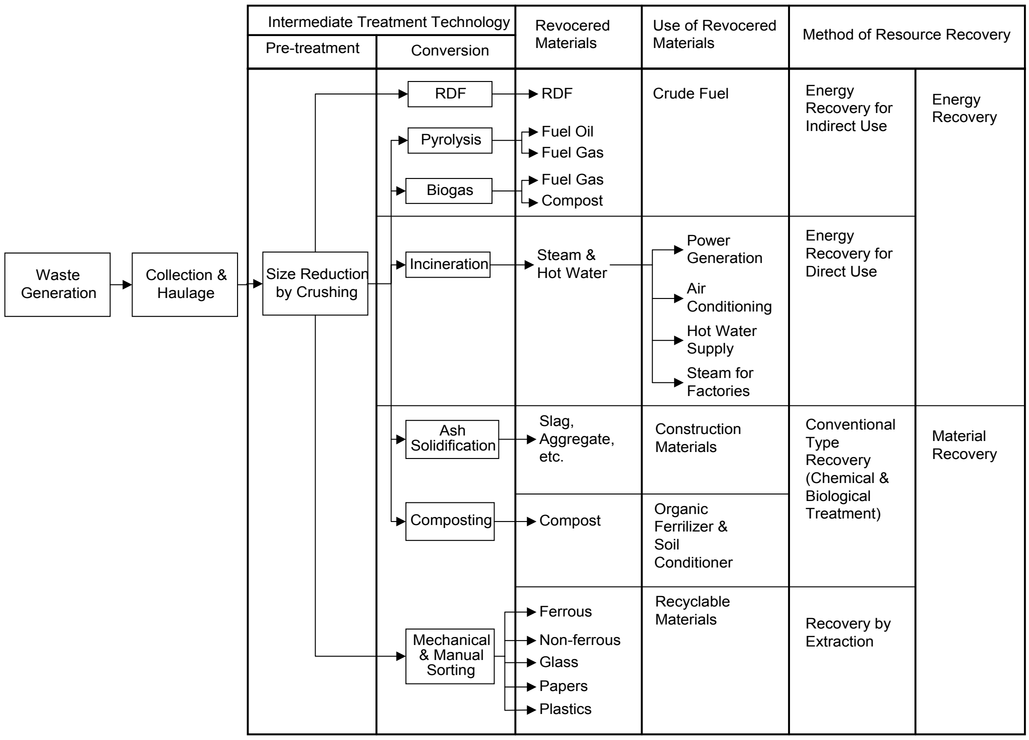

Figure 5-1: Intermediate Treatment Technologies and Resource Recovery Method

d.1 Incineration

Incineration of municipal solid wastes is one of the most popular method recently adopted for processing wastes in developed countries. Waste is mainly converted into stable oxidised gases and partly into stable inorganic matters by high temperature combustion. Of the various intermediate treatment technologies, incineration generally reduces waste volume to a large degree. It also stabilises putrescible organic wastes. Energy from waste incineration can be utilised for the production of electricity and/or district heating, and the income from the sale of energy may contribute to the economics of the plant.

A general observation would indicate that incinerators may be feasible where land for landfilling is scarce, expensive or very remote from the actual solid waste generation centre. Modern incineration and flue gas cleaning technology makes waste incineration an environmentally acceptable form of waste treatment, it is, therefore, possible to locate such plants even in densely populated areas. Accordingly, incineration has played a role in municipal waste management for more than 50 years in many major cities in Japan, Europe and the USA.

A modern incinerator consists of a number of basic components. Typically they include an unloading area, refuse feeding device, burning grate area, combustion chamber, air supply system, residue quench and disposal system, flue gas scrubber and water treatment system, and stack. Selection and design of these basic components will be the deciding factor in differentiating one incinerator from another.

Major differences in typical modern incinerators are noted in both refuse feed systems and grate designs. Feeding of refuse may be accomplished by either batch or continuous mode. Batch feed of refuse has experienced a decline in use over recent years in favour of continuous feed methods.

Applicability for Adana and Mersin

One of the most important factors that would determine whether incineration is feasible is the calorific values of the waste being generated. It is said that the required calorific value of waste to burn without supplementary fuel is 1,700 cal/kg. According to the result of the waste composition survey, the calorific value of the waste generated in Adana and Mersin could be estimated far below 1,700 cal/kg due to large composition of kitchen wastes (more than 65 % of MSW). It will therefore require supplement fuel for burning.

The income from the sale of energy generated by incineration of waste, either by the form of heat or electricity, is often expected when it is introduced. To generate electricity by incineration of waste is not appropriate for Adana and Mersin because it requires considerable amount of costs not only for installation but also for operation and maintenance. Although to supply heat is easier in terms of technology, the demand for heat in Adana and Mersin is estimated to be very small therefore, a large income from sale of energy cannot be expected.

A purpose-built automated incineration facility involves very high capital outlay. The technology is sophisticated and requires high levels of technical expertise to operate. Appropriate gas cleaning equipment needs to be installed, and operational and maintenance costs are high. In addition, it requires continuous spending for support fuel therefore, both the investment cost and O & M cost are too expensive.

It is accordingly believed that incineration is inappropriate in Adana and Mersin for technical and economic reasons, except for the purpose of hazardous waste including infectious medical waste treatment. Furthermore, the Ministry of Environment is preparing a draft to pass the law from the parliament to prevent incineration.

d.2 Production of Refuse-Derived Fuel (RDF)

In this system the combustible fraction of the waste is separated by some mechanical or manual means primarily to extract the paper and plastic fractions which is then either used as its raw state or compacted into pellets.

The production of refuse-derived fuel can be done in several ways. In some of the earlier systems, raw refuse was first shredded to a nominal particle size of about 4 inches. More recent systems employ a rotary trammel before shredding. This trammel allows for prior separation of heavy, larger materials. After shredding, ferrous metals are separated magnetically for recycling. The remainder is then separated into a lighter, mostly combustible fraction and a heavier, mostly non-combustible fraction using an air classifier.

The lighter fraction is then further processed to produce the RDF through secondary shredding and screening. The RDF that is produced can be burned as a coal or a primary fuel in a specially designed boiler.

Today, RDF systems are mainly adopted in Japan, the United States and Canada. But the extensive use of this technology in the developing countries may not be recommendable due to the following problems observed.

- There is a need to alter the combustion conditions of conventional boilers and burners if a significant amount of RDF is to be burnt.
- The pre-treatment plant is capital intensive leading to high waste disposal prices in order to make the pellets competitive with coal.
- The pellets still have a high content of pollutants (heavy metals and chloride) which conventional coal fired plants are not equipped for filtering.
- Occupational health problems at the plants specially at manual sorting lines.

Advantages

- Combustibles in municipal waste can be converted to substitute fuel which can be stored and is easy to handle.

Disadvantages

- Waste which can be converted to RDF is very limited, and their availability can be found only in waste with a high paper content.
- The market for RDF will be limited due to the necessity of a special burner which can burn hard solid fuel such as coal.
- Some technical difficulties such as explosions in crusher, clogging in storing silo, etc., have to be solved.

The viability of this system would depend on the composition of the waste. In Adana and Mersin the combustible fraction of high calorific value is very small and therefore such a system will not be viable.

d.3 Composting

Composting is the biological decomposition and stabilisation of organic substrates, under conditions that allow development of thermophilic temperatures as a result of biologically produced heat, to produce a final product that is stable, free of pathogens and plant seeds, and can be beneficially applied to land.

The technology of composting municipal waste is well-established and operating experience and information is available in great detail. In spite of this wealth of experience, few of the refuse composting plants around the world are economically successful the drawbacks commonly experienced with composting are its high cost and the low value of the compost products.

d.3.1 Composting Plant in Mersin

A large scale composting plant has been operated in Mersin since 1985. The plant is described in Chapter 3.2.2. Shortcomings occurred very soon after the plant had started to operate. The main problem was the **inability of the aeration system** to keep the waste fully aerobic during the pre-composting in containers. This resulted in very bad working conditions for the employees of the plant.

When all efforts to alleviate the problems failed the pre-composting part of the plant was dismantled. Still the enclosing buildings remain and the original constructed unloading ramp for refuse trucks is not in use.

In 1990 the capacity of the plant did no longer meet the requirement for treatment of waste from Mersin, and an effort to rehabilitate and upgrade the composting plant was undertaken. However, too large investments were required and the rehabilitation and upgrading of the composting plant was given up.

d.3.2 Waste to Compost

It is possible to compost the following organic wastes:

- Food wastes from households, including meat
- Flowers, including herb wastes from gardens
- Coffee grounds - tea leaves including paper filters
- Paper kitchen towels and tissues
- Fruit and vegetables wastes
- Organic waste from gardens and parks
- Organic waste from street cleaning
- Organic waste from comers and markets
- Sewage sludge from wastewater treatment plants
- Organic waste and sludge from industry, including the food industry

However, one should exclude sludge and wastes containing heavy metals, and wastes from some branches of the chemical industry.

The most important factors that determine the quality of the compost are:

- The **contents of unwanted materials** (heavy metals, glass, and plastics) in the waste to be composted.
- The **oxygen and water content** during the composting process
- The **C/N ratio** (Carbon/Nitrogen ratio) of the waste to be composted.

These factors are briefly discussed as follows.

d.3.3 Contents of Unwanted Materials

The waste from the households and markets of Adana and Mersin contains a relative low quantity of tin canes, bottles, and plastics.

However, to produce high quality compost with low contents of heavy metals and without bits and pieces of glass and plastics, these unwanted materials have to be removed before the organic waste is composted.

d.3.4 C/N Ratio

Experience has shown that the most favourable C/N-ratio of waste to be composted lies between 25 and 35.

- When the C/N-ratio is more than 40, the duration of the decomposition becomes too long.
- When the C/N-ratio is less than 20, there will be loss of nitrogen.

At the end of the composting process the C/N-ratio should drop to below 20 and sometimes even to 15.

In October 1998 a number of samples of waste from Adana and Mersin were analysed. The chemical analysis presented the C/N-ratio for kitchen waste to be in the range of 13 to 18. The samples indicate that prior to composting the C/N-ratio should be raised by mixing with materials that have a relative high C/N-ratio, e.g., organic garden and park waste.

d.3.5 Aeration and Water Content

The most important technical issue about composting concerns the precise nature of the product. Compost is not a fertiliser but a soil conditioner. It does contain some plant nutrients but its value lies primarily in that it improves the soil structure by introducing humus, promotes microbial activities, and can help to retain fertilisers and moisture in the soil.

Before compost is offered for sale, it is important that the product is stable, free off pathogens and plant seeds. To achieve this, it is important to control and optimise the oxygen and moisture content to develop thermophilic temperatures during the decomposition process.

The objective of aeration is to supply the aerobic micro-organisms with sufficient oxygen and to permit the maximum exhaustion of the carbonic gas exhaled. To allow sufficient aeration “chimneys” can be arranged in the heap and especially during the initial period of decomposition, when most carbonic gas is liberated, the pile must be aerated and turned over.

After ventilation the most important factor remains water. An excess of it in the waste will cause the decomposition to be anaerobic, especially in the lower part of the waste pile. It is estimated that in order to avoid this the waste must not contain more than 60 - 65 % of moister. The **ideal is around 55 %**. Aerobic decomposition, however, cannot take place when the moister content of the pile is lower than 40 %.

d.3.6 Conclusion Regarding Waste Quality

Household waste from Adana and Mersin is clearly compostable, provided materials (plastics, glass, metals, etc.) not appropriate for composting are sorted out prior to composting.

d.3.7 Sorting Facility with Reference to Composting

Most essential for achieving success when composting MSW is that the waste is sorted in a “green fraction” (i.e., organic waste) and in a fraction that is not appropriate for composting (plastics, glass, metals, etc).

The following methods for sorting of waste are available:

- Source separation of waste at households, shops, comers and markets. This requires a good deal of public participation.

- Mechanical/manual sorting at the central composting plant. This requires a good deal of mechanical equipment as well as manual sorting with due consideration of workers' hygienic conditions.

Mixed household waste requires thorough sorting, size reduction and homogenisation before composting. Thus, a sorting plant at a central composting plant that receives mixed household waste will typically contain some of the following components:

- Bag opener for gentle opening of bags used in the collection.
- Feed hopper for feeding of conveyors, screens, mills, etc.
- Screens to sort waste materials in of different sizes for the subsequent treatment.
- Mills and crushers for size reduction of oversize materials.
- Metal and ballistic separators.
- Baling equipment for recyclable materials such as metal and plastic.

A sorting plant includes a storage pit from where an overhead crane supplies waste to a bag opener situated in front of a 50-mm primary screen.

The primary screening sorts out about 60% of the waste input, which after passing an overhead magnet is transferred directly to the composting. The oversize material from the primary screening enters a secondary screening. The 50-250 mm fraction will pass a picking belt and hammer mills prior to transfer to the composting area. Oversize fractions of more than 250 mm are rejected.

Beyond this, a comprehensive and successive segregation program predicting the medium and long term needs and implementations should be envisaged by the counterpart. A facility financed completely or partially by the segregated material dealers should be studied.

d.3.8 Composting Methods

Despite the perennial announcement of breakthrough innovations in the technology of composting, it is believed the major economically feasible advances have all been made. The so-called breakthroughs are either a minor modification of existing systems or the utilisation of mechanical devices unrealistically expensive either in capital or in operating costs, or in both.

Several composting methods are used and many more have been tested at the pilot scale. The most common composting methods are the following:

- Centralised composting plants using decomposition in windrows.
- Centralised composting plants using some kind of digester before being placed in windrows.
- Decentralised composting using the windrow system.

All composting plants require the removal of non-compostable materials like metals, plastic, glass, stones, etc., prior to composting. Although not all such materials will be removed, the process will keep the contents of harmful materials in the finished compost at a low and acceptable level.

The composting plants are briefly described as follows.

d.3.9 Centralised Windrow Composting

Figure 5-2 presents principles of centralised windrow composting plant based on source separated organic waste and organic park and garden waste. If mixed waste is applied, pre-sorting plant must be integrated.

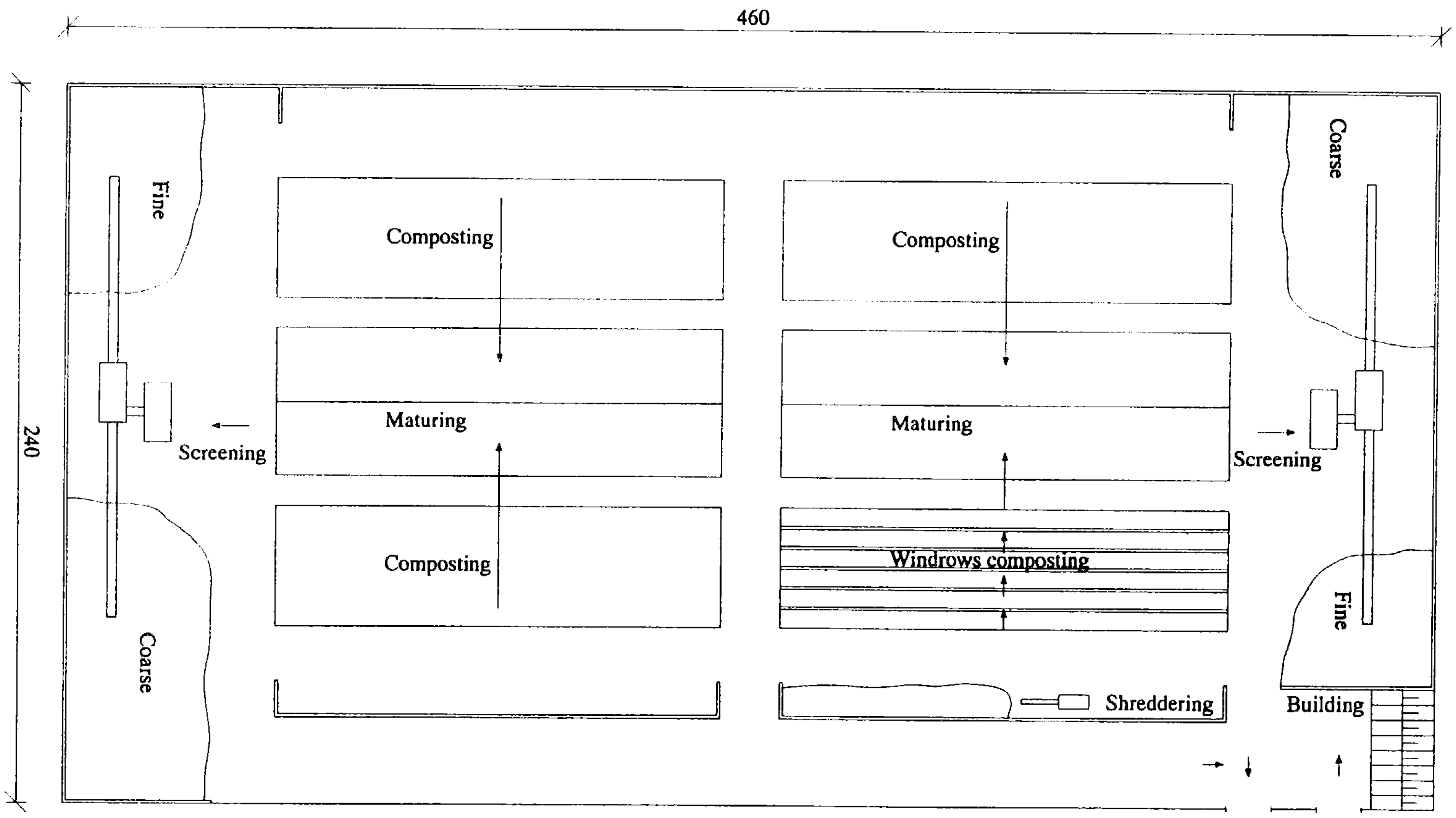

Figure 5-2: Windrow Composting Plant for 100,000 ton/year

Before being placed in windrows, the water content of the waste is adjusted to optimum level to approximately 55 % by weight. The waste is placed in windrows for a period of up to 9 weeks. The windrows have a height of approximately 2.5 m and a width of 5 m and are turned weekly.

During turning of the windrows, the water content is adjusted. Care must be taken to ensure that material previously on the surface of the windrow is placed in the central part after turning, so that all material are exposed for the high temperature inside the windrow. Turning can be performed either by front-end loaders or by special portal windrow turning machines.

Depending on the final application, the mature compost may be sieved using screens with coarse and fine meshes.

d.3.10 Centralised Digester/Windrow Composting

After the sorting process, the compostable part of the waste is treated in a mechanical digester to provide optimum conditions, and hence accelerate the composting process.

A number of mechanical digesters are available in the market. Probably one of the more successful is the Dano-drum. This system involves the use of a large, slowly rotating drum and the required grinding, watering and aeration of the waste takes place in the horizontally rotating drum furnished with knives.

Material is injected in one end and after one to three days of slow rotation is ejected from the opposite end of the machine where the material is sieved by a coarse screen. Air is injected into the interior of the drum to ensure constant supply of oxygen. The water may be subsidised by wet sewage sludge, increasing the nutrient content of the finished compost.

The homogenised waste is piled in windrows for a period of 8 weeks and the windrows are turned weekly.

Figure 5-3 presents principles of centralised windrow digesting/composting plant based on source separated organic waste and organic park and garden waste. If mixed waste is applied, pre-sorting plant must be integrated.

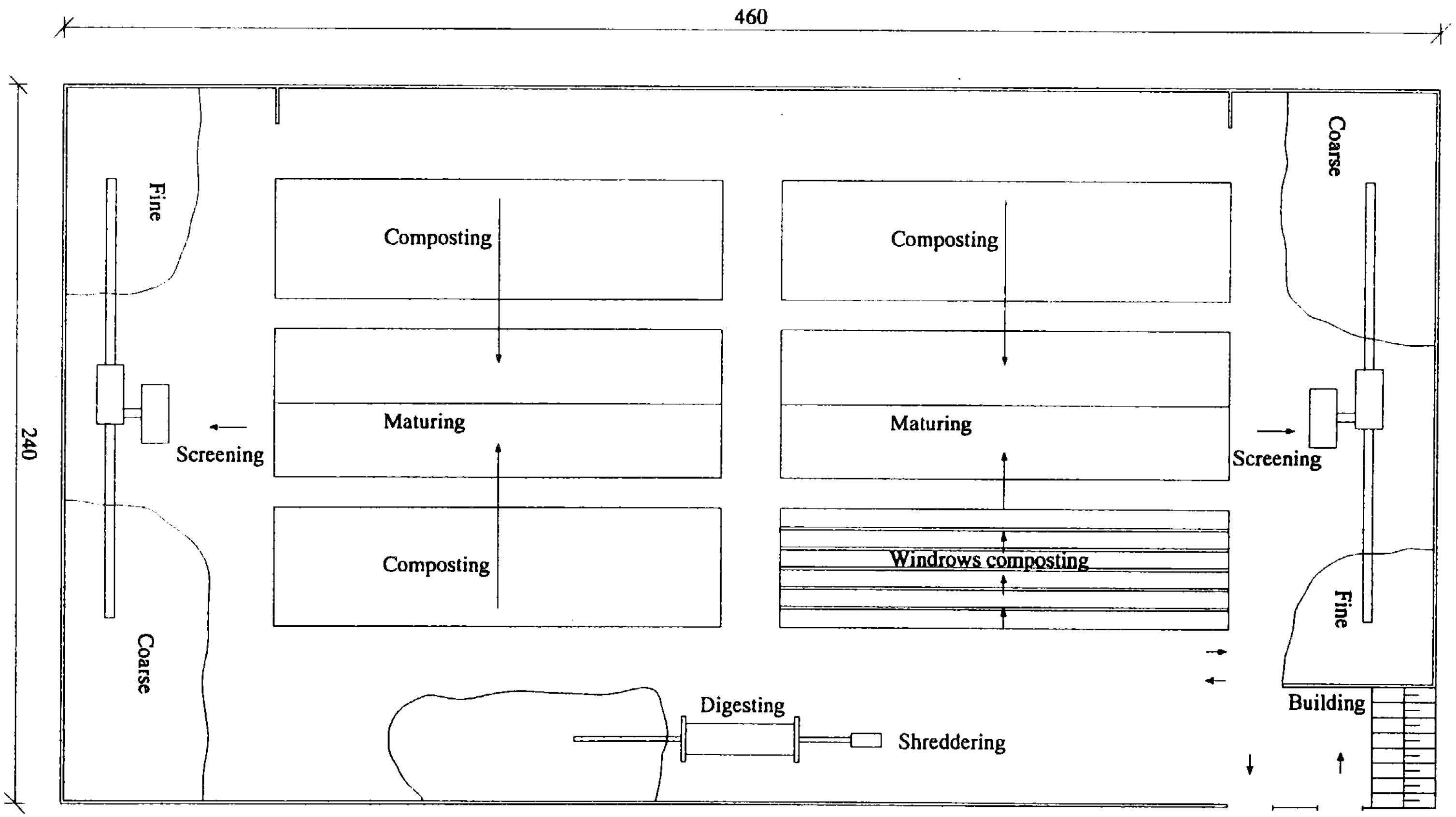

Figure 5-3: Digester and Windrow Composting Plant for 100,000 ton/year

d.3.11 Decentralised Windrow Composting

Composting is a natural process that does not require sophisticated equipment. Any community, farmer or garden owner may produce compost by turning and watering a pile of organic wastes.

The pile must be sufficiently large to avoid rapid drying-up and small enough not to turn anaerobic. After turning and mixing the pile three or four times at 1 to 2 weeks intervals depending on the actual climatic conditions, the compost may be used after 8 to 12 weeks as a soil conditioner

Figure 5-4 presents principles of decentralised windrow composting plant based on source separated organic waste and organic park and garden waste. If mixed waste is applied, pre-sorting plant must be integrated.

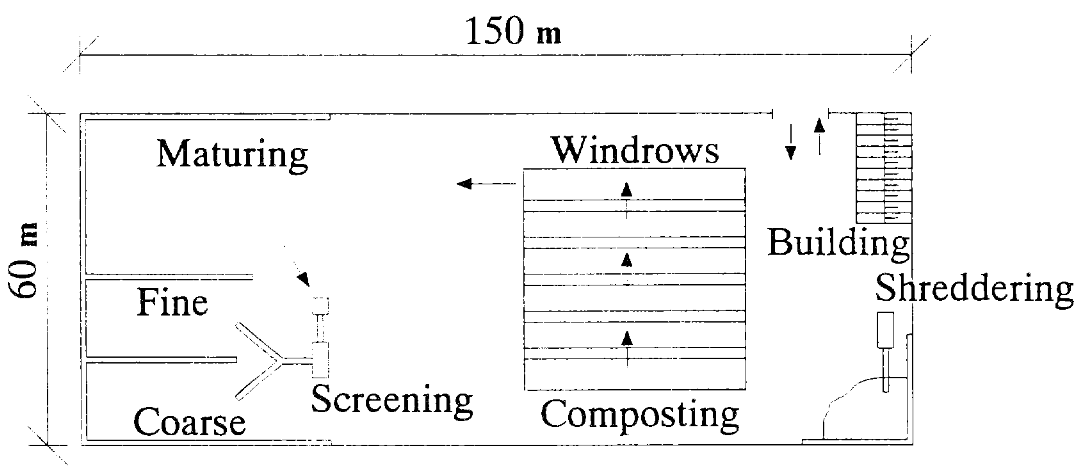

Figure 5-4: Windrow Composting Plant for 1,000 ton/year

d.3.12 Markets for Compost

The drawbacks commonly experienced with composting are its production cost and the low market value of composts. However, the waste from Adana and Mersin has a very high content of organic matter, implying that composting should be feasible.

There is therefore undertaken a survey on the potential market for compost in the Mersin area where a composting plant has been operated since 1985 and most farmers have tried to use compost as described in the Section 2.5.1.

The survey indicates that there might be a market for compost amongst farmers. Further the municipalities of Adana and Mersin are potential buyers of compost since they use compost for public parks, streets plantation, and other projects for "greening of the City".

Advantages

- Resource recovery of wastes into potentially useful compost for soil improvement purposes
- Low construction and operation costs

- Low technology suitable for use every where
- Minimal potential soil, water and ground water pollution

Disadvantages

- Transportation costs
- Requires separation of organic wastes by source or pre-sorting.

Applicability

Although there is a compost plant (since 1985) in Mersin, the plant has not been satisfactorily operated. The main reason is the quality of the compost presently produced by the plant is extremely poor. Especially coarse compost contains a lot of impurities that the farmers tend not to use the product again.

However, according to the preliminary compost marketability survey done in October 1998, the potential demand for compost seems to be very high. In addition the MWS in Adana and Mersin contains a lot of compostables, more than 65 % at present. Therefore, the composting is one of the most applicable method of the waste processing.

d.4 Biogas Production

Biogas is the combustible gas developed when organic matter is degraded under anaerobic conditions, i.e., without the presence of oxygen. The energy will be bound in the hydrocarbon combination methane, which is the main element of natural gas. Anaerobic degradation of organic matter, resulting in biogas production, is an efficient means of degrading organic wastes, and making it hygienic.

Anaerobic waste treatment is a well known process relating to treatment of farmyard manure, sewage sludge and industrial waste water and other sludge. In the process, part of the organic material is transformed into carbohydrates, proteins, and fat by means of micro organisms. First the material is decomposed by certain bacteria to organic acids and carbon dioxide, after this process other bacteria decompose the organic acids and convert hydrogen to methane. Biogas can be utilised both for heat and power production. First certain bacteria decompose the material to organic acids and carbon dioxide, after this process other bacteria decompose the organic acids including hydrogen to methane. Biogas can be utilised both for heat and power production. The residues are sludge, which can be utilised as compost (a soil-improving agent) when not contaminated with non-organic matter.

In Denmark several biogas plants has been established within the last 5 – 10 years. Only a few of these plants process organic waste from households and gained experience is still limited. Whilst experimental plants have been built to anaerobically digest municipal solid waste, to date these have not all proved successful.

A large-scale plant (capacity: 80 ton per day, price: US$ 10 mill.) constructed in Helsingor, Denmark was operated for 4 years. It was closed in 1996 because of complaints from neighbours due to nuisance from bad smells and because the required separation of municipal waste into organic waste and material not appropriate for the process was too expensive.

Grindsted biogas (price: US$ 15 mill.) plant handles approximately 2,000 ton of organic household waste per year together with approximately 20,000 ton of sewage sludge. Herning biogas plant (price: US$ 7.5 mill.) handles approximately 1,300 ton of organic household waste per year together with approximately 5,200 ton of sewage sludge. In the cities of Herning and Grindsted organic waste has been processed in their biogas plants in the last few years.

These 2 biogas plants has experienced that the following conditions must be present to ensure the operation of the plant and to produce reusable residues:

- To ensure the operation of the plant without breaking down and to avoid problems with neighbours due to nuisance of bad smells the organic waste from households must only contain organic matter. It is particularly important that the organic matter is free from plastics in the waste because such contamination often causes a break down of the plant. Due to these problems some household waste has been rejected from the plant in the city of Herning. In the city of Grindsted a plant has been established based on source separation of waste by every household. Organic waste is collected in **bio degradable paper bags** and is therefore free of contamination.

- To secure reusable residues from the biogas plant the organic matter used in the plant must be free from non organic matter to avoid pollution when using residues as soil improvement agent.

- To insure an optimal quality of organic waste from households the experience in Denmark is, that it is of the greatest importance to establish a collection system for organic waste based on source separation at each household.

It is possible to add the following wastes to biogas producing waste treatment plants:

- organic wastes from households, including meat and vegetables
- flowers, including herb wastes from gardens
- coffee grounds - tea leaves including paper filters
- fruit wastes
- paper kitchen towels and tissues
- organic sludge and waste water from industry, including the food industry
- sewage sludge (activated)

However, one should exclude waste water and wastes containing heavy metals, and wastes from some branches of the chemical industry.

From a practical point of view, it is an advantage to place the biogas producing plant near a waste water treatment plant, in order to supply the biogas plant with water to dilute incoming wastes, and to supply power to the waste water treatment plant and achieve useful synergy.

Its advantages and disadvantages are summarised as follows:

Advantages

- resource recovery of wastes into potentially useful products, i.e., methane gas and compost (sludge for soil improvement purposes

- minimal potential soil, water and ground water pollution

Disadvantages

- high investment cost
- only few years operational experience of municipal wastes
- transportation costs
- requires pre-sorting of organic wastes.
- Not possible to locate near urban areas because of nuisance from offensive odour, unless expensive technical measures are taken.

Applicability

The process of anaerobic digestion of animal manure and sludge from treatment of wastewater has a relatively long history (1,000 years or more). Plants based on this kind of raw material are being operated all over the world. However, a biogas production applying MSW as the raw materials does not appear to be an appropriate technology for adoption in Adana and Mersin for time being due to the following reasons:

1. The operation technology has not been established because the requirements are very high and complicated. Even in Japan, which is one of countries having advanced solid waste technologies, it is still on the stage that only pilot plants have started operation in order to realise commercial plants in future.
2. This technology is more appropriate for liquid waste rather than for heterogeneous waste like those MSW because of high demands for organic waste not contaminated with non-organic matter.
3. The required investment for facilities is very high. （Note: The construction cost of the Helsingor plant with the capacity of 80 ton per day is US$10 million)

d.5 Pyrolysis

Pyrolysis or gasification of waste involves the “cooking” of waste in a furnace in the absence of air. Depending on the way the reaction is controlled, oil, ashes, and gas are produced.

Pyrolysis is a process for breaking down organic substances by applying heat, in the range of 700-1,200 °C, in the absence of oxygen or at oxygen levels insufficient for total combustion. Under these temperature and pressure conditions, organic materials break down to shorter chain organic compounds and in some cases are reduced to charcoal, a carbon residue. A variety of potentially useful products may be produced, depending on refuse composition and operating conditions. Master products are charcoal tar and pitch, light oil, organic acids, ammonium sulphate and combustible gases.

Theoretically, pyrolytic operations lend themselves well to a total recycling approach. Prior to the actual pyrolysis step, waste materials must go through a number of preparatory operations. Generally, solid wastes are first shredded, glass and metals are separated, and these materials are sold where an available market exists. Unusable residue, reduced to a small percentage of the original, is left for ultimate disposal at a sanitary landfill.

In the USA, the technology aims at recovery of storable energy, while in Japan it is being developed for non-pollution intermediate system for wastes.

Pyrolytic processing operations have the following advantages and disadvantages:

Advantages

- reduced land requirements for final disposal;
- reduction of solid wastes to a minimum volume;
- little air or water pollution (since little or no oxygen is involved, combustion products may not be a factor of pollution.);
- recycling of solid wastes into potentially useful products. Considering effective energy saving, production of such items as fuel oils, gas and steam are desirable and needed.

Disadvantages

- Large capital investment and high operation cost.
- The nature of oil or gas obtained from the facility is still insufficient for commercial use, therefore the market is limited to factory use only. The purification of oil or gas is cost intensive, and is not as effective as its cost may suggest.

Applicability

The first commercial pyrolysis gasification plant in Japan, which holds a capacity of 150 ton/day, started its operation in 1981. However, due to several accidents during its operation the plant underwent numerous reconstruction work. Another large scale plan is currently under way to improve the plant’s energy recovery productivity, simplify the technologies employed, and further reduction of waste volume.

The following statement was made on the use of pyrolysis in the United States: “The pyrolysis of municipal waste to produce a marketable oil or gas product has not been proven feasible. The pilot plants that were being developed for that purpose have been closed.”

Pyrolysis is not a recently developed technology, but has been around in various forms for thirty years or more. However, since its role in the treatment of municipal solid waste is still theoretical, it is not suited to the conditions of Adana and Mersin.

d.6 Size Reduction (Crushing and Shredding)

A size reduction facility is normally equipped with crushing and shredding functions, and is generally used as a pre-treatment facility of an incineration plant, composting plant and other intermediate treatment facilities. It is also used to improve sanitary landfill operations.

Shredding reduces the volume of waste to be transported to the final disposal site for sanitary landfill operations. Shredded waste settles more quickly than unshredded waste, making the landfill sanitary and less subject to complaints from nearby residents. This condition also ensures fewer spontaneous combustion during landfill operations. Because this condition produces fewer rodents and insects, less insecticides and pesticides shall be required.

Shredded wastes cause less damage to the landfill equipment and trucks than unshredded waste, and has a high compaction rate.

The term "crush" has various meanings, i.e., shredding, milling, pulverising, grinding, cutting, tearing, ripping, etc., for which appropriate machines are developed.

An ordinary hammer mill with a swing hammer attached to the horizontal or vertical shaft rotates very fast. Waste is dumped from above, and discharged from the opening at the bottom after it is pulverised by the shearing force of the cutting board.

The grindability of a machine depends upon the substances to be crushed and the size required by the treatment system. The pulverising process will be accompanied with sieving, if necessary.

Advantages

Advantages of shredding and crushing are listed below.

- Shredding and crushing (size reduction) contribute to the work efficiency of other intermediate treatment facilities.
- It is well adapted to the local conditions and intended plans because (1) shredding reduces volume by about 50%, thus making transportation easier and more efficient, and (2) shredded waste spreads more easily. Shredded waste is compacted better in the sanitary landfill and takes up less space making the landfill area last longer.
- Shredding and crushing produce a more compact and ultimately more stable sanitary landfill, hence raising the post-closure value of the land.
- Since shredding and crushing facilitate waste compaction, ensures fewer spontaneous combustion and propagation of fewer flies and rodents during landfill operations, particularly if solid waste disposed receives a final cover.
- Shredding and crushing definitely increase compaction, making landfills denser and reduce the percentage of settlement.

Disadvantages

- The use of the rotary type hammer crusher consumes large amount of electricity as it usually requires a high powered electric motor.
- Damage due to explosion caused by flammable matters in waste might occur frequently. Therefore, strict checking and sorting out of dangerous matters have to be done.
- Frequent repair works or replacement of damaged parts shall be necessary for the tremendous wear and tear of mechanical parts such as hammer beaters, shear blades, etc.

Applicability

Simple application of the system is not recommended due to few amount of bulky waste in Adana and Mersin. But this system is useful when used with other intermediate treatment technologies.

d.7 Mechanical and Manual Sorting

Mechanical sorting and manual sorting are inexpensive technologies used to recover as much valuable materials as possible from waste generated without causing any secondary environmental pollution.

Metals, non-ferrous metals, papers, cardboard, glass, plastics, rags, leather are separated manually or by use of an air classifier or a magnetic separation equipment, depending on their respective characteristics. Air for the operation of an air classifier can be supplied by low-pressure blowers or fans.

Advantages

- With the existence of various sorting devices such as pneumatic, mechanical, and magnetic separation equipment, sorting is effectively executed under hygienic conditions.
- Many sorting systems are relatively simple and easy to operate.
- These sorting systems require comparatively cheaper investment, utility cost, and maintenance cost.

Disadvantages

- This system does not contribute to the compaction of waste as its use is generally limited to relatively dry wastes with rich inert material content.
- Objects rejected after usable materials are sorted have to be re-hauled to the landfill site.
- The materials obtained by mechanical separation are generally of inferior quality in comparison to materials manually sorted out. For example, with the pneumatic device, materials recovered are usually a combination of light fractions, e.g., plastic and paper. Each fraction cannot be completely separated because the specific gravity of both materials is almost equal to the specific weight.
- Manual sorting puts the workers at risk due to the possible inclusion of infectious or hazardous wastes.

Applicability

The technical examination on the collection system concluded to adopt the separate collection system that non-compostable (non-putrescible) wastes and compostable (putrescible) wastes are collected separately. Even though it is employed, to use a sorting process, whichever manual or mechanical, is necessary to sort non-compostable wastes by the type of material.

d.8 Summary of Screening Work for Intermediate Treatment Technology

The above-mentioned screening work for intermediate treatment technology is summarised in the table below.

Table 5-6: Characteristics of Possible Intermediate Treatment System

Intermediate Treatment Technology	Recovered Material	Main Target of System	Contribution to Landfill		Special Cautions								Remarks
			Volume Reduction	Stabilisa-tion	Stability of Technology	Pre-treatment	Post treatment	Rejected Sub-stances	Acceptability of Refuse Quality	Construction Cost (US$/ton)	Marketability of recovered Material	Environmental Impact	
Incineration	Heat or Electric Power	Volume Reduction & Energy Conversion	A	A	A	Not Necessary	Not Necessary	Non-combustibles	A	High	B	B	• Initial/Running Cost • Possibility to find User of Heat/Power
RDF	Solid Fuel	Conversion to Fuel	B	B	B	Necessary	Necessary	Non-combustibles	B	Low	C	B	• Marketability of Products
Biogas	Gas & Compost	Conversion to Fuel & Soil Conditioner	B	B	C	Necessary	Necessary	Glass, Stone, Plastic, etc.	C	High	B	C (Odour)	• Strict Segregation of Waste for Production • Treatment of Waste Water • Stability of Market for Products
Pyrolysis	Gas or Oil	Conversion to Fuel	B	A	C	Necessary	Necessary	Non-combustibles	C	High	D	B	• Technology is not completed. • Initial/Running Cost
Composting	Compost	Conversion to Soil Conditioner	B	B	A	Necessary	Necessary	Glass, Stone, Plastic, etc.	B	Middle	B	C (Odour)	- Stability of Market for Products
Size Reduction (Crushing & Shredding)	Ferrous etc.	Volume Reduction of Bulky Waste	C	B	B	Extraction of Explosive Object	Necessary	Discarded Material	C	Low	C	C (Noise & Dust)	- Large Consumption of Electricity - Much Expense for Maintenance - Possibility of Explosion
Sorting (Mechanical or Manual sorting)	Ferrous, Glass, Paper, Plastic, etc.	Recycling	C	C	A	Occasionally Necessary	Necessary	Discarded Material	C	Low	A	B	- Stability of Market for Salvaged Materials

Note : A: Excellent B: Good C: Fair D: Poor

e. Final Disposal

e.1 Possible System Alternatives

Upon consideration of the possible system alternatives for final disposal the following aspects are to be taken into account:

- location of final disposal sites
- final disposal methods
- landfill structure
- level of sanitary landfill development and operation

e.2 Location of Final Disposal Sites

e.2.1 Agreed Matters

During the first study period in Turkey, from August to November 1998, the following policy for the final disposal plan was agreed between the counterpart team and the Study Team.

a) Each municipality shall have a final disposal site only for their own use until the target year, 2020.

b) The existing Sofulu final disposal site will be used for Adana. The capacity of this disposal site will be sufficient until the year 2006 according to the rough calculation based on the 1/25,000 map surveyed in 1955.

c) The Cimsa site will be used as a new disposal site for Mersin. The capacity of this disposal site will be sufficient until the target year, 2020.

The remained issue in the final disposal system to be solved is to identify a future disposal site for Adana which will be used after 2007 until the target year, 2020. Because it is difficult to identify a future site for final disposal for Adana as of now, the study here discuss about the following three cases to find the appropriate policy.

It should however be noted that the north-east part of Adana Cement Factory excavation area likely to be out of operation within 5 - 6 years. This area could be an adequate sanitary landfill area if further investigations prove the same.

a) To use cavities in a mining quarry site where mineral resources have been exhausted.

b) To use flat land.

c) To use a valley area.

e.2.2 Comparison of Three Cases

The general suitability of the three cases for final disposal will be compared. The table below shows the items for assessing the suitability of a site for final disposal. These items will be applied for the three cases in general for comparison.

Table 5-7: General Items for Assessment

Assessment Items	Description	Indices
Social Aspect		
Land acquisition		Present user
Public acceptance	Nearby residents' acceptance	Location and area of communities
Social separation	Separation of community	Location and area of communities
Displacement	Impact on residents	Number of houses to be displaced
Religious matter	Impacts on churches, mosques, cemeteries	Location of churches, mosques, cemeteries
Public facilities	Impacts on public facilities	Location of schools and hospitals
Visibility of landfill site	Aesthetic	Visibility from outside
Future land use near the site	Possible future residential area	Land use plan
Environmental Aspect		
Water pollution	Water use downstream of the site	Water use of stream water or well
Odour		Location and area of communities
Noise		Location and area of communities
Vibration		Location and area of communities
Landscape		present land use
Flora	Impact on existing flora	Existence of natural forest
Fauna	Effect on fauna	Existence of wild animals
Inundation		Condition of present topography
Technical Aspect		
Capacity	Volume for waste	volume
Availability of coverage soil		Existence of coverage soil nearby
Accessibility	Condition of access road	Availability of access road in general
Financial Aspect		
Transport cost	Transport cost for waste	Transport distance
Construction cost of road		Newly constructed road length

The table below shows the summary of general assessment of the three cases for final disposal.

Table 5-8: Summary of General Assessment

Assessment Items	Case A (Old Quarry)	Case B (Flat land)	Case C (Valley)	Description
Social Aspect				
Public acceptance	N/A	N/A	N/A	0: many nearby residents 1: few nearby residents 2: Few nearby residents within 300m
Social separation	N/A	N/A	N/A	0: Community exist in the site. 1: Community exist nearby. 2: No existing community within 300m.
Displacement	2	0	1	0: Many inhabitants 1: A few inhabitants 2: No inhabitants within the site
Religious matter	N/A	N/A	N/A	0: Religious facilities within the site. 1: Religious facilities within 300m. 2: No religious facilities within 300m.
Public facilities	N/A	N/A	N/A	0: Public facilities within the site. 1: Public within 300m. 2: No public facilities within 300m.
Aesthetic	2	0	1	0: Visible 1: Partially visible 2: Screened
Future land use	N/A	N/A	N/A	0: Residential are in all surrounding areas. 1: Residential area on some sides. 2: Industrial area, Agricultural area.

Assessment Items	Case A (Old Quarry)	Case B (Flat land)	Case C (Valley)	Description
Environmental Aspect				
Water pollution	N/A	N/A	N/A	0: Many people using stream and well water 1: Not many people using stream and well water 2: No use of stream and well water
Odour	N/A	N/A	N/A	0: Many residents within 300 m 1: Not many residents within 300 m 2: No resident within 300 m
Noise	N/A	N/A	N/A	0: Many residents within 300 m 1: Not many residents within 300 m 2: No resident within 300 m
Vibration	N/A	N/A	N/A	0: Many residents within 300 m 1: Not many residents within 300 m 2: No resident within 300 m
Landscape	2	0	1	0: Steep slope 1: Gentle slope 2: Flat
Flora	2	0	0	0: Abundant natural condition 1: Some natural condition 2: No natural condition
Fauna	2	0	0	0: Abundant natural condition 1: Some natural condition 2: No natural condition
Inundation	2	0	0	0: Stream within the site 1: Stream by the site 2: No stream nearby
Technical Aspect				
Capacity	N/A	N/A	N/A	0: Less than 1 million m^3 1: 1 million m^3 - 5 million m^3 2: More than 5 million m^3
Availability of coverage soil	2	0	1	0: Not available nearby 1: Available nearby 2: Available within the site
Accessibility	2	1	0	0: No access road in general 1: May not be access road 2: An access road exists
Financial Aspect				
Land acquisition cost	2	0	1	0: High 1: Average 2: Low
Transport cost for waste	N/A	N/A	N/A	0: More than 25 km 1: 15 - 25 km 2: Less than 15 km
Construction cost	2	1	0	0: More than 5 km 1: 0 - 5 km 2: No new road construction
Total	**20**	**2**	**5**	

There are several important items which can not be assessed unless the specific site is identified. When the site is selected, the assessment results for these items based on reliable detailed information have to be taken into account because they will be very important.

However, when we consider the general policy without detailed information available, the implication of Table 5-8 should be useful and therefore respected.

It concludes the use of quarry site for final disposal, Case A, is the most appropriate. Moreover, it has following advantages which are not included in the comparison table.

a) Small negative environmental impacts because the natural environment in this site has been damaged by quarry operation.

b) Coverage soil generally can be obtained from overburden (residues from mining operation) within the site.

c) Disposal operation can be easily screened by providing with small buffer such as planting trees because waste filling will be below the original ground.

d) The land value of an old quarry is very little.

e) No displacement will be involved in general.

f) To fill up cavities with waste will enable the land to be used for new purpose. It will increase the land value remarkably.

There are several considerable advantages for using an old quarry site as described above, while no particular disadvantages are identified in general. In Adana, there are many old quarry sites which are generally quite suitable to be used for final disposal. It can be, therefore, a wise policy to use old quarry sites for final disposal in Adana.

To use flat land, Case B, can not be a general policy recommended due to its lower marks in the comparison table.

Case C of using a valley for a final disposal site in Adana is generally not recommended because most hilly areas in Adana overlap with the areas for water source. Since this can be one of the critical factors for selecting a site, the possibility of selecting valley sites for a disposal site in Adana will be most unlikely and generally not preferable for Adana.

e.3 Final Disposal Methods

The final disposal methods can be divided into the following three types:

- open dumping
- controlled tipping
- sanitary landfill

Although the open dumping method is generally employed in the disposal sites in Adana and Mersin, this operation shall be terminated in view of its adverse effects on landscape, public health and the environment.

Sanitary landfill should be adopted as it has been proven to be the most economical final disposal method in terms of controlling environmental impacts within the acceptable level.

The advantages of sanitary landfill are as follows.

- Where land is available, sanitary landfill is usually the most economical solid waste disposal method.

- Sanitary landfill is not investment intensive compared with other disposal methods, i.e., composting and incineration.
- In contrast to incineration and composting, sanitary landfill does not require additional treatment or disposal operations for residue, quenching water, unusable materials, etc.
- A sanitary landfill can receive all types of solid wastes, eliminating the necessity for separate collections.
- A sanitary landfill is manageable; increased quantities of solid wastes can be disposed of with a minimum number of personnel and equipment.
- Submerged land may be reclaimed for use as parking lots, playgrounds, golf courses, botanical gardens, etc.

e.4 Landfill Structure

There are five types of landfill structure as shown below.

- anaerobic landfill
- anaerobic sanitary landfill
- improved anaerobic sanitary landfill
- semi-aerobic sanitary landfill
- aerobic sanitary landfill

Either of the above landfill structures contribute to the mitigation of environmental pollution. Figure 5-5 illustrates each of the above landfill structures.

Anaerobic landfill

As leachate generated in landfill layers is hardly drained, the landfill layers constantly maintain anaerobic condition. The quality of leachate is very poor, causing bad odour and propagating vectors and vermins.

Anaerobic sanitary landfill

Covering soil is applied on each layer of waste thereby preventing the outbreak of bad odour and incidental fires, and the propagation of harmful insects to a certain extent. However, leachate and gas generation problems remain.

As in anaerobic landfill the landfill layers maintain anaerobic conditions.

Improved anaerobic sanitary landfill

In addition to covering soil this landfill structure is constructed with a leachate drainage facility at the bottom of the disposal site. Leachate quality is improved and anaerobic conditions are maintained.

Semi-Aerobic sanitary landfill

Leachate quality is favourably improved with constant drainage. Drainage pipes stimulate natural ventilation, achieving aerobic conditions in the landfill layers and consequently accelerating solid waste decomposition.

Aerobic sanitary landfill

In addition to the drainage pipes used in semi-aerobic landfills, air supply pipes are introduced for forced air injection to achieve aerobic conditions in the layers, thereby accelerating solid waste decomposition and stabilisation and improving leachate quality.

Applicability

Where the annual precipitation is large, the semi-aerobic sanitary landfill or aerobic sanitary landfill methods are generally adopted aiming at the improvement of leachate quality. When the utilisation of biogas by using anaerobic digestion is planned in the region where the annual precipitation is little, the improved anaerobic sanitary landfill with liner is generally adopted.

The best landfill method depends on many factors such as the total solid waste management system, especially the type of processing and treatment method adopted, the climate, the natural condition of the disposal site, the available budget for solid waste management, etc. Therefore, these all factors have to be taken into account to select the best landfill method so that its own advantages can be effectively utilised.

e.5 Level of Sanitary Landfill Development and Operation

The sanitary landfill development and operation levels are classified as follows:

- Level 1, Controlled tipping
- Level 2, Sanitary landfill with dike and daily soil covering
- Level 3, Sanitary landfill with primary leachate circulation system
- Level 4, Sanitary landfill with leachate treatment system

The prospective sanitary landfill development and operation levels are illustrated in Figure 5-6.

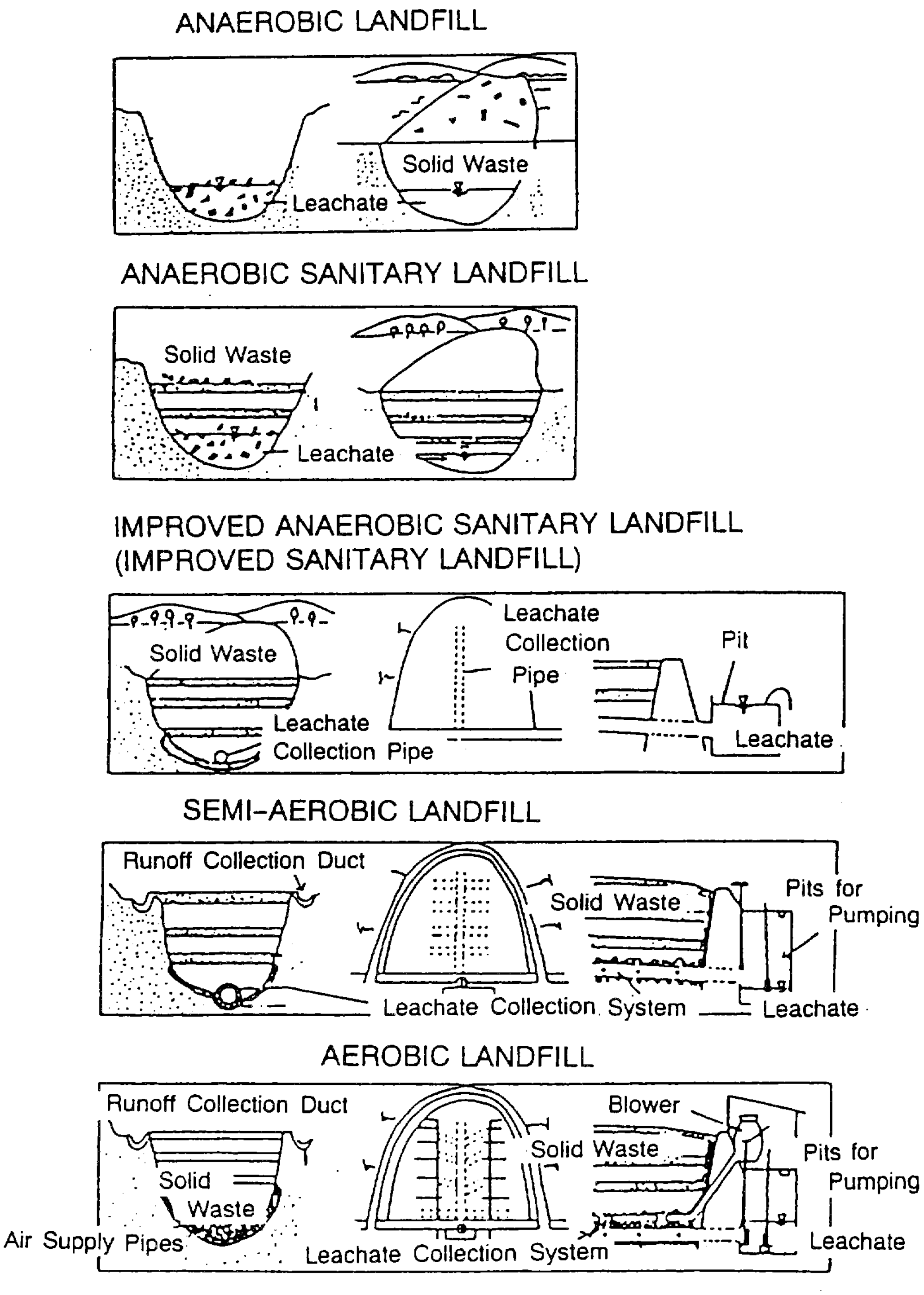

Figure 5-5: Landfill Structures

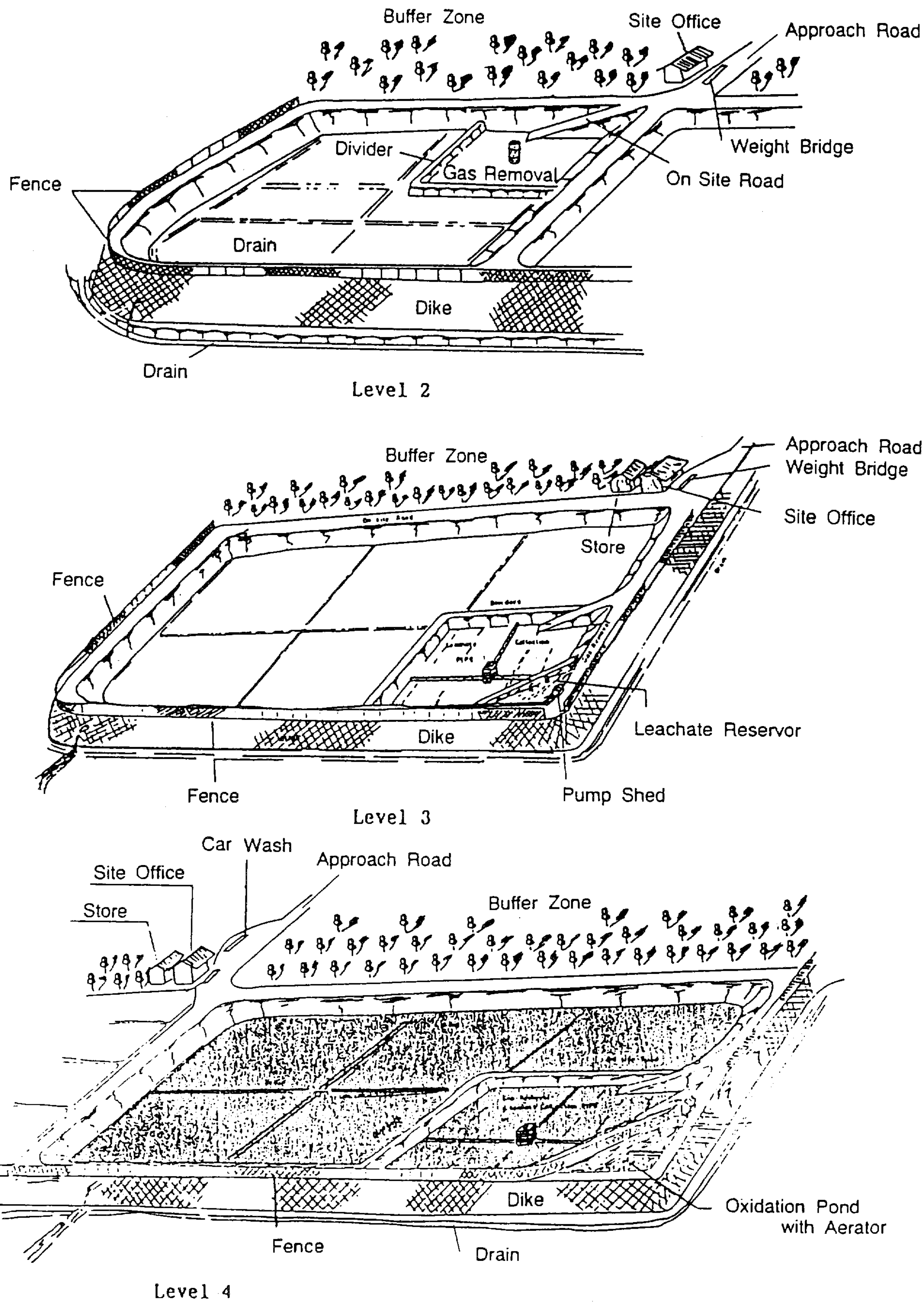

Figure 5-6: Illustration of Prospective Sanitary Landfill Development and Operation Levels 2, 3 and 4

The above mentioned sanitary landfill development and operation levels are described below.

Level 1: Controlled Tipping

Introduction of controlled tipping through:

- Establishment of access to site.
- Provision of cover materials for the prevention of fire outbreaks and the dispersion of rank odour.
- Establishment of inspection, control and operational recording system for incoming waste.

Level 2: Sanitary Landfill with Dike and Daily Soil Covering

Introduction of sanitary landfill through:

- Establishment of disposal site boundary to eliminate scavenging and to avoid light waste scattering by wind.
- Execution of sufficient cover over waste disposed.
- Enclosing the disposal area with a dike.
- Construction of a divider between present and future landfill areas.
- Establishment of a drainage system in order to divert storm water flow from surrounding areas away from the disposal site and to reduce leachate.
- Construction of environmental protection facilities, such as buffer zone, litter control and gas removal facilities, to abate direct impact on surroundings.
- Installation of gas removal facilities to achieve the conditions necessary for a semi-aerobic sanitary landfill.
- Introduction of amenities for staff.

Level 3: Sanitary Landfill with Leachate Circulation

Establishment of leachate control through:

- Installation of leachate collection, circulation and monitoring facilities.
- Installation of liners for seepage control.
- Construction of semi-aerobic sanitary landfill to accelerate waste decomposition and facilitate stabilisation.
- Introduction of water sprinkling for dust prevention.

Level 4: Sanitary Landfill with Leachate Treatment

Establishment of leachate treatment through:

- Installation of an oxidation pond.

The above mentioned sanitary landfill development and operation levels are described and tabulated in the table below. Table 5-10 shows the environmental standard each landfill level has to meet.

Table 5-9: Outline of Sanitary Landfill Development and Operation

	Items	Level of Sanitary Landfill 1	2	3	4	Remarks
1	**Site Development**					
1.1	*Main Facilities*					
a.	Enclosing Structures					
	• Enclosing dikes		A	A	A	
	• Dividers		B	A	A	B means a dike made of refuse and soil
b.	Drainage System					
	• Surrounding drains		A	A	A	
	• On-site drains (surface water)		A	A	A	
	• On-site drains (spring)		A	A	A	If necessary
	• Drains for reclaimed area		A	A	A	
c.	Access					
	• Approach roads	A	A	A	A	
	• On-site roads	A	A	A	A	
	• Others	A	A	A	A	Improvement of existing road network to access the sites
1.2	*Environmental Protection Facilities*					
	Buffer zones		A	A	A	
	Litter control facilities		B	A	A	Movable fences, etc.
	Gas removal facilities		B	A	A	
	Leachate collection facilities			A	A	
	Leachate circulation facilities			A	A	
	Seepage control facilities			B	A	
	Leachate treatment facilities				A	
1.3	*Building and accessories*					
	Site office	B	A	A	A	
	Weighbridge	A	A	A	A	
	Store			A	A	
	Safety facilities		A	A	A	Gate, fence, lights, etc.
	Fire prevention facilities		B	A	A	Water tank, extinguisher, etc.
	Monitoring facilities			A	A	Monitoring well, etc.
	Car washer			A	A	
2	**Equipment**					
	Landfill Equipment	A	A	A	A	
	Others			A	A	Water truck, inspection vehicles, etc.
3	**Operation and Maintenance**					
3.1	*Operation*					
	a. Personnel					
	b. Cover material	B	A	A	A	B means insufficient soil cover.
	c. Utility					
	• Fuel tank	A	A	A	A	
	• Water		A	A	A	
	• Electricity	B	A	A	A	
	d. Chemicals					
	• Insecticide	A	A	A	A	
	• Monitoring chemicals			A	A	
	e. Others		A	A	A	Divider, drain for reclaimed area, leachate collection pipes, etc.
3.2	*Maintenance*					
	• Main facilities		A	A	A	
	• Environmental protection facilities		A	A	A	
	• Building and accessories	A	A	A	A	
	• Equipment	A	A	A	A	

A: necessary
B: necessary under certain conditions, or may be omitted when budget is not enough

Table 5-10: Environmental Standards for Each Sanitary Landfill Development and Operation Level

Items		Sanitary Landfill Development and Operation Level			
		Level 1	Level 2	Level 3	Level 4
1	**Landfill Structure**				
1.1	Landfill Structure	Anaerobic Sanitary Landfill	Improved Anaerobic Sanitary Landfill	Semi-aerobic Sanitary Landfill	Semi-aerobic Sanitary Landfill
1.2	Achieved Condition	• Leachate generated in solid waste layers is seldom drained; an anaerobic state is maintained. Generally, the quality of leachate is poor. • Because of inactive decomposition of wastes, stabilisation is slow.	• Through gas removal facilities, the quality of leachate is slightly better than in Level 1; an anaerobic state is maintained. • The rate of decomposition is slightly improved.	• Leachate accumulated at the bottom of landfills is promptly discharged through drain pipes (leachate collection pipes). The pipes also permit natural ventilation. • This structure facilitates decomposition of solid waste because a semi-aerobic condition is maintained. The quality of leachate is much improved and generation of offensive odour is further reduced. • Water content of solid wastes is lower than Level 2	• Leachate accumulated at the bottom of landfills is promptly discharged through drain pipes (leachate collection pipes). The pipes also permit natural ventilation. • This structure facilitates decomposition of solid waste because a semi-aerobic condition is maintained. The quality of leachate is much improved and generation of offensive odour is further reduced. • Water content of solid wastes is lower than Level 2
2	**Leachate and it's Impacts on Surroundings**	•			
2.1	Leachate Generation Amount	• Leachate is freely discharged outside of both landfilling and reclaimed areas because of the absence of an enclosing structure. • Rain water flows into the landfill from catchment area and increases leachate amount.	• As for reclaimed areas, surface water is drained and discharged outside. • Rain water from the catchment area is diverted into surrounding drains. • A divider separates the area for leachate generation from the working area. • The separation of the area for leachate generation reduces leachate amount.	• As for the reclaimed areas, surface water is drained and discharged outside. • Rain water from the catchment area is diverted into surrounding drains. • A divider separates the area for leachate generation from the working area. • The separation of the area for leachate generation reduces leachate amount.	• As for the reclaimed areas, surface water is drained and discharged outside. • Rain water from the catchment area is diverted into surrounding drains. • A divider separates the area for leachate generation from the working area. • The separation of the area for leachate generation reduces leachate amount.
2.2	Leachate Control Facilities	• None	Enclosing dike and divider prevents direct discharge of leachate.	• In addition to the facilities for Level 2 are leachate cycling and monitoring facilities. • Leachate is discharged only during heavy rain from regulating pond. Leachate discharged is therefore, diluted.	• Conditions are similar to Level 3 except for effluent which is constantly treated and discharged from oxidation pond.
2.3	Leachate Treatment Facilities	• None	• None	• Retention and regulation ponds may work as oxidation pond.	• Leachate is treated in an oxidation pond with aerator.

Items		Sanitary Landfill Development and Operation Level			
		Level 1	Level 2	Level 3	Level 4
2.4	Leachate Quality	• High leachate content, and the quality is the poorest of all the landfill levels. The quality is also not expected to improve much even after a long period of time.	• Amount of leachate is limited because of dike and divider. However, leachate quality does not improve even after a certain period of time.	• Amount of leachate is limited as in Level 2. • The quality of leachate improves because of the semi-aerobic condition of the landfill. • Leachate circulation facilitates waste purification • Since leachate is discharged only during heavy rain, it is therefore, diluted.	• Amount of leachate is limited as in Level 2 • The quality of leachate will be treated in order to meet the effluent standards.
2.5	Leachate Impact				
a.	Impacts on Underground water	• The degree of the impact varies depending on the permeability of bottom soil. • If bottom soil is permeable, the impacts on underground water will be immense because of high pressure head and large amount of leachate.	• The degree of the impact varies depending on the permeability of bottom soil. • The amount of leachate is much less than Level 1. However, leachate would still have immense impact if bottom soil is permeable.	• Liner is laid to protect underground water from leachate seepage. • There is very little underground water contamination	• Liner is laid to protect underground water from leachate seepage. • There is very little underground water contamination.
b.	Impacts on Surface Water	• Because leachate is freely discharged from the landfill site, the impacts on surrounding water area is very high.	• Discharge of leachate may occur when the divider is submerged and through seepage. • Although leachate amount is limited, impacts on surrounding water area is high because of uncontrolled and unimproved leachate.	• Discharge of leachate occurs only during heavy rain. • Leachate can be monitored. In case leachate to be discharged would affect the surroundings, the construction of leachate treatment facility is encouraged.	• Effluent from landfill site will satisfy the required effluent standards.
3	**Others**				
3.1	Vector control	• generates a large amount of flies, insects and rodents. • entices the huge gathering of crows • constant generation of rank	• Vector control is achieved and at a much improved level compared to Level 1.	• Vector control is achieved and at a much improved level compared to Level 1.	• Vector control is achieved and at a much improved level compared to Level 1.
3.2	Odours and Gas Production	• Occasional fires occur due to spontaneous ignition	• Conditions are much better than Level 1. • No fire outbreaks	• Due to semi-aerobic landfill structure, conditions are better than Level 2.	• Due to semi-aerobic landfill structure, conditions are better than Level 2.
3.3	Others	• scattering of wastes, dusty condition. • Deterioration of Landscape. • Noisy • Presence of scavengers.	• It is improved in all aspects.	• In addition to the condition achieved at Level 2, dust problems are mitigated with the use of a water sprinkler.	• Same as Level 3.

Applicability

The Turkey's regulation stipulates that all disposal site shall meet the standard of the fourth sanitary level. However, in fact the sanitary levels of both existing disposal sites in Adana and Mersin are worse than the first sanitary level which is the poorest.

Since it is too difficult to improve the existing disposal site to the condition which comply with the legal requirement within the reasonable budget amount, the strict enforcement to the legal requirement will be applied only for newly constructed disposal sites.

f. Operation and Maintenance of Vehicles and Equipment

Solid waste management requires investment in expensive and complex machinery and equipment both for collection and disposal. It is essential that such investment is accompanied in maintenance and repair facilities and spare parts and that there is a strong management commitment to ensuring that all plant, vehicles and equipment are properly serviced and kept in good repair. This commitment requires the availability of adequate workshops, spare parts and maintenance consumables such as lubricants, tyres, etc.; and qualified staff to carry out the maintenance and repair work. Expensive and complex equipment, which is not properly treated, will have a much reduced economic life and lack of commitment to proper care of capital equipment should be considered an abuse of public money.

Provision of fully equipped and staffed vehicle workshops is a major commitment for the municipalities with small vehicle fleets. As such, independent provision would be uneconomical. However, it is essential that basic facilities that are provided by every municipality are operating vehicles and equipment, and that arrangements are made for the use and support of more extensive facilities and resources.

Options for provision of these facilities are:

- Provided independently by a municipality with large vehicle fleet which has more than 30 vehicles or so;
- Provided by contract with one or more private sector heavy vehicle servicing companies;
- Provided by an adjoining municipality by contractual agreement or formation of union.

Most leading vehicle manufacturers will give guidance on service and maintenance procedures, staff training and on minimum spare part holdings.

5.1.5 Selection of An Optimum Technical System

a. Collection and Haulage System

Basing on the preliminary study that achieved in the study are, Adana and Mersin are reflecting similar kind of social and technical conditions and inadequacies related with solid waste storage, collection and disposal.

Proposed technical system should be consistent with the existing conditions and existing practices, giving provision for improvements within the system, in order to coupe with the system much easily.

A technical system may consist and built up from various technical alternatives. The system can be formed from one of these or from the combination of these alternatives.

a.1 Discharge and Storage

There is a wide range of issues to be considered in the selection of the best storage system for the target area. The examples are as follows.

- The amount and composition of waste discharged.
- Waste composition and components.
- The collection frequency, most often determined by climate and waste composition.
- The spaces available near the source and the accessibility of the area to collection vehicles.
- Environmental and occupational health hazards.
- Suitability to the actual environment, i.e., functions suitable for the actual user.
- The ability to stand misuse, rough climate, and animals scavenging.
- The total investment and operational costs over a given period.
- The habits and traditions of users and collection crews.

In Adana and Mersin, the waste is generated on a somewhat continuous basis and the collection occurs mostly daily, depending on the quantity generated at a specific location and climatic conditions. Therefore, it is necessary to provide proper on-site storage for waste until it is collected.

Storage is quite important because it has significant effect on public health and aesthetic conditions, collection and the attitudes of public who are very much concern on the operation of the system. The effects on these aspects vary depending on the generation source, i.e., residences, shops, office buildings, etc.

a.1.1 Selection of Discharge and Storage System for Adana

When discussing the refuse storage in Adana, two systems are being identified:

- Communal
- Curbside

Communal storage is where a number of dwellings, sometimes commercial, uses one common container. The average container size in this system in Adana is 200-800 lit., and types of containers used are often standard wheeled containers, and some stationary cubicles.

Curbside storage is a system where residents place their own containers onto the footway. The average container size in this system in Adana varies from 20 lit. to 800 lit.

It would be beneficial to aim to extend the communal storage system, with standardised wheeled container system with 400-800 lit. capacity containers in all parts of Adana, especially high and middle income areas. In the low-income areas, wherever it is affordable by the residents, it will be necessary to introduce wheeled container system.

Thus, the existing storage units and vehicles with mechanical lifting devices will have the opportunity to continue to carry on their duties, and therefore the efficiency of the collection will be improved technically and economically.

The plastic and metal bin containers and the use of metal drums, which have extensive usage, should be discontinued in the low-income areas, due to the restrictions to the proposed communal storage system.

In the areas (high and middle income mahalles) where residents consumes liquid fuels, it is proposed to use plastic wheeled containers of 800 lit. capacity. In the low-income mahalles, solid fuels are extensively in use, and therefore metal wheeled containers of 800 lit. have to be used.

The wheeled container system requires a reasonable amount of investment but contributes to the reduction of large collection and haulage operation costs.

Aesthetic considerations are related to the production of odours and the unsightly conditions that can develop when adequate attention is not given to the maintenance of sanitary conditions. Most odours can be controlled through the use of sealed containers and with the maintenance of a reasonable collection frequency, or through the timely discharge of waste by dischargers with punctual waste collection services. To maintain aesthetic conditions, the container should be scrubbed and washed periodically.

On the other hand the remaining collection vehicles (tractor trailers, trucks, etc,) have to be replaced with compactors with mechanical lifting devices, in order to achieve an efficient collection process.

a.1.2 Selection of Discharge and Storage System for Mersin

When discussing the refuse storage in Mersin, one system is being identified:

- Communal

Communal storage is where a number of dwellings, sometimes commercial, uses one common container. The average container size in this system in Mersin is 400-800 lit., and types of containers used are often standard wheeled containers.

There is an intensive usage of 400 – 800 lit. standard wheeled containers. The 400 lit. containers are metal, where the 800 lit. containers are plastic and metal.

Though the communal system is the most efficient system for storage, it is proposed to continue with this system (800 lit. capacity containers) in Mersin. Thus, the existing storage units and vehicles with mechanical lifting devices will have the opportunity to continue to carry on their duties, and therefore the efficiency of the collection will be improved technically and economically.

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a.2 Initiation of Source Separation for Adana and Mersin

It has been declared in the previous chapter that waste separation at the source is usually accomplished by manual means. It is mainly not a technical but an organisational way of resource recovery. The number and types of components separated depend on the waste diversion goals established for the program. Even though waste materials have been separated at the source, additional separation and processing will usually be required before the materials can be reused or recycled.

It is also mentioned that source separation can be accomplished mainly in two methods:

- Source separation by plastic bags
- Source separation by containers

The source separation by containers is mainly achieved in developed countries, where living conditions are high and public awareness is very much developed and improved and needs huge initial investment. So, it is proposed to initiate source separation by plastic bags in Adana and Mersin. Although there is an intention of practising a composting scheme in Mersin, it is extremely important to achieve a state-of-art application in Mersin, in order to improve the compost quality.

The system will consist of special plastic bags of 50-150 lit. for storing non-compostables (recyclables) and compostables (organic matter). Collection frequency for the recyclables will be once a week. The compostables (organics) will be stored in a separate bag, if possible green in colour, and will be collected daily.

The collection system for the source separated recyclables will be separately collected, by other collection vehicles than compactor trucks. The source separated non-compostables (recyclables) will be transported to simply and manually sorting centres to be salvaged.

At the beginning, it will be beneficial to start the application in high-income pilot mahalles of Adana and Mersin and after evaluating the results and making the necessary improvements, it should be extended to the other part of cities.

a.3 Collection and Haulage System

The objective of the waste collection and haulage system is to collect and to haul waste from specific locations to a disposal site at regular intervals, with minimal cost and in a reliable manner, and with due considerations for sanitary conditions. It is very important to always bear in mind that the cost for the collection and haulage of waste is by far the most expensive part of the overall waste management system.

The following aspects mainly affect the collection and haulage system:

- collection frequency
- collection method (mixed or separate)
- collection system
- collection schedule
- collection vehicle
- haulage distance
- haulage method
- transfer system

a.3.1 Selection of Collection and Haulage System for Adana

Existing collection system within the municipal districts of Adana is a mixed system of three collection methods:

- Communal collection
- Curbside collection
- Door-to-door collection

Considering the climatic conditions, i.e., high temperature and moisture, waste composition including a high percentage of organic fraction, and high population density, existing collection practices, communal collection system is recommended for Adana City.

The proposed frequency of collection for Adana District Municipalities is daily collection (six days a week).

It is also recommended that the collection vehicles must be 12 m^3 - 16 m^3 capacity compactor trucks with mechanical lifting devices, in order to achieve a satisfactory level of service. The tractor trailers should be replaced with compactor trucks equipped with lifting devices.

The waste generated in the narrow streets of the old city of Adana, where the compactor trucks would not be able to enter and collect waste, would be served by satellite collection vehicles, which would achieve a short-range transfer. The satellite collection vehicle will collect the waste from narrow streets and will dispose its content to a large capacity container (preferably a skip container), and a skip loader will haul the skip container to disposal.

a.3.2 Selection of Collection and Haulage System for Mersin

Existing collection system within the municipal districts of Mersin, also witnessed in Adana, is a mixed system of three collection methods:

- Communal collection
- Curbside collection
- Door-to-door collection

Mersin is reflecting the similar climatic, social conditions and participates same collection practices as Adana, and therefore communal collection system is recommended for collection of wastes.

Collection frequency in Mersin is daily and municipal cleansing services are collecting the waste six days a week.

The waste collection fleets of Mersin district municipalities are composed of compactor trucks, with mechanical lifting devices, capacities of 12 m^3 - 16 m^3. Therefore the proposed collection system will be consistent with the existing conditions and existing practices, and will coupe easily with the system by some relative improvements within the existing system.

The waste generated in the narrow streets of Mersin, where the compactor trucks would not be able to enter and collect waste, would be served by satellite collection vehicles, which would achieve a short-range transfer. The satellite collection vehicle will collect the waste from narrow streets and will dispose its content to a large capacity container (preferably a skip container), and a skip loader will haul the skip container to disposal.

a.4 Selection of Transfer and Haulage System of Solid Wastes in Adana and Mersin

Waste discharged in transfer stations are hauled to the final disposal sites using large trucks with a capacity of 20 to 50 m^3 to minimise overall transport costs. A transfer station is where waste from collection vehicles of limited capacity are loaded into vehicles of larger capacity for haulage to a disposal site.

The main purpose of using a transfer station is to reduce the net cost of transporting waste from collection areas to the final disposal site. The issue of whether or not to build and operate a transfer facility is almost entirely depends on the distance of the disposal site to the collection zones.

Although this system reduces haulage expenses, it requires additional cost for the construction of a transfer station, as well as for dumping and loading work. Accordingly, this system is not financially beneficial unless the disposal site is located far away.

a.4.1 Adana

The existing disposal site (Sofulu dumpsite) in Adana is located 10 km away from the city centre. Generally, the construction of a transfer station is considered to be impractical if the transport distance is less than 20 km (one way). Therefore, no financial benefits can be expected from the introduction of a transfer station while Sofulu dumpsite is in use in Adana. In near future, the existing dumpsite will be rehabilitated and a new landfill site will be put in to operation, which will be far from the city. Additionally, future urban expansion limits in Adana will also force the collection system and therefore, there will be a need of putting in action a transfer station(s).

a.4.2 Mersin

The situation in Mersin is same. Existing landfill site (landfill site in the composting plant - Cavuglu) is located 6km from the city centre. Under existing conditions, it is obvious that there is no need for a transfer station. But the capacity of the landfill will be exceed in very near future, and the future urban expansion limits in Mersin will force the existing collection system and therefore there will also a need of introducing a transfer station(s) in Mersin.

a.5 Summary of the Collection and Haulage System for Adana and Mersin

The best collection and haulage system for Adana and Mersin are concluded in the table below.

Table 5-11: Summary of the Collection and Haulage System for Adana and Mersin

Item	Adana	Mersin
Discharge & storage	• Communal container	• Communal container
Storage receptacles	• 800lit. wheeled containers in residential areas	• 800lit. wheeled containers in residential areas
Collection method	• Communal collection with wheeled containers	• Communal collection with wheeled containers
Collection frequency	• Daily – 6 days a week	• Daily – 6 days a week
Collection schedule	• Day collection in all collection zones	• Day collection in all collection zones
Collection and haulage vehicles	• Compactor trucks	• Compactor trucks
Haulage system	• Direct haulage • Provision of transfer station(s) if necessary	• Direct haulage • Provision of transfer station(s) if necessary

b. Public Area Cleansing

Previously, street sweeping methods have been grouped under these general headings:

- manual sweeping
- mechanical sweeping
- vacuum sweeping
- flushing

In Adana and Mersin, there is a mixed system of manual/mechanical street sweeping application. The main roads and boulevards are mostly swept by mechanical street sweeper, where other streets are cleaned by labour force, manually.

The flushing system is not at all suitable for the Adana and Mersin in view of the expensive investment and problems that would occur from maintenance and supply of spares for the equipment.

Full application of mechanical and vacuum sweeping systems are also not suitable for the target area, because they require large capital, and incur high operational and maintenance costs and in addition due to the inadequate road and parking conditions in the town. This system would be applicable to the main boulevards and roads, taking the necessary precautions related with parking.

Conclusively, manual sweeping generally is most appropriate system for Adana and Mersin because of an abundant and inexpensive supply of labour force. The jobs that are generated by the sweeping system can contribute, albeit to a smaller degree, to the betterment of the municipalities economic situation and create opportunities to unemployment. This system is also flexible and can cope with waste containing lots of dust and sand, which is a main problem in target area cities.

On the other hand, manual cleansing services have to be supported with mechanical and vacuum sweeping practices.

Therefore the street sweeping system of Adana and Mersin should be a mix system of manual sweeping and mechanical sweeping systems. This will also give provision to coupe with the existing system. However, the ratio of manual and mechanical sweeping services shall be reviewed considering future labour forces and costs in view of cost/benefits relation.

c. Recycling

The Study Team concluded to propose that the government related recycling system as described below should be established.

1) In order to minimise the waste generation amount, it is firstly necessary to manufacture products which can be easily recycled, taking such factors into account in the design process of products. Therefore, it is necessary to establish the proper administrative system which help to forward the change of socio-economic system.
2) Secondary, the technical system which maximise the recycling amount of generated waste should be established. In the concrete, the essential measures are to establish the efficient source segregation system, to collect separated waste in minimal cost and to promote recycling waste.

The public sector should be greatly involved in forwarding the society to the establishment of such recycling system by the following reasons.

1) The Study Team forecast the GRDP in 2020 US$3,891/capita for Adana and US$3,307/capita for Mersin. Since the solid waste problems are ordinary related to the economic growth, it is forecast that both cities will have the similar solid waste problems as the current problems which developed countries have, such as shortage of disposal sites, high cost for waste treatment

and disposal, etc. Therefore, in order to avoid to meet such problems, it is necessary to create "the closed loop society" regarding solid waste.

2) The present recycling system is greatly supported by the abundant cheap labour forces of the informal sector. It is projected that the present recycling system will diminish with the growth of economy and disappear in 2020 when GRDP reach the projected level.

3) The present recycling system is mainly dealing with commonly recyclable wastes. However, in order to increase the recycling rate it is necessary to establish the system to recycle non-recyclable wastes such as putrescible (organic) wastes. To materialise such system, the public sector has to take the initiative for the promotion of separate discharge and separate collection systems.

Based on the above, the Study Team proposes that the recycling system, as described below, for the target area will be established in 2020.

1) To establish the separate discharge and collection system which deals with compostable (organic/putrescible) wastes and non-compostable (non-putrescible) wastes separately.

2) To collect the valuable materials as much as possible at sorting plants to be constructed.

3) To utilise as much compostable (putrecible) wastes as possible to produce compost after removing impurities.

The above statement 1) is described in "a" of this section and statements "2) and 3)" is in "d".

d. Intermediate Treatment

The introduction of intermediate treatment system is generally demanded by the following needs in this order.

1) To expand the life year of disposal sites by reducing the final disposal amount of waste.

2) To make landfill waste inert.

3) To promote the waste recycling.

At present, since it is relatively easy to acquire land for final disposal in the target areas, the demand of urgent introduction of the intermediate treatment system is not so high.

On the other hand, In the creation of a "closed loop society", the following three points are significant issues to be addressed.

1) To make all possible efforts to reduce the amount of waste generated during production and consumption, and through waste management.

2) To thoroughly recycle waste, the generation and discharge of which is unavoidable, even after the efforts in 1) above has been made.

3) To minimise adverse environmental impacts to the surrounding areas of the disposal sites with the appropriate environmental protection measures.

The best intermediate treatment system is concluded to be the following combination based on the above discussion.

1) To thoroughly recover materials at generation sources and materials recovery facilities.

2) To increase the recycling of putrescible (compostable) waste by the introduction of compost plants or biogas production plants.

3) To produce refuse derived fuel (RDF) from residues of the above mentioned facilities.

Provided that such best intermediate treatment system is established, and that manufacturing recycling friendly products is administratively extended, and that the efficient solid waste management system, including the proper discharge and collection system, is executed, it is possible to approach the target recycling rate, 90%, for the Ministry of Environment. In fact, in some of developed countries like Japan, there is a trend to change the current policy which gives too much importance to incineration to the new policy which gives more importance to recycling.

However, the introduction of the best intermediate treatment system requires not only huge investment but also overcoming various difficult barriers such as high operation and maintenance cost and accumulation of appropriate technologies for operation and maintenance. Considering the present situation of disposal sites which often have fire, it is not easy to believe that the best intermediate treatment system will be realised in 2020. Therefore, a few scenarios composing of sub-technical systems are discussed in the following sections 5.2 and 5.3.

e. Final Disposal System

Consequently, the first priority should be to construct the sanitary disposal site which complies with the legal requirement of the Ministry of Environment. The most important factor in final disposal is to select an appropriate site. In terms of site condition, to use old quarry sites scattering in the target areas is considered to be suitable. The issue whether the aerobic or anaerobic landfill method should be adopted has to be judged taking the total solid waste management system into account.

f. Operation and Maintenance of Vehicles and Equipment

There are basically two possible alternatives for the maintenance of vehicles and equipment.

The first alternative would be the allocation of preventive services to the municipal workshop and large-scale repair and maintenance services to private garages.

The second alternative would be the allocation of all maintenance and repair works to the municipal workshop.

Since preventive services are basic and essential for the maintenance of vehicles, the first alternative would be inexpensive, as it would only require basic facilities and a minimum number of mechanics and workers. The private workshops must have sufficiently skilled personnel to properly provide the municipal fleet with the required technical services. Since there are many private workshops in Adana and Mersin with skilled mechanics to provide these services, the first alternative would be appropriate for the both all district municipalities in Adana and Mersin

The second alternative demands a large number of skilled mechanics, a large workshop, as well as sophisticated machinery. It is capital intensive and requires a lot of money for operation and maintenance, as well as management of technical difficulties that may arise, with a degree of uncertainty and risks.

Communal organisations tend to inefficiently conduct operations due to inflexibility, political interference, lack of motivation among staff, slow decision-making processes, etc. Therefore, the services to be conducted by the municipal workshops should be minimised and the first alternative is concluded to be more appropriate operation and maintenance of vehicles and equipment in Adana and Mersin.

g. Medical SWM

The main aims of the medical waste management master plan are:

- Waste minimisation
- Recycling
- Waste stabilisation

Waste minimisation and recycling are closely related, because through these two actions the final waste volume can be reduced. Waste stabilisation, on the other hand, is a way to safely dispose of the waste so that harm to both the environment and the public are eliminated. In order to achieve the goals of the master plan, therefore, the overall waste flow (see Figure 5-7) must be considered, possible remedies identified, and an improvement strategy devised.

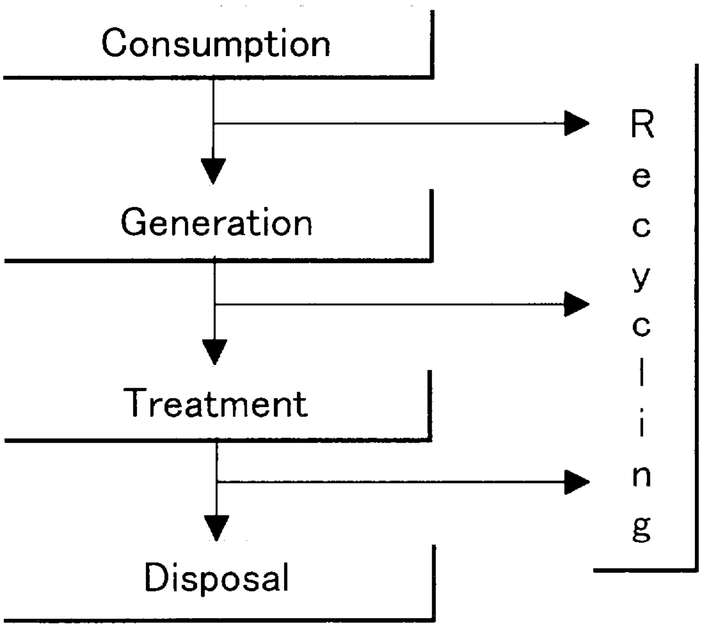

Figure 5-7: Medical Waste Flow Concept

g.1 Current Medical SWM

Since the disposal of infectious and hazardous waste is defined as inappropriate even after they are separately collected from their generation sources, the medical SWM currently practised in the target areas is considered to be poor.

g.2 Separation of Infectious and Hazardous Waste at the Source

To reduce the health hazards that may result from the handling of general wastes mixed with infectious and hazardous wastes, source separation should be strongly encouraged.

g.3 Disposal Without Incineration

Because the amount of infectious and hazardous waste materials generated by hospitals in the target areas is not particularly large, disposal without incineration is selected. The selection is also influenced by the fact that an incinerator is difficult to operate. For the time being, wastes discharged at the final disposal site should be sprayed with disinfectant prior to covering.

Incineration is not recommended because: (1) the generated waste amounts are negligible; (2) high construction costs; (3) the incinerator requires very strict design protocols to reduce the amount of dioxins. Medical waste typically contains a high proportion of plastic, disposal equipment, most of which is made from PVC. Typically in the US, plastics comprise 15 - 30% of the medical waste stream; PVC is found typically in ventilator and oxygen therapy tubing, endotracheal tubes, ambu bags, facemasks and oral airways, IV bags and tubing, dialysis equipment, patient ID bracelets, gloves, protective covers and record binders, mattress covers, and packaging. PVC contains 50% chlorine by weight, and represents a large source of chlorine necessary for dioxin formation in incinerators.

Incineration is also not recommended in the short term because the amount of infectious waste discharged is too small to justify the continual operation of an incinerator. The combustion chamber lining of small scale incinerators are particularly sensitive to corrosion, especially when it is not operated continuously.

Incineration at a cement factory should be examined as an alternative for the incineration of infectious waste, in case disposal without incineration causes any health risk.

g.4 Crushing and Steam Sterilisation

The regulation on the control of medical waste specifies that lacerating and piercing materials be crushed prior to discharge, but hospitals have responded that this is not done. The regulation also states that pathological waste be autoclaved in steam resistant bags, a practise not observed by any of the hospitals interviewed. Therefore, an intermediate treatment system of crushing for lacerating and piercing materials, and steam sterilisation pathological waste, is recommended for all medical institutions.

g.5 Waste Recycling

The POS revealed that 58% of institutional waste is paper, one of the more easily recycled commodity, and yet only 7% in both Adana, and Mersin, separate paper at the point of discharge, and nearly 72% in Adana, and 85% in Mersin do not have a recycling, or recovery, system for paper. Further, hospitals have indicated that some of the recoverable hazardous chemicals listed in the medical waste regulation, such as mercury from fluorescent lighting, are not recovered. Therefore, an early introduction of an extensive recycling system is recommended for all medical institutions, as an integral part of the cities' recycling program.

g.6 Hazardous Waste Management

Our survey revealed that 61 % of the hospitals responded that do not generate hazardous waste. The characteristics and criteria of hazardous waste is clearly defined in the medical waste regulation, but the high number of hospitals not reporting hazardous waste indicate that waste management staff are either not given the correct instructions, or they do not understand the nature of the substances they handle.

In particular waste containing mercury, which is included in broken thermometers, sphygmomanometers, fluorescent light strips, and batteries, should be separated and collected separately. Also, materials that are corrosive, flammable, reactive, or with a flash point of less than 60^{o}C should be treated prior to discharge, for these substances when untreated could potentially damage landfill structures such as the bottom liner and leachate drainage system.

A system for the management, handling, and disposal of infectious and hazardous medical waste should be immediately established. As the construction of a facility for the handling and disposal of infectious and hazardous medical waste requires major investment, there is a need to devise a plan that would cover the provinces of Adana and Icel, as well as the entire region of Cukurova.

h. Selection of an Optimum Technical System

Following the examination of SWM technical sub-systems, an optimum SWM technical system for Adana and Mersin was proposed as shown in the table below. However, as described in the table an optimum intermediate treatment sub-system was subject to the examination of scenarios to be presented in the next sections.

Table 5-12: Optimum Technical System

Work	Proposed System
Storage & Discharge	• Source separation: separation of compostable and Non-compostable waste • Storage container: communal containers
Collection	• Collection frequency: 6 times a week for compostable and once or twice a week for non-compostable • Collection method: separate collection • Collection system: communal container collection system (point collection) • Collection time: daytime collection • Collection vehicle: compactor trucks ($12m^3$ - $16m^3$) • Haulage system: examine direct haulage and the introduction of a transfer station in accordance with the disposal site location
Street Sweeping	• Mix system of manual and mechanical street sweeping but the ratio of manual and mechanical sweeping services shall be reviewed considering future labour forces and costs in view of cost/benefits relation.
Recycling	The following government related recycling systems will be established. • An administration system that promote production of recyclable goods/products from the manufacturing stage, with government assistance, in order to minimise waste generation (generation control) to as much as possible. • A system that enables recycling at source, in particular, separate discharge at source and promote the recycling of segregated waste materials.
Intermediate Treatment	After deliberations with the counterpart in the second and third study work in Turkey, the most suitable of the following scenarios was selected: Scenario 1 Full Recycling • non-compostable waste: sorting plant • compostable waste biogas production • residue of sorting plant: RDF treatment • residue from biogas production and RDF treatment: sanitary landfilling Scenario 2 Composting • non-compostable waste: sorting plant • compostable waste: composting plant • residue from sorting plant and composting plant: sanitary landfilling Scenario 3 Landfill Gas Recovery • non-compostable waste: sorting plant • compostable waste: sanitary landfilling with gas recovery • residue from sorting plant: sanitary landfilling
Final Disposal	• Promote as the first priority project the construction of a sanitary landfill site that meets the standards established by MoE. • The selection of an appropriate site is very important in the development of a final disposal site. Hence, the use of one of the number of sites previously used for quarry for soil, etc. in the target areas will be promoted. • The anaerobic or aerobic structure of the landfill site will be determined depending on the best intermediate treatment system to be selected.
Equipment & Facility O/M	• Building of a small workshop for preventive maintenance. Major repairs will be entrusted over to private workshops.
Medical SWM	• Infectious and hazardous medical SW shall be strictly segregated from generation to final disposal. • After treatment at the point of generation, all of the infectious and hazardous medical SW generated in the target area shall be disposed of at medical SW landfills.

5.2 Selection of the Best Technical System Scenario for Adana

In the former section 5.1 through the screening potential technologies, an optimum technical system was selected. However, an optimum intermediate treatment sub-system including resource recovery sub-system could not be decided. This section presents 3 technical system scenarios for the SWM master plan for Adana and examines their advantages/disadvantages in overall SWM technical system, i.e., from collection to final disposal. After the careful discussion and examination with the C/P (counterpart) the best technical system scenario for Adana was selected.

5.2.1 Presentation of Technical System Scenarios

a. Scenarios for the Technical System

The selection of the best technical system to be realised by the M/P target year will be influenced by the social, economic, and financial conditions in 2020. One of the problems to consider in particular is whether the technical system is financially feasible. With regard to this, the following scenarios were prepared in accordance with present and estimated future financial conditions.

a.1 Scenario 1: Full recycling

Financially, this is the most expensive scenario but coincides with the full recycling system proposed by the MoE.

1. Separate collection of two types of waste: Compostable and non- compostable
2. Non-compostable waste: Sorting plant
3. Compostable waste: Biogas production
4. Residue of sorting plant: RDF treatment
5. Residue from biogas production and RDF treatment: Sanitary landfilling

a.2 Scenario 2: Composting

This is financially the second most expensive scenario but would help realise a recycling system that excludes the residue from the sorting plant. However, compostable waste will be recycled into ordinary compost, a method that is considered inexpensive and one that will not result in methane gas recovery.

1. Separate collection of two types of waste: Compostable and non- compostable
2. Non-compostable waste: Sorting plant
3. Compostable waste: Composting plant
4. Residue from sorting plant and composting plant: Sanitary landfilling

a.3 Scenario 3 Landfill Gas Recovery

This is financially the cheapest scenario and recycles compostable waste by the recovery of gases through anaerobic sanitary landfill operation.

1. Separate collection of two types of waste: Compostable and non- compostable
2. Non-compostable waste: Sorting plant
3. Compostable waste: Sanitary landfilling with gas recovery
4. Residue from sorting plant: Sanitary landfilling

b. Targets for Each Scenario

The aforementioned scenarios and their targets for the year 2020 are as shown in the table below.

Table 5-13: Targets of Each Scenario for 2020 (Adana)

	Scenario 1 (Full Recycling)	Scenario 2 (Composting)	Scenario 3 (Landfill Gas Recovery)
Separate collection	100%	100%	100%
Sorting plant	all non-compostable waste	all non-compostable waste	all non-compostable waste
Biogas plant	all compostable waste	none	none
Composting plant	none	all compostable waste	none
RDF plant	all residues from sorting plant	none	none
Sanitary landfill	all residues from biogas and RDF plant	all residues from sorting and compost plants	all compostable waste and all residues from sorting plant

5.2.2 Conceptual Design

a. Future Waste Stream without Implementation of the M/P (Continuation of the Present System)

For the formulation of a SWM Master Plan (M/P) the forecast of future waste stream in the target area is indispensable. In order to clarify the difference between with and without M/P the case of the future waste stream for the continuation of the present technical system is prepared for a reference (baseline data) of the SWM M/P. Although it is not realistic, the case bases on the present waste stream and assumes its factor such as self-disposal rate, source recycling rate, etc. will not change in future. The outcomes of forecast are described as below.

a.1 Waste Discharge Amount

Waste discharge amount for the year 2005, 2012 and 2020. The future waste discharge amount is summarised as follows;

Year 2005

- MSW 1,161 ton/day
- Other Waste 40 ton/day

Year 2012

- MSW 1,689 ton/day

- Other Waste 63 ton/day

Year 2020

- MSW 2,292 ton/day
- Other Waste 87 ton/day

a.2 Bulky Waste

As stated earlier, bulky waste is recycled and is not disposed of at the landfill at present. The study team believed that it will be discharged and need to be disposed in future. It is, however, very difficult to forecast when and how much it will be discharged. Therefore, the future amount of bulky waste is not forecast.

a.3 Self-disposed Waste Amount

Self-disposed waste amount for the year 2005, 2012 and 2020 is estimated based on the present conditions as described before, as follows;

- *3% of total population have not received collection service. Among these people (no refuse collection service), 33% disposed their waste by themselves such as burned/ buried in their premises or vacant lot.*

The study team estimated future self-disposed waste amount as shown below;

Year 2005

Self-disposed Waste Amount = 1,479,477 x 0.03 x 0.33 x 558 g/day
= 8.2 ton/day

Year 2012

Self-disposed Waste Amount = 1,831,770 x 0.03 x 0.33 x 663 g/day
= 12.0 ton/day

Year 2020

Self-disposed Waste Amount = 2,268,174 x 0.03 x 0.33 x 729 g/day
= 16.4 ton/day

a.4 Illegally Dumped Waste Amount

Future illegally dumped waste amount for the year 2005, 2012 and 2020 is estimated based on the present conditions as described before, as follows;

- *50% among 3% of total population which have not received collection service dumped their waste in the vacant lot.*

Therefore, the study team estimated future illegally dumped waste amount as shown below;

Year 2005

Illegally Dumped Waste Amount = 1,479,477 x 0.03 x 0.5 x 558 g/day
= 12.4 ton/day

Year 2012

Illegally Dumped Waste Amount = 1,831,770 x 0.03 x 0.5 x 663 g/day
= 18.2 ton/day

Year 2020

Illegally Dumped Waste Amount = 2,268,174 x 0.03 x 0.5 x 729 g/day
= 24.8 ton/day

a.5 Recycled Waste Amount

Future recycled waste amount for the year 2005, 2012 and 2020 is estimated based on the present conditions as described in earlier, as follows;

- *Recycled waste amount by generation sources per capita is estimated at 20.9 g (25 ton ÷ 1,196,620).*
- *Recycled waste amount by street waste pickers is estimated at 12.5 g per capita (15 ton ÷ 1,196,620).*
- *Recycled waste amount by scavengers at dump site is estimated at 7.5 g per capita (9 ton ÷ 1,196,620).*

Therefore, the study team estimated recycled waste amount in each part concerned in waste stream as shown below;

Year 2005

Recycled waste amount by generation sources = 1,479,477 x 20.9 g
= 30.9 ton/day

Recycled waste amount by street waste pickers = 1,479,477 x 12.5 g
= 18.5 ton/day

Recycled Waste amount by scavengers at dump site = 1,479,477 x 7.5 g
= 11.1 ton/day

Year 2012

Recycled waste amount by generation sources = 1,831,770 x 20.9 g
= 38.3 ton/day

Recycled waste amount by street waste pickers = 1,831,770 x 12.5 g
= 22.9 ton/day

Recycled Waste amount by scavengers at dump site = 1,881,770 x 7.5 g
= 13.7 ton/day

Year 2020

Recycled waste amount by generation sources = 2,268,174 x 20.9 g
= 47.4 ton/day

Recycled waste amount by street waste pickers = 2,268,174 x 12.5 g
= 28.4 ton/day

Recycled Waste amount by scavengers at dump site = 2,268,174 x 7.5 g
= 17.0 ton/day

a.6 Waste Collection Amount

Future collected waste amount for the year 2005, 2012 and 2020 is estimated as follows;

Collected Waste Amount = Waste Discharge Amount - Illegally Dumped Waste Amount - Recycled Waste Amount by Street Waste Pickers

Therefore, the study team estimated future collected waste amount as shown below;

Year 2005

Collected Waste Amount = 1,161 - 12.4 - 18.5 ton/day
= 1,130.1 ton/day

Year 2012

Collected Waste Amount = 1,689 - 18.2 - 22.9 ton/day
= 1,647.9 ton/day

Year 2020

Collected Waste Amount = 2,292 - 24.8 - 28.4 ton/day
= 2,238.8 ton/day

a.7 Final Disposal Amount

Future final disposal amount for the year 2005, 2012 and 2020 is simply calculated according to the following formula;

Final Disposal Amount = Collected Waste Amount + Other Wastes - Recycled Waste Amount by Scavengers at Dump Site

Therefore, the study team estimated final disposal amount as shown below;

Year 2005

Final Disposal Amount = 1,130.1 + 40 - 11.1 ton/day
= 1,159.0 ton/day

Year 2012

Final Disposal Amount = 1,647.9 + 63 - 13.7 ton/day
= 1,697.2 ton/day

Year 2020

Final Disposal Amount = 2,292.8 + 87 - 17.0 ton/day
= 2,362.0 ton/day

Therefore, amount of each component of waste stream is summarised in the following table.

Table 5-14: Summary of Future Waste Stream Component for Adana GM

Waste Stream Component	Ton/day		
	2005	2012	2020
Waste Generation Amount	1,200.1	1,739.3	2,355.8
Recycling by Generation Sources	30.9	38.3	47.4
Self-Disposed Waste Amount	8.2	12.0	16.4
Waste Discharge Amount	1,161.0	1,689.0	2,292.0
Recycling by Street Waste Pickers	18.5	22.9	28.4
Waste Collection Amount	1,130.1	1,647.9	2,238.8
Illegally Dumped Waste Amount	12.4	18.2	24.8
Recycling by Scavengers at Dump site	11.1	13.7	17.0
Other Waste	40.0	63.0	87.0
Final Disposal Amount	1,159.0	1,697.2	2,362.0

a.8 Future Waste Stream Diagram

In conclusion, the study team presented the future waste stream diagram for Adana in the following figures.

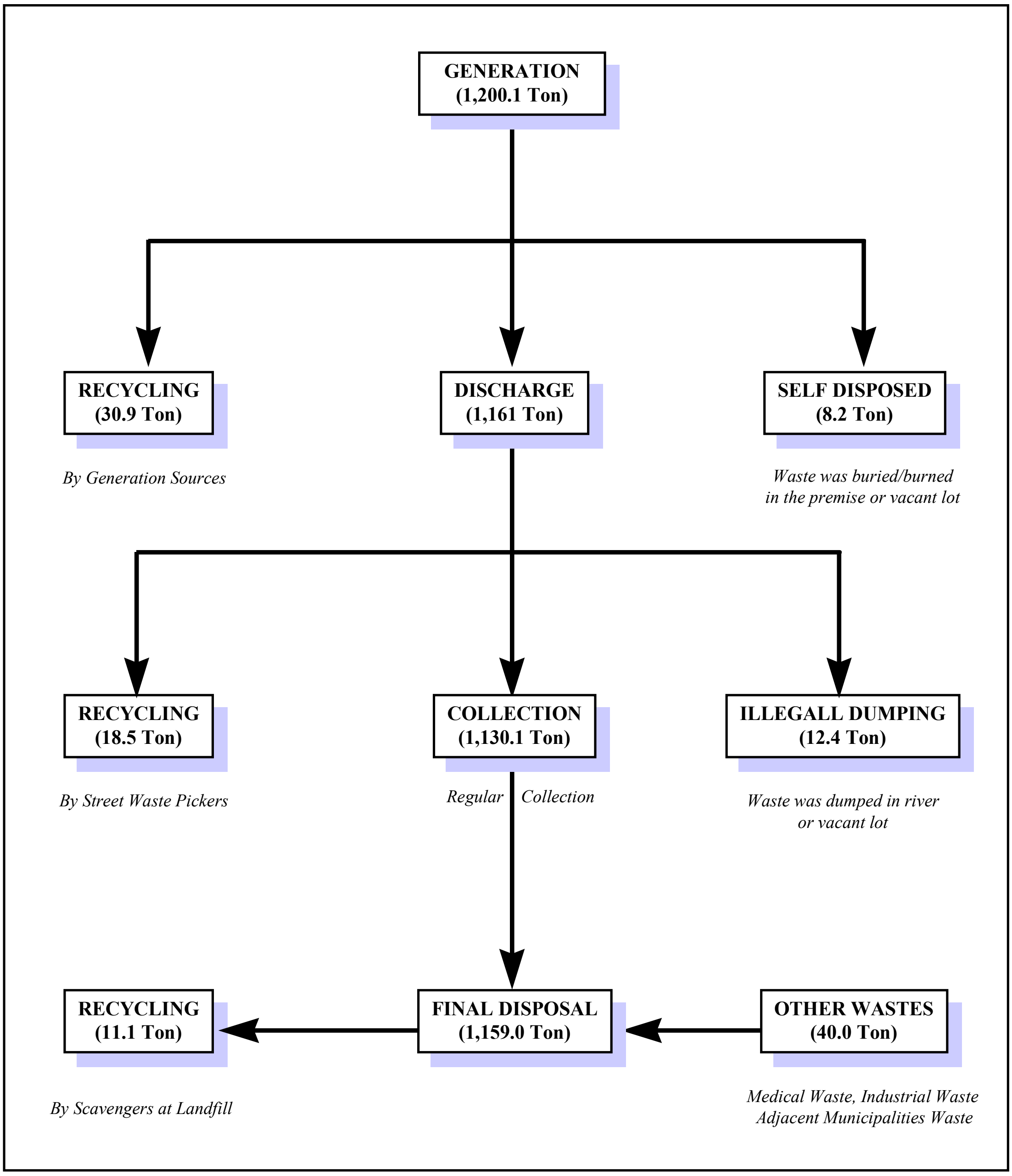

Figure 5-8: Waste Stream Diagram for Adana in Year 2005

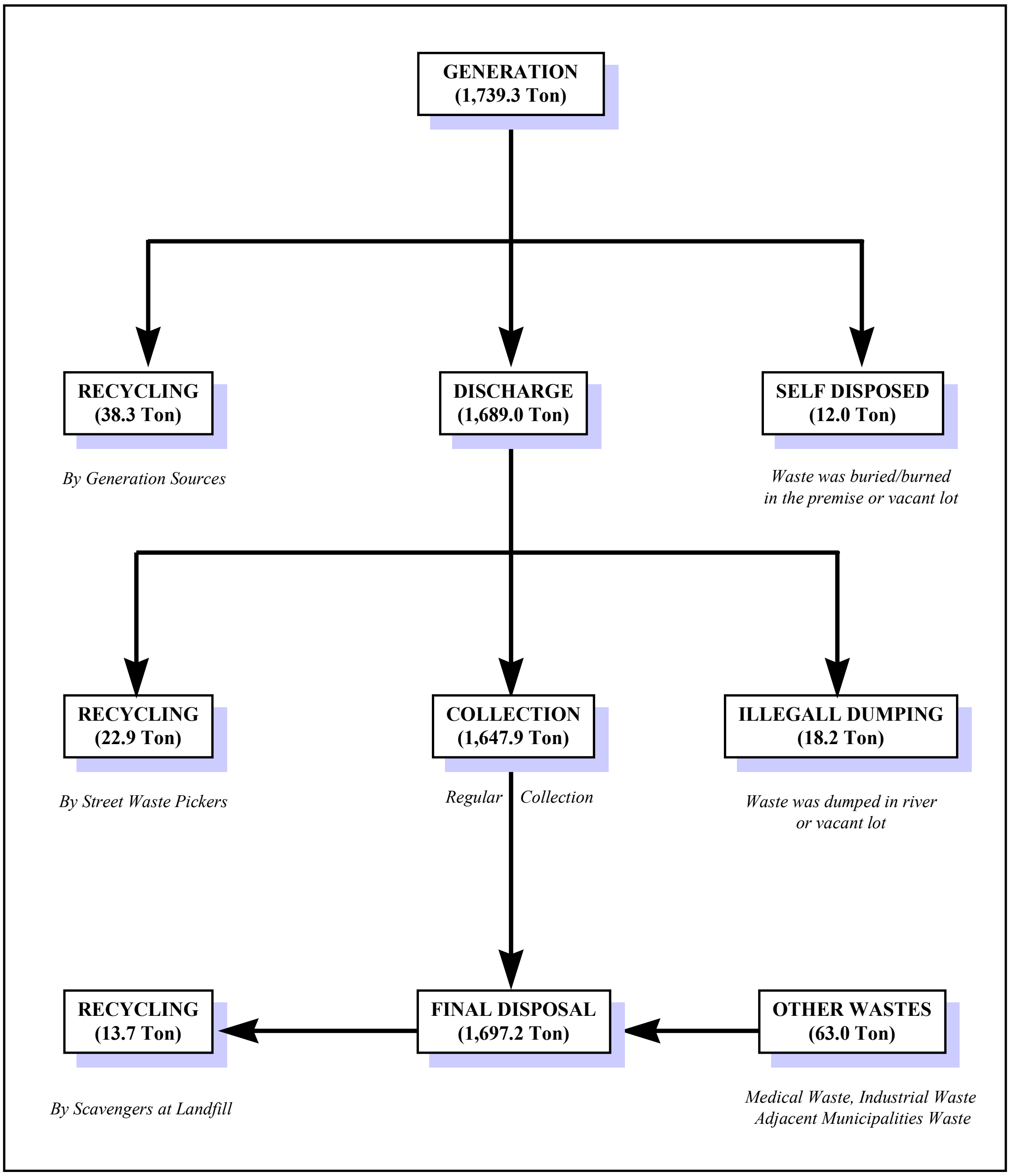

Figure 5-9: Waste Stream Diagram for Adana in Year 2012

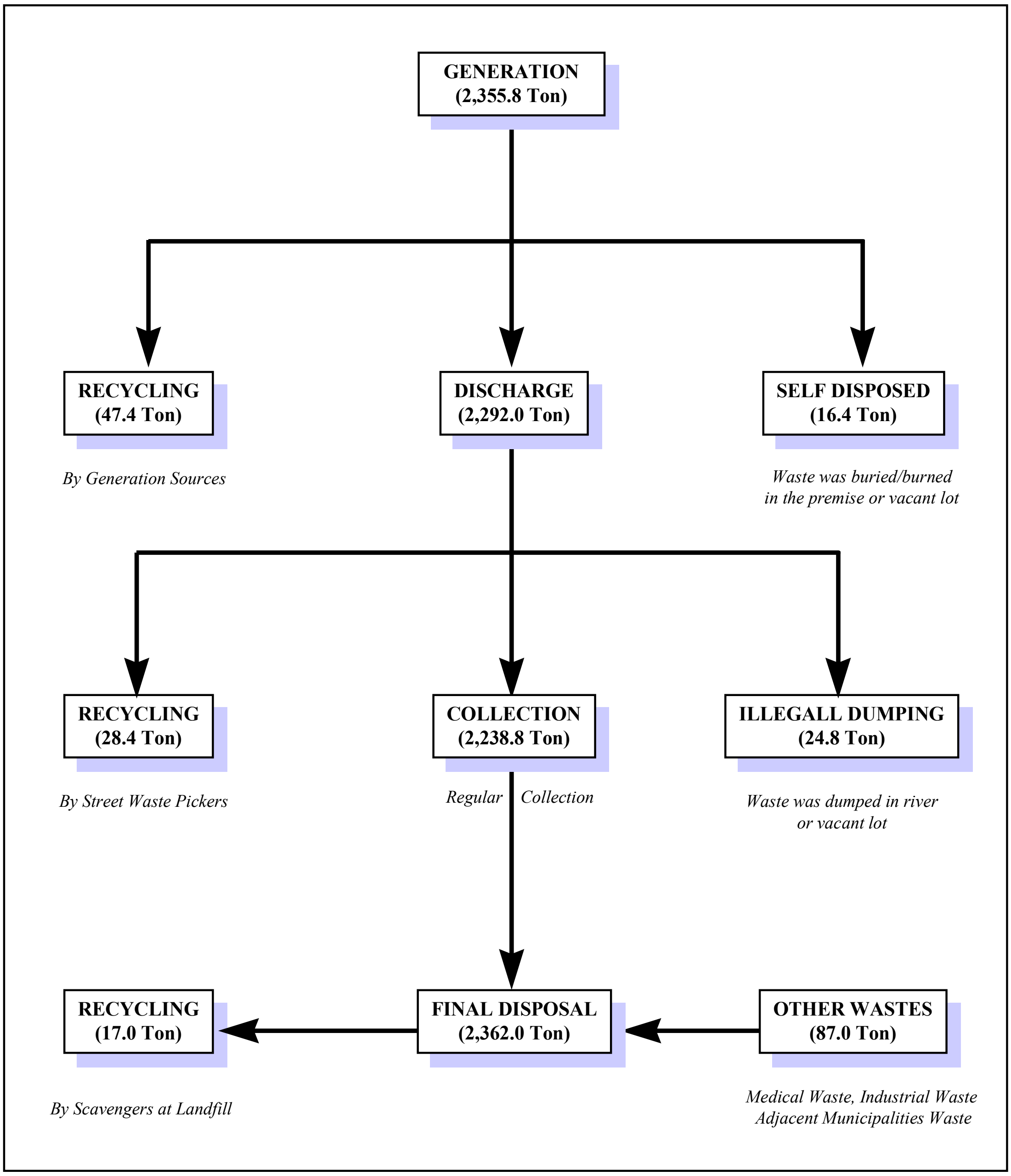

Figure 5-10: Waste Stream Diagram for Adana in Year 2020

b. Collection and Haulage

The collection and haulage system is basically associated with the final disposal and intermediate treatment systems. The collection and haulage systems for Adana will be improved within a phased program as given below.

Phase	Target Year	Aim
Phase 1	1999-2005	• The direct haulage of wastes will be continued. • The usage of tractor-trailers in Yuregir DM will be improved gradually due to the operation of communal container storage/collection system. • Usage of wheeled containers will be extended gradually within the city. • A pilot stage source separation system will be initiated in the high-income mahalle(s).
Phase 2	2006-2012	• The new landfill site is presumed to be constructed at a farther location. Therefore, the introduction of a transfer station will be examined to cope with the haulage of the waste to landfill site, if it will locate far from the city centre. • The usage of tractor-trailers will be changed with compactor trucks. • The whole storage system will be changed with communal container system • The pilot stage source separation will be extended to other mahalles of city, therefore separate collection will start.
Phase 3	2013-2020	• The transfer station(s) will be in full operation. • The source separation will be in full operation

b.1 Storage and Discharge in Adana

The following main policies will be applicable for Adana.

- The type of containers used will be regulated, standard wheeled container system will be extended.
- A source separation system will be initiated for discharging the non-compostable (recyclable) and compostable wastes in a controlled manner, in order to give provision for a composting/recycling scheme.
- The usage of litter bins will be extended, especially starting from high-income and middle-income areas.

b.2 Collection and Haulage in Adana

- The usage of compactor trucks will be extended. Satellite collection vehicles will be introduced for the collection in narrow streets.
- Communal container collection system will be applied in order to increase the collection efficiency.
- It is assumed that the existing collection equipment will be used in Phase 1, and gradually they will be replaced with the new vehicles, after they exceed the life span of 7 years.
- Collection frequency will be daily, 6 days a week for residential and commercial and market waste for compostable waste.

- Collection frequency for source separated non-compostable waste (recyclable materials) will be once or twice a week.
- Direct hauling of collected waste will be achieved in the Phase 1, and after the new landfill site will be in operation in the Phase 2, there may be a need of transfer station(s) in Adana.
- The remaining economic life of collection vehicles in Adana is given below.

Production Year	Seyhan DM		Yuregir DM	
	Municipal	Private	Municipal	Private
1970-1986	-	-	3	43 (TT*)
1990	19	-	1	-
1991	4	-	-	-
1992	5	10	10	-
1994	5	2	-	3 (TT)
1995	3	-	-	-
1996	-	-	-	1 (TT)
1997	18	-	-	-
1998	-	1	-	-

Note: TT: tractor-trailer

The economical lifespan of collection equipment is given below.

1) Communal containers : 7 years
2) Waste collection vehicles and heavy equipment : 7 years
3) Machinery : 15 years
4) Buildings and civil works : 30 years

As can be understood from the tables, the equipment that was produced in 1970-1986 (leased tractor-trailers) has exceeded its lifespan but still in function in Yuregir DM. Therefore, they have to be replaced by newer ones by the new leasing contract.

Additionally the other collection vehicles of Yuregir DM (compactors and TT), except 4 will be economically unsuitable for usage in 1999. It is unrealistic to propose the replacement of all these equipment at once because the present solid waste management systems rely heavily on them. It is, therefore, proposed that all the existing equipment would be operational until the end of 2005 (by the beginning of Phase 2), requiring higher maintenance costs and should be replaced gradually.

The type of collection equipment and collection methods proposed for each type of area is summarised below.

Area	Collection Equipment	Collection Method
Standard residential areas and commercial areas	Compactor truck (12 - 16 m^3)	Communal container collection
Narrow streets, old town	Satellite vehicles (4 m^3)	Communal container collection
Source separated non-compostable waste (recyclables)	Collection truck	Separate collection
Street waste	Compactor truck (12 - 16 m^3)	Communal container collection

b.3 Haulage/Transfer Station

As mentioned before, the direct haulage of wastes to the disposal site in Phase 1 will be accomplished by the existing collection vehicles and no transfer station will be necessary due to the location of Sofulu disposal site, which is planned to be used in a more controlled manner, till the end of 2005.

Transfer station option in Adana, especially siting of transfer station has been discussed with the municipal officials of DMs (District Municipalities) in Adana, but unfortunately it was not possible for them to propose us appropriate alternative sites for selection. Although the investment and operation of the transfer stations are under the responsibility of Greater Municipality, they are much going to be located in DM grounds and therefore have to be proposed by DM's.

Due to these arguments, the Study Team was not able to locate the transfer station in Adana at this stage of the project, and therefore highlighted the issue in an more theoretical approach.

b.3.1 Siting Issues for Transfer Station

It is worth at this stage to give some idea how to locate the transfer station. Several criteria determine where a transfer station should be located. Some of these are more obvious than others, as given below;

- First of all, the transfer station should be as near as possible to weighted centre of the individual collection area, since the minimisation of travel distances is the whole purpose of the transfer station.
- In addition to proximity to the collection routes, access to major haul routes is also important in optimising transfer vehicle productivity.
- Access roads must be able to handle heavy truck traffic, and truck routes should be designed to minimise the impacts of the vehicles on neighbourhoods.
- Aside from the routing issues, the land on which the facility will be built should provide adequate isolation.
- Siting the facility will also involve garnering neighbourhood and community acceptance, where there will be minimum of public and environmental objection, which in many cases is the most difficult task.
- Transfer station should be located to where the construction and operation will be most economical.
- Additionally, if the transfer station site is to be used for processing operations involving recycling/material recovery, requirements and as well as the environmental conditions for those operations must also be assessed.

Transfer Stations

In the field of solid waste management, the functional element of transfer and transport refers to the means, facilities, and appurtenances used to effect the transfer of waste from one location to another, usually more distant, location. Typically, the contents of relatively small collection vehicles are transferred to larger vehicles that are used to transport the waste over extended distances either to waste treatment facilities or to disposal sites. In some cases, transfer and transport operations are also used in conjunction with waste treatment facilities to transport recovered materials to markets or to other intermediate waste facilities and to transport residues to landfills.

b.3.2 The Need for Transfer Operations

Transfer and transport operations become a necessity when haul distances to available processing centres or disposal sites increase so that direct hauling is no longer economically feasible. Transfer stations are centralised facilities where waste is unloaded from several small capacity collection vehicles and loaded into a larger capacity vehicle for hauling. This tends to increase the efficiency of the system, as collection vehicles and crews remain closer to the routes, while larger vehicles, designed for transfer, make the trip to the disposal facility.

Because of siting problems, and the lack of available spaces, landfills and other disposal facilities are being sited in more remote areas, away from municipal waste sources or generation points. Consequently, the costs associated with transporting the waste from the collection route to the disposal facility are increasing. Transfer stations are becoming a more attractive alternative for controlling these rising costs.

In addition, transfer station operation may be integrated with other waste management options, such as recycling programs and waste - to - energy facility operation, which further enhances the attractiveness of transfer stations.

Despite the benefits associated with transfer stations, significant capital and operating costs may remove them as feasible options.

Additionally, operating a transfer station can have significant impacts on other elements of integrated solid waste management system and, if properly planned, these impacts can be extremely positive and cost effective.

Transfer operations can be used successfully with all types of collection vehicles and conveyor systems. Additional factors that tend to make the use of transfer operations attractive include;

- The occurrence of illegal dumping due to the excessive haul distances,
- It gives provision to locate the disposal sites far from collection routes,
- The use of small capacity collection vehicles,
- The existence of low-density residential service areas,
- The use of a hauled container system (if needed) with relatively small capacity containers for the collection of wastes from commercial sources.

b.3.3 Transfer Station Planning and Design Requirements

Although the specific details vary with size, important factors that must be considered in the design of transfer stations are given below:

- The type of transfer operation to be used
- Storage and throughput capacity requirements
- Equipment and accessory requirements

- Sanitary requirements
- Transfer station cost and benefits.

Type of Transfer Station

Transfer stations are used to accomplish transfer of solid wastes from collection and other small vehicles to larger transport equipment. Depending on the method used to load the transport vehicles, transfer stations may be classified into three general types:

1) Direct-load
2) Storage-load
3) Combined direct-load and discharge-load

On the other hand, transfer stations may be classified with respect to throughput capacity (the amount of material that can be transferred and hauled) as follows:

1) Small, less than 100 ton/day
2) Medium, between 100 – 500 ton/day
3) Large, more than 500 ton/day.

Transfer station categories, based on the method used are briefly outlined below, and some of the associated advantages and disadvantages are also included.

Table 5-15: Transfer Station Design Alternatives

Design Option	Advantages	Disadvantages
Direct-Load - Collection vehicles dump load directly into a open-top trailer via large hopper - Waste is gravity-fed to the trailer	- No intermediate handling of waste, increasing efficiency - Facility shutdown rare because no complicated equipment involved - Easy to operate	- Additional tipping floor/storage space may be required in order to operate in efficient way
Storage-Load - Large tipping pit/floor/hopper where the collection vehicles unload - Mobile plant/crane organise and push the waste into trailer/container	- Requires little site work - Involves relatively low building costs - Recyclables can be separated - Floor/pit acts as storage area during peak arrival	- Usually insanitary /unaesthetic conditions - Operation cost are higher than direct-loading method - Sometimes complicated mechanical systems are used
Combined Direct-Load and Discharge-Load - Usually a multipurpose facility - Materials recovery	- Can achieve resource recovery and recycling - Can handle big capacities of waste	- Higher investment/operation and maintenance costs - Very complicated to operate

b.3.4 Selection of Type of Adana Transfer Station

For Adana, direct-load is the most cost effective and efficient type of transfer station because it possesses simple operation conditions, low investment/operation and maintenance costs, and non-complicated mechanical systems.

Transfer Station Capacity Requirement

A fundamental transfer station design factor is the communities waste volume estimate. Practices show that estimates are often inaccurate, resulting in oversized or undersized facilities faced with operating losses and high tipping fees. Accurate waste stream assessment data and estimating the changes in the waste stream due to recycling or other waste management program are the only way to avoid this problem. This issue has seriously been taken into consideration in the project studies in Adana and accurate values have been identified.

Both the throughput and storage capacity requirements must be evaluated carefully in planning and designing transfer stations. The throughput capacity of a transfer station must be such that the collection vehicles do not have to wait too long to unload. In most cases, it will not be cost-effective to design the station to handle the ultimate peak number of hourly loads. Ideally, an economic trade-off analysis should be made.

b.3.5 Selection of the Capacity of Adana Transfer Station

The estimated future collected waste amount in Adana for the year 2005, 2012 and 2020 are given below:

Year	Collected Waste Amount
2005	1,158 ton/day
2012	1,695 ton/day
2020	2,308 ton/day

The transfer station for Adana will be put into operation in the second phase (2005) of the project implementation period. Basing on the estimated future collected waste amounts and transfer station capacity requirements, the capacity of Adana transfer station will be 1,200 ton/ 8 hr shift. Table given below will illustrate the operational capacity of Adana transfer station for the years 2005, 2012 and 2020.

Year	Operation Capacity
2005	1,200 ton/ 8 hr shift
2012	1,800 ton/ 12 hr shift
2020	2,400 ton/16 hr shift

Equipment and Accessory Requirements

The equipment and accessories used in conjunction with a transfer station depend on the function of the transfer station in the waste management system. The types and amounts of equipment required also vary with the capacity of the station. Additional equipment is required to distribute the waste and equalise the loads. Scales should be provided at all medium and large size transfer stations, both to control and monitor the operation and to develop meaningful engineering data.

If the transfer station is to be used as a dispatch centre or district headquarters for a solid waste collection operation, a more complete facility should be constructed. For headquarters facility, fuel depot, a lunchroom, meeting room, offices, locker rooms, showers, and toilets should be provided. Facilities for providing equipment maintenance may also be incorporated.

One of the most important equipment in transfer stations is the transfer vehicle. Transfer vehicles come in two basic varieties:

- Open-top trailers
- Enclosed trailers

Where the point of final disposition can be reached by motor vehicle, the most common means used to transport solid wastes from transfer stations are trailers, semi-trailers and compaction vehicles.

In general, vehicles used for hauling on highways should satisfy the following requirements:

1) Wastes must be transported at minimum cost
2) Wastes must be covered during haul
3) Vehicles must be designed for highway traffic
4) Vehicle capacity must be such that the allowable weight limits are not exceeded, and
5) The methods for loading and unloading must be simple and dependable.

The decision-makers should consider the factors given below, which would be affecting transfer vehicle selection:

1) Capital costs
2) Capacity of the trailer
3) Type of transfer station
4) Distance of haul to disposal site
5) Hours of haul per day
6) Quantity of waste to be transported, and
7) Weight limits.

Sanitary Requirements

Environmental Requirements

By proper design, construction and operation, the objectionable problems of transfer stations can be minimised. Most of the modern, large transfer stations are enclosed and are constructed of materials that can be maintained and cleaned easily. To eliminate inadvertent emissions, enclosed facilities should have air-handling equipment that creates a negative pressure within the facility. In most cases, fireproof construction is used for direct-loading transfer stations with open loading areas if necessary. Special attention should be given to the problem of blowing paper. The best way to maintain overall sanitation of a transfer station is to monitor the operation continually. Spilled wastes should be picked up immediately or in any case should not be allowed to accumulate for more than 1 or 2 hour. The area should also be washed in reasonable intervals. The produced wastewater in the facility should also be handled in a sanitary manner, if necessary should be treated.

Health and Safety

Health and safety issues in transfer stations are related to dust and vapour inhalation. Overhead water sprays are used to keep the dust down in the facility. To prevent inhalation, workers should wear dust masks. For reasons of safety, the public should not be allowed to discharge wastes directly into the facility, but to containers at the reception area of vehicles.

Transfer Station Cost and Benefits

Developing and operating transfer stations involves significant capital costs, including land acquisition, construction of buildings, purchase of equipment, and haul vehicles. Cost of design, site preparation, and construction are also significant.

Substantial benefits, however, can also be realised. Cost savings resulting from transfer station implementation may include;

1) Reduced non-productive time of collection crew
2) Reduced collection truck mileage
3) Reduced maintenance costs of collection trucks, and
4) Increased use of lighter duty collection vehicles.

c. Public Area Cleansing

c.1 Public Area Cleansing Basic Concepts

- In most mahalles of the city all streets sweeping work will be generally carried out manually.
- The existing mechanical street sweepers will be used for the cleaning of main roads and boulevards in the Phase 1, renewing them when necessary. In Phase 2, the ratio of the mechanical sweeping operation will be increased if the labour cost will be increased and the road conditions will be improved. If these labour and road condition allows, whole system for major road will be exchanged to fully mechanical system.
- An appropriate collection and transportation system for street waste will be introduced.
- The street waste, which is collected manually, will be stored in wheeled containers that are allocated only for this purpose and will be collected by the existing collection vehicles.
- Prevention of littering in the city will be achieved.
- The supervision system of labourers will be improved.

The present street sweeping work, mainly conducted manually, is deemed to be an appropriate method due to cheap labour costs and inferior road conditions that would hamper mechanical street sweeping equipment. However, the ratio of manual/mechanical sweeping work shall be examined and changed according to the labour cost increase and the improvement of road conditions.

c.2 Public Area Cleansing Master Plan Program

- **To install more litter boxes along streets**

More litter boxes will be installed to reduce the workload for street sweepers and preventing waste from scattering.

- **To increase the number of collection points**

In order to shorten the haulage distance of the collected waste, communal containers will be used as collection points, which will be placed in close proximity. The haulage distance will be controlled, which will be less than one km.

- **To use a new type of cart to carry litter collected**

A new type of cart with a larger haulage capacity will be introduced to improve the efficiency of the haulage work.

- **To set up site offices with space**

The municipalities will set up site offices with storage space in accordance with the increase in street sweeping area. These offices will function as a storehouse to stow carts, tools, etc., and to enable a foreman to supervise street sweepers.

- **Sweeping Frequency**

The street sweeping frequency in Adana is proposed as follows:

Road Classification	Frequency
Commercial roads and market zones	Once a day
Main roads in the Central Zone	Once a day
Suburban commercial streets	4 times per week
Secondary streets	2 times per week
Residential Streets	2 times per week
Main roads (boulevards)	Once a day

d. Recycling

The following government related recycling systems will be established.

- An administration system that promote production of recyclable goods/products from the manufacturing stage, with government assistance, in order to minimise waste generation (generation control) to as much as possible.
- A system that enables recycling at source, in particular, separate discharge at source and promote the recycling of segregated waste materials.
- Recycling by the several intermediate treatment facilities.

e. Intermediate Treatment

In order to draw up waste streams for 3 scenarios, the team set up the following figures for each intermediate treatment facility. These figures are deduced from the waste composition forecasted by the team and various operational data which the consultants gained from Japan, Denmark, etc.

Items	Rates(%)
Separate Collection Amount	
• Non-compostable Waste	55
• Wompostable Waste	45
Sorting Plant	
• Recycled Waste	24
• Residues	76
Bio-gas Plant	
• Water Content	70
• CH_4, H_2O, etc.	77
• Compost	18
• Residues	4
• Recycling	1
RDF (Refuse Derived Fuel)	
• RDF	60
• Residues	40
Compost Plant	
• Water Content	70
• CH_4, H_2O, etc.	77
• Compost	18
• Residues	4
• Recycling	1

f. Final Disposal

Since future final disposal site in 2020 is not identified, the team assumed a cavity in a mining quarry site as recommended in the previous chapter. The future landfill shall be designed in accordance with the design standard prepared by the MoE.

g. Operation and Maintenance of Vehicles and Equipment

Only preventive and daily maintenance as well as small repair services will be done at municipal workshops. The heavy repairs will be undertaken by the private sector.

g.1 Operation and Maintenance Plan Basic Concept

The number of people who are involved in SWM works in Adana is currently more than 1,100 (municipal and private cleansing companies all together – 1,157) and it is expected to reach more than 2,000 people by the year 2020. SWM works change on a day to day basis; to maintain the efficiency of operations, making a prompt decision and taking swift action are essential. Employing a large number of people is risky and is also difficult to maintain the level of management required, so it is recommended that the private sector participation in SWM works will be extended in order to reduce the burden and work load on the authority responsible for SWM, and minimise the costs.

g.2 Operation and Maintenance Master Plan Program

Item	Program
Maintenance of Equipment	At present, the workshop owned by the municipalities only provides preventive maintenance service for equipment, and the major repairs are executed by the private workshops. The M/P proposes to continue this application till the end of Phase 2. That is; the preventive maintenance will be executed by the existing municipal facilities and major repairs be conducted at private garages. The reason for this is as follows: • It takes time for the municipal workshop to purchase spare parts. So spare parts only used frequently will be purchased and kept in storage. • Complex repair works will be consigned to the private sector although the cost is higher than if directly conducted at the municipal workshop because private garages are able to purchase spare parts much more readily. In the Phase 3, it is our recommendation that the whole repair and maintenance works will be privatised.
Operation of Collection Vehicles	To limit the burden and workload, currently experienced by the Cleansing Departments, various measures of private sector participation will be encouraged. The proposed measures are as follows: • The municipalities will own some compactor vehicles. The rest will be hired to or supplied by the private sector. The contract would include drivers, collection workers, fuel, and maintenance. • As for other collection vehicles, the municipalities can contract out most of the operation work to the private sector. The private collection company will be entrusted a small percentage of collection vehicles owned by the municipalities. Through the gradual expansion of this system, the municipality responsible for SWM can nurture the potential of the private section, in preparation for the future hand-over of all collection work.
Street Sweeping	Street sweeping workers will be employed in a contract base as at present, because it is very difficult for the DM to manage many street sweepers and employee cost will be high. The municipalities task is mainly to supervise contracted sweepers.
Source Separation and Recycling	In collaboration with DMs the Adana GM will initiate a source separation scheme in pilot scale in the Phase 1. Additionally they will educate people and to promote recycling. At this phase the concrete plans for action are as follows: • The collection of the source-separated reusables from recycling points will be contracted out to the private sector. • The GM will construct a sorting plant and entrust the operation of it to the private sector. In Phase 2, GM and DM will extend the source separation schemes to other mahalles of Adana. In Phase 3, the source separation program will be extended to the whole city and the private sector will be in charge of the actual recycling work.

h. Future Waste Stream for Each M/P Scenario

The future waste stream when the SWM M/P will be implemented is drawn up based on the following concepts:

1. Since the current self-disposal method such as open burning is not properly done and it gives adverse impacts on the surrounding. It should be eliminated by providing collection services by 2005.
2. The illegal dumping shall be also excluded by 2005, providing collection services and strict enforcement as well as control.
3. The current recycling rate (20.2 g/day/person) by waste generation sources will be kept until 2020
4. The recycling activities by street waste pickers will be gradually decreased and it will be disappeared by 2020.
5. The scavenging activities at the landfill shall be prohibited by January 2003 when a new recycling/composting plant will start operation.

The future waste stream for each scenario is drawn up based on the conceptual design described in the previous section. The following table is the summary of the future waste stream. For better understanding waste streams for 3 M/P scenarios are illustrated in the following Figures.

Table 5-16: Future Waste Stream for Each M/P Scenario for Adana

ADANA Scenario1 2020year			(ton/day)	(ton/year)
Generation			2,355	
Recycling			47	
Discharge			2,308	
Collection①			2,308	
Non-Composatble	Sorting Plant(②=①×55%)		1,269	463,331
		Recycling(③=①×13.2%)	305	
		Residue(④=①×41.8%)	964	
	RDF Plant(=④)		964	351,860
		RDF(⑤=①×25.1%	579	
		Residue(⑥=①×16.	385	
Compostable	Bio-Gas Plant(⑦=①×45%)		1,039	379,089
		Residue(⑧=①×1.8%)	42	
		Compost(⑨=①×8.1%)	187	
		CH_4,H_2O,CO_2(⑩=①×34.7%)	800	
		Recycling(⑪=①×0.4%)	10	
	Other Waste⑫		75	
	Final Disposal	(⑥+⑧)	427	155,855
		(⑥+⑧+⑫)	502	183,230

ADANA Scenario2 2020year			(ton/day)	(ton/year)
Generation			2,355	
Recycling			47	
Discharge			2,308	
Collection①			2,308	
Non-Composatble	Sorting Plant(②=①×55%)		1,269	463,331
		Recycling(③=①×13.2%)	305	
		Residue(④=①×41.8%)	964	
Compostable	Compost Plant(⑤=①×45%)		1,039	379,089
		Residue(⑥=①×1.8%)	42	
		Compost(⑦=①×8.1%)	187	
		CH_4,H_2O,CO_2(⑧=①×34.7%)	800	
		Recycling(⑨=①×0.4%)	10	
	Other Waste⑩		75	
	Final Disposal	(④+⑥)	1,006	367,190
		(④+⑥+⑩)	1,081	394,670

ADANA Scenario3 2020year			(ton/day)	(ton/year)
Generation			2,355	
Recycling			47	
Discharge			2,308	
Collection①			2,308	
Non-Composatble	Sorting Plant(②=①×55%)		1,269	463,331
		Recycling(③=①×13.2%)	305	
		Residue(④=①×41.8%)	964	
Compostable	Residue(⑤=①×45%)		1,039	379,089
	Other Waste⑥		75	
	Final Disposal	(④+⑤)	2,003	731,095
		(④+⑤+⑥)	2,078	758,470

ADANA Continuation present system 2020year

Final Disposal = 2,435(ton/day) = 888,777 (t/year)

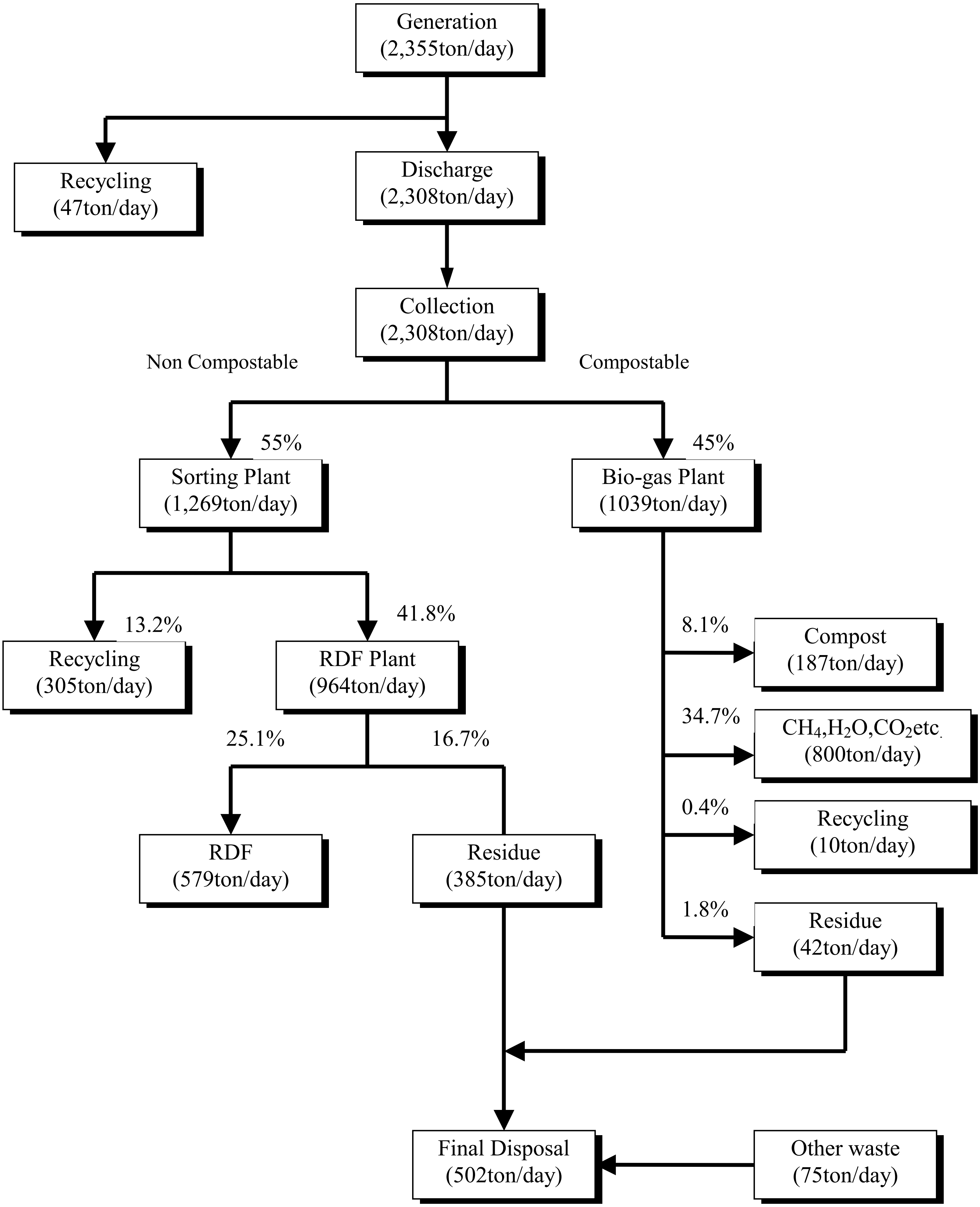

Figure 5-11: Waste Stream of M/P Scenario 1 for Adana in 2020

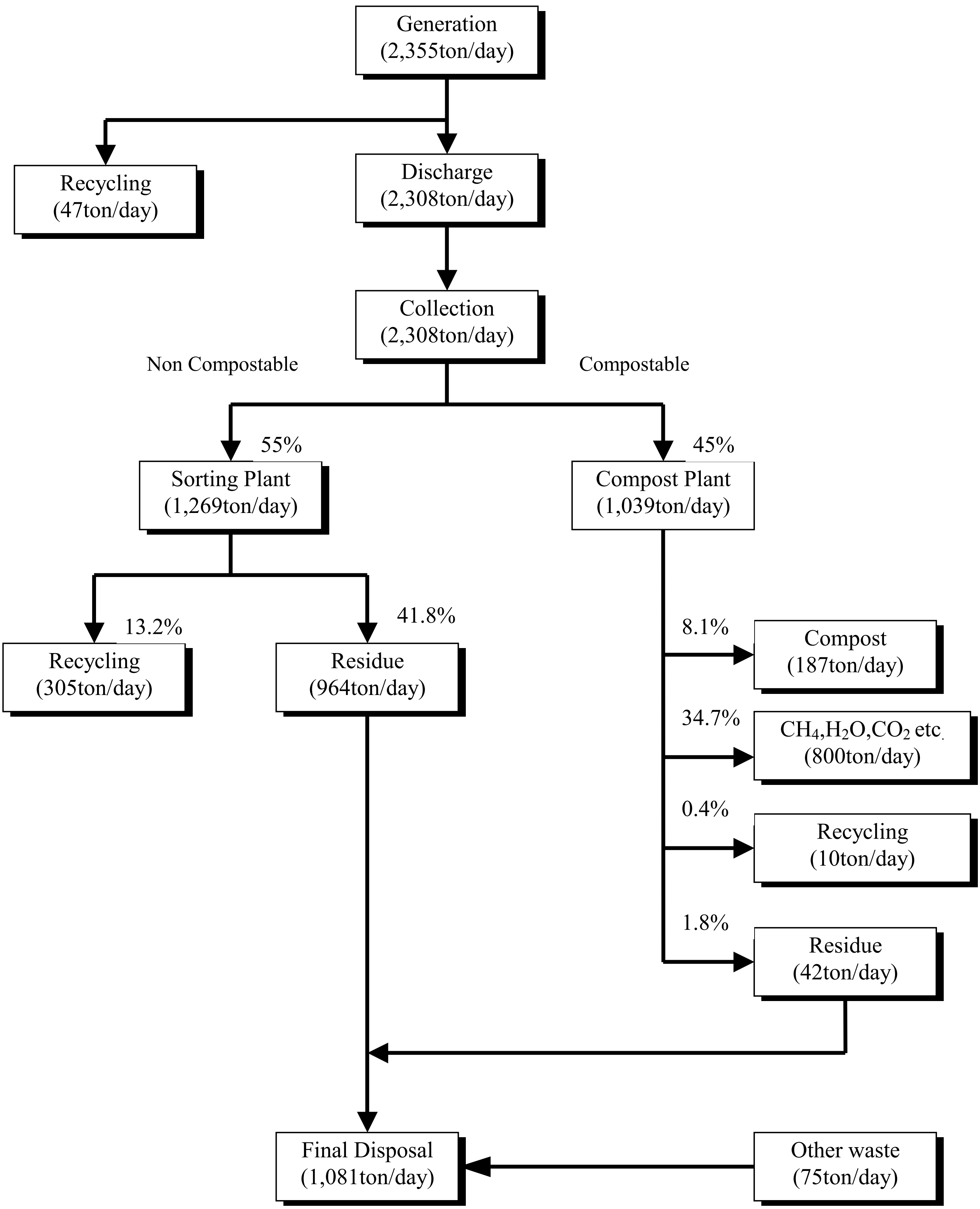

Figure 5-12: Waste Stream of M/P Scenario 2 for Adana in 2020

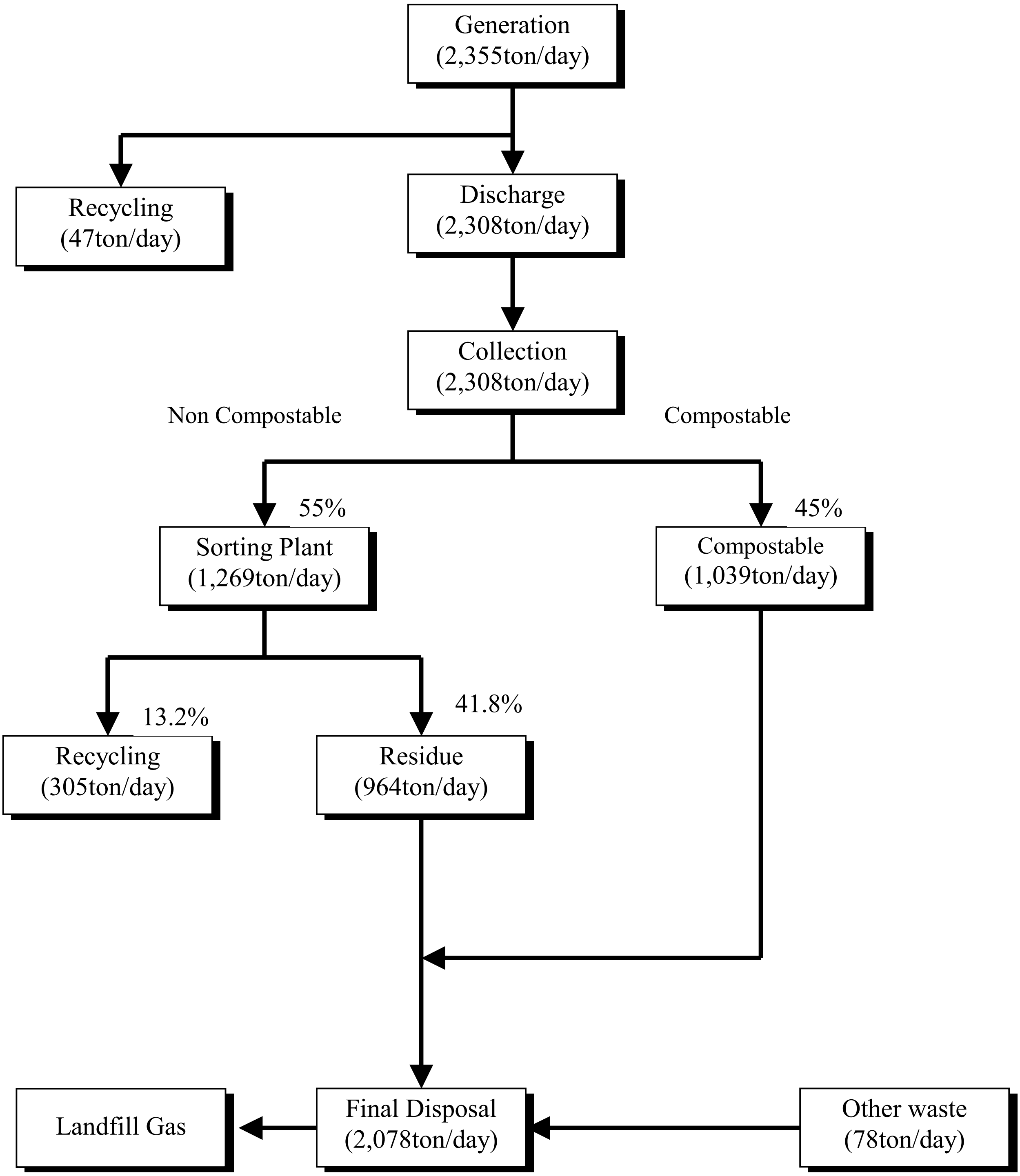

Figure 5-13: Waste Stream of M/P Scenario 3 for Adana in 2020

5.2.3 Cost Estimation

a. Cost Estimation Items

Cost Estimation of Adana GM in 2020 will be required for as follows;

- Refuse Collection & Transportation Cost
- Public Area Cleansing Cost
- Intermediate Treatment and Recycling Cost

Scenario1 -Sorting Plant
-RDF Plant
-Bio-Gas Plant

Scenario2 -Sorting Plant
-Compost Plant

Scenario3 -Sorting Plant

- Landfill Gas Collection Facility(Only Scenario 3)
- Final Disposal Cost

b. Unit Cost for Cost Estimation

US dollar is used for the calculation as fluctuation of Turkish Lira is sharp. Calculation is carried out using the May 1999 prices and at an exchange rate of US$ 1 = 407,000 Turkish Lira. Depreciation period for facility, heavy machinery and equipment, and the residual value are shown in Table 5-17.

Table 5-17: Depreciation Period of Facility and Equipment

Items	Depreciation Period (Year)	Residual Value (%)
Vehicle and heavy machinery	7	10
Machinery	15	0
Building	30	0

Note: The life span of civil works and facilities other than building depends on the period of its operation.

Unit Cost of each items is shown in Table 5-18.

Table 5-18: Unit Cost

Item		Unit Cost(US$/ton)
Refuse Collection & Transportation		22.7
Public Area Cleansing		186
Intermediate Treatment and Recycling	Sorting Plant	13.0
	RDF Plant	30.0
	Bio-Gas Plant	70.0
	Compost Plant	14.9
Landfill Gas Collection Facility		0.2
Final Disposal		9.6

c. Waste Amount for Each Items

c.1 Refuse Collection & Transportation and Public Area Cleansing Amount

Refuse collection and Public Area Cleansing Amount are shown in Table 5-19.

Table 5-19: Refuse Collection & Transportation and Public Area Cleansing Amount

Item	Unit	AGM	SDM	YDM	Sub Total	Total
Refuse Collection & Transportation	ton/year	0	573,213	232,085	805,298	842,420
Public Area Cleansing	ton/year	12,062	20,797	4,263	37,122	

c.2 Recycling Intermediate Treatment Amount

Intermediate Treatment Amount are shown in Table 5-20.

Table 5-20: Recycling Intermediate Treatment Amount

Plant / Scenario	Unit	Sorting	RDF	Bio-gas	Compost	Landfill gas
Continuation of Present System	ton/year	-	-	-	-	-
Scenario 1	ton/year	463,331	351,860	379,089	-	-
Scenario 2	ton/year	463,331	-	-	379,089	-
Scenario 3	ton/year	463,331	-	-	-	758,470

d. Landfill Disposal Amount

Landfill Disposal Amount are shown in Table 5-21.

Table 5-21: Landfill Disposal Amount

Scenario	Unit	Landfill Disposal Amount
Continuation of Present System	ton/year	888,777
Scenario 1	ton/year	183,230
Scenario 2	ton/year	394,670
Scenario 3	ton/year	758,470

d. Comparison of Operation Cost of Each Scenario

The following table shows the operation cost, including depreciation costs, of each scenario in the year 2020. The operation cost in the table is calculated by subtracting revenues from selling materials and energy recovered by the recycling facilities. For reference, the operation cost of the continuation of present waste management system until 2020 was also calculated.

Table 5-22: Operational Cost of Each Scenario (Adana)

Adana Greater Municipality												Total (US$/year)	Discharge Amount (ton/year)		Population	(US$pc)
			(US$/ton)	(ton/year)		(US$/ton)	(ton/year)		(US$/ton)	(ton/year)						
Continuation Present System	Collection					22.7	573,213	13,011,935	22.7	232,085	5,268,330	18,265,000				
	Road & Park		186.0	12,062	2,243,532	186.0	20,797	3,868,242	186.0	4,263	792,918	6,820,000				
	Landfill		9.6	888,777	8,532,259							8,532,000				
	Administra	5%			538,790			844,009			303,062	1,681,000				
	Total				11,314,581			17,724,186			6,364,310	35,298,000	842,420	41	2,268,174	16
	Collection					22.7	573,213	13,011,935	22.7	232,085	5,268,330	18,265,000				
	Road & Park		186.0	12,062	2,243,532	186.0	20,797	3,868,242	186.0	4,263	792,918	6,820,000				
	Plant	Sorting	13.0	463,331	6,023,303							6,031,000				
		Bio-gas	70.0	351,860	24,630,200							24,630,000				
		RDF	30.0	379,089	11,372,670							11,373,000				
	Landfill		9.6	183,230	1,759,008							1,759,000				
	Medical waste	Landfill	61.9	4,636	286,968							287,000				
	Administra	5%			2,315,784			844,009			303,062	3,458,000				
	Total				48,631,465			4,712,251			6,364,310	72,623,000	842,420	86	2,268,174	32
	Collection					22.7	573,213	13,011,935	22.7	232,085	5,268,330	18,265,000				
	Road & Park		186.0	12,062	2,243,532	186.0	20,797	3,868,242	186.0	4,263	792,918	6,820,000				
	Plant	Sorting	13.0	463,331	6,023,303							6,031,000				
		Compost	14.9	379,089	5,648,426							5,652,000				
	Landfill		9.6	394,670	3,788,832							3,805,000				
	Medical waste	Landfill	61.9	4,636	286,968							287,000				
	Administra	5%			899,553			844,009			303,062	2,043,000				
	Total				18,890,615			17,724,186			6,364,310	42,903,000	842,420	50	2,268,174	19
	Collection					22.7	573,213	13,011,935	22.7	232,085	5,268,330	18,265,000				
	Road & Park		186.0	12,062	2,243,532	186.0	20,797	3,868,242	186.0	4,263	792,918	6,820,000				
	Plant	Sorting	13.0	463,331	6,023,303							6,031,000				
		Gas-collection	0.2	758,470	151,694							152,000				
	Landfill		9.6	758,470	7,281,312							7,281,000				
	Medical waste	Landfill	61.9	4,636	286,968							287,000				
	Administra	5%			799,340			844,009			303,062	1,942,000				
	Total				16,786,150			17,724,186			6,061,248	40,778,000	842,420	48	2,268,174	18

5.2.4 Selection of the Best Technical System Scenario

The results of the comparison of the above 3 scenarios was presented to the counterparts for deliberation and the selection of the best scenario.

a. Comparative Analysis of Scenarios

The following table summarises the features of each of the 4 scenarios which include the scenario of continuation of the present system.

Table 5-23: Comparison of M/P Scenarios (Adana)

Scenario Items	Without M/P Continuation of Present System	Scenario 1 Full Recycling	Scenario 2 Composting	Scenario 3 Landfill Gas Recovery
• **Technical**	• With the exclusion of sanitary landfilling, the adoption of this technical system is not forecast to incur problems because it is identical to the system currently in use. • On the other hand, the adoption of this system would incur no developments in the solid waste management technical system. • Since sanitary landfilling has already been introduced in some Turkish cities, the transfer of relevant technology can be satisfactorily carried out.	• To successfully produce biogas the separation of putrescible waste should be very strictly carried out. • The use of biogas plants to treat municipal SW is a relatively new approach, hence there is no assurance regarding its functions. Accordingly, the application in the target area, where even sanitary landfill is not conducted, is forecast to incur problems. • The operation of RDF facilities for waste treatment is only foreseen to incur minor problems. However, there is a need to consider the fact that recipients/users of RDF should adopt air pollution control measures. Hence sufficient considerations should be paid to the adoption of this technique.	• To successfully conduct composting, the separation of putrescible waste should be rigorously carried out. • As opposed to biogas plants, the technical problems that may arise in the composting of putrescible waste are minimal as long as separate collection is practised. • Nonetheless, difficulties are foreseen in view of the current manpower (skills) of Adana GM.	• Separate collection is not stringently required for the sorting facility as it is for biogas production and composting. • Although not perceived as a difficult technique, landfill gas recovery is unheard of in Turkey. This would, therefore, require transfer of technology and training opportunity, etc. from other countries. • Of the three scenarios, this alternative is considered to incur the least technical problems.
• **Social**	• Since this scenario proposes the continued use of the current collection system, no social issues are forecast to arise. • On the other hand, site acquisition for the development of the final disposal site would be the most difficult as, of the 4 scenarios, this scenario requires the largest disposal site (**1,333,000m^3/year**).	• Since this scenario requires separate collection to be very strictly carried out, proper education of and full co-operation from the public are important. • With the establishment of an highly advanced recycling system, public awareness regarding the importance of realising a closed-loop society on solid waste will be considerably heightened. • Site acquisition would be the easiest as, of the 4 scenarios, this scenario requires the smallest disposal site capacity (**275,000m^3/year**).	• Since this scenario requires separate collection to be strictly carried out, proper education of and full co-operation from the public are important. • With the establishment of an advanced recycling system, public awareness regarding the importance of realising a closed-loop society on solid waste will be heightened. • Site acquisition would be relatively easy as it only requires a disposal site capacity of **592,000m^3/year**.	• Since this scenario requires separate collection, proper education of and co-operation from the public are important. • Except for the sorting facility, the disposal site is the most essential waste management facility, hence site acquisition is extremely important. • Because this scenario requires a huge disposal site capacity (**1,138,000m^3/year**), gaining the consensus of the residents is considered to become increasingly difficult by the year.
• **Environmental**	• Except for the conversion of the dump site into a sanitary landfill, problems brought about by current SWM, e.g., illegal dumping, scavenging, will remain unsolved.	• Excluding residues from the RDF plant and biogas production plant, the majority of the waste will be recycled into some form. • The rate of waste recycling activities is very high at **82%**. Accordingly, this scenario will	• All waste generated will be taken to the recycling facility (compost plant and sorting facility). • This will incur a **57%** recycling rate, thereby reducing the amount	• Of the waste generated, only non-putrescible waste types will be handled at the sorting facility. • This will only incur a **15%** recycling rate, thereby hardly

Items / Scenario	Without M/P Continuation of Present System	Scenario 1 Full Recycling	Scenario 2 Composting	Scenario 3 Landfill Gas Recovery
	• The rate of waste recycling activities is very low at **3.9%**. Accordingly, this scenario will hardly contribute to global environmental preservation.	highly contribute to global environmental preservation.	for final disposal. • This scenario will contribute less to global environmental preservation than biogas production (Scenario 1) due to the CO2 emission levels the aerobic fermentation of putrescible waste for composting would emit.	reducing the final disposal amount. • The recovery of landfill gas (biogas) through the anaerobic fermentation of putrescible waste in the disposal site will curtail the emission of CH4 which is believed to accelerate global warming four or five times more than CO2. Accordingly, this scenario will highly contribute to global environmental preservation.
• **Economic**	• Through sanitary landfilling practices, waste disposal activities in the final disposal site will be environmentally-friendly.	• Maximum waste recycling will be achieved. Thermal recycling through biogas and RDF production, and improvement in compost quality will contribute to industrial development in the region. • Recovery of recyclable materials will be carried out in the sorting plant. • The disposal amount will be significantly reduced, and the landfill life span will be extended **5.7** times more than the case of continuation of present system.	• Recycling of organic waste is possible. Improvement in compost quality will contribute to industrial development in the region. • Recovery of recyclable materials will be carried out in the sorting plant. • The disposal amount will be reduced, and the landfill life span will be extended **2.4** times more than the case of continuation of present system.	• Thermal recycling through landfill gas recovery is possible. • Recovery of recyclable materials will be carried out in the sorting plant. • The disposal amount will be slightly reduced.
• **Financial**	• Will incur the smallest financial responsibility for SWM expenses: **US$16/person/year.** • Requires that the SWM expenses should be raised **1.5** times the expenses in 1998 (10.8 US$/person)	• The cleansing expenses will incur **2.10** times more than the case of continuation of present system. • Asking the residents to shoulder the SWM expenses is forecast to be difficult.	• The cleansing expenses will incur **1.22** times more than the case of continuation of present system. • Because this scenario will contribute to economic development in the region, the scenario could be realised, although it will depend on efforts exerted to gain resident consensus.	• The cleansing expenses will incur **1.27** times more than the case of continuation of present system. • Because this scenario will contribute to economic development in the region, the scenario could be realised, although it will depend on efforts exerted to gain resident consensus.

•

b. Selection of the Best Scenario

The team presented three (3) SWM M/P scenarios for Adana GM in the IT/R and requested the C/P to carefully examine their advantages and disadvantages, problems to be encountered, issues to be solved, etc., and select by the end of the second study work in Turkey mid-April 1999. The team recommends <u>Scenario 2: Composting</u> based on the following reasons:

1. The revenues from the operation of the recycling facility will never exceed the depreciation cost and O&M (operation and maintenance) expenses. In general unless a tipping fee is imposed, the revenues will never outbalance the depreciation cost and O&M expenses.
2. Although scenario 1 presents an ideal recycling system, realising this system would require each resident to pay US$ 32 for the waste handling cost (2.96 times more than present costs estimated by the team).
3. Composting using the biogas plant is extremely favourable in terms of global environmental protection because the plant emits low CO_2 levels in the atmosphere. Nonetheless, it is still not a well-established technology. In particular, it is a very expensive system and quite difficult to strictly control the mixing of unsuitable waste types. In addition it requires a large amounts of wastewater treatment for the operation.
4. For RDF, the acquisition of users who have combustion facilities with air pollution countermeasures is of utmost importance.
5. Although scenario 3, which focuses on sanitary landfilling and the recovery of landfill gas, would require very little expenses, the system cannot be realised unless a large and appropriate sanitary landfill site is acquired.

The Adana GM decided to select scenario 2 for this study. However, since year 2020, the M/P target year, is very far from now, they expressed they like to be free to change the scenario in accordance with socio-economic situation, technology progress, etc. in future.

5.2.5 Environmental Issues for EIA of F/S Projects

a. Selection of F/S Projects

Since scenario 2 was selected, the projects to be covered by the F/S are as follows:

1. Introduction of the separate collection of two waste types
2. Construction of a sorting and composting plant
3. Construction of a sanitary landfill site

b. Environmental Issues for EIA of F/S Projects

EIA shall be conducted in accordance with EIA procedures in Turkey. In the phase of formulation of M/P, the priority projects for the F/S are selected and the items for EIA for the projects are decided. The priority projects are detailed below.

1. Introduction of separate collection system
2. Construction and operation of sorting plant

3. Construction and operation of composting plant
4. Construction and operation of final disposal site

The items to be subject to the EIA should have been as instructed by Ministry of Environment, but to proceed with the study, the items were selected by the study team based on the JICA guidelines for environmental considerations for the conduct of development studies and the result was approved by Ministry of Environment.

For Adana, it was determined and agreed that the site for the F/S of the above-mentioned facilities 2, 3 and 4 is the present Sofulu disposal site. The EIA for the use of this disposal site will cover the following items:

- Economic activities
- Public health
- Hazards/risks
- Topographic and geological conditions
- Groundwater resource conditions
- Hydrological conditions
- Fauna and flora
- Landscape/aesthetics
- Air pollution
- Water pollution
- Soil contamination
- Noise and vibration
- Offensive odour

In accordance with the format of EIA prepared by Ministry of Environment, the following EIA issues need to be implemented.

Table 5-24: EIA issues to be implemented for priority projects

Items	Contents, Frequency, Points, etc.	Method
1. Economic Activities	① Loss of arable lands ② Halt in scavenging activities ③ Construction & operation of sorting plant and composting plant	Hearing from Farmers and Scavengers Marketability of recyclable materials and compost
2. Public Health	④ Sanitary condition of residents ⑤ Work environment at waste treatment and disposal facilities	Data from medical facilities Hearing from residents
3. Hazards /Risks	⑥ Collapse of slope ⑦ Gas explosions ⑧ Fire breakouts	Plans and design
4.Topographic /Geological Condition	Distribution of significant topographic and geological features	Data from topographical and geological survey
5. Groundwater Resources	① Flow condition ② Possibility of diverting flow	Data from geological survey
6. Hydrological Conditions	Flow condition and runoff rate (2 times during one month x 2 points)	Flow rates are measured. Well data from other projects
7. Fauna/Flora	① Endangered species ② Condition of ecosystem (An area of radius 1 km outside of the boundary of the proposed site)	Field survey

Items	Contents, Frequency, Points, etc.	Method
8. Landscape/Aesthetics	① Determination of visibility area and representative view stations ② Preparation of a montage photo from two view stations on the vicinity land (An area of radius 1.5 km outside of the boundary of the proposed site)	Site survey Photographs
9. Air Quality	① Understanding of impact from the dumping site ② Forecast of impact from the sanitary landfill (2 times during one month x 2 points Dust, SO_2, NOx, Cl_2, PM, Pb)	Method of Turkish standard or EU standard
10. Water Quality	Present situation and Forecast of impact from sanitary landfill (Stream; 2 times x 3 points Groundwater; 2 times x 6 points Leachate; 2 times x 1 point Colour, pH, Total dissolved matter, DO, COD, BOD, Fecal Coliform, T-N, T-P, NH+4, Na+, Cl-, SO4, Cr_6, Hg, Cd, Pb, As)	Method of Turkish standard or EU standard
11. Soil Contamination	Conjecture from the existing sanitary landfill	Qualitative way
12. Noise/Vibration	Forecast of noise and vibration due to construction and operation of facilities	Calculation
13. Offensive Odour	Conjecture from the existing sanitary landfill	Qualitative way
14. Land use	(An area of radius 1 km outside of the boundary of the proposed site)	Site survey and development plans
15. Water Use	Groundwater; within a radius of 5 km south of the site Surface water; from the site to Seyhan River	Hearing from residents
16. Meteorological data	Wind direction/velocity, precipitation, evaporation	Data collection and analysis

5.3 Selection of the Best Technical System for Mersin

In the former section 5.1 through the screening potential technologies, an optimum technical system was selected. However, an optimum intermediate treatment sub-system including resource recovery sub-system could not be decided. This section presents 3 technical system scenarios for the SWM master plan for Mersin and examines their advantages/disadvantages in overall SWM technical system, i.e., from collection to final disposal. After the careful discussion and examination with the C/P (counterpart) the best technical system scenario for Mersin was selected.

5.3.1 Presentation of Technical System Scenarios

a. Scenarios for the Technical System

Financially, this is the most expensive scenario but coincides with the full recycling system proposed by the MoE.

1. Separate collection of two types of waste:
   Compostable and non- compostable
2. Non-compostable waste: Sorting plant
3. Compostable waste: Biogas production

4. Residue of sorting plant: RDF treatment
5. Residue from biogas production and RDF treatment: Sanitary landfilling

a.2 Scenario 2: Composting

This is financially the second most expensive scenario but would help realise a recycling system that excludes the residue from the sorting plant. However, compostable waste will be recycled into ordinary compost, a method that is considered inexpensive and one that will not result in methane gas recovery.

1. Separate collection of two types of waste:
   Compostable and non- compostable
2. Non-compostable waste: Sorting plant
3. Compostable waste: Composting plant
4. Residue from sorting plant and composting plant: Sanitary landfilling

a.3 Scenario 3 Landfill Gas Recovery

This is financially the cheapest scenario and recycles compostable waste by the recovery of gases through anaerobic sanitary landfill operation.

1. Separate collection of two types of waste:
   Compostable and non- compostable
2. Non-compostable waste: Sorting plant
3. Compostable waste: Sanitary landfilling with gas recovery
4. Residue from sorting plant: Sanitary landfilling

b. Targets for Each Scenario

The aforementioned scenarios and their targets for the year 2020 are as shown in the table below.

Table 5-25: Targets of Each Scenario for 2020 (Mersin)

	Scenario 1 (Full Recycling)	Scenario 2 (Composting)	Scenario 3 (Landfill Gas Recovery)
Separate collection	100%	100%	100%
Sorting plant	all non-compostable waste	all non-compostable waste	all non-compostable waste
Biogas plant	all compostable waste	none	none
Composting plant	none	all compostable waste	none
RDF plant	all residues from sorting plant	none	none
Sanitary landfill	all residues from biogas and RDF plant	all residues from sorting and compost plants	all compostable waste and all residues from sorting plant

5.3.2 Conceptual Design

a. Future Waste Stream without Implementation of the M/P (Continuation of the Present System)

For the formulation of a SWM Master Plan (M/P) the forecast of future waste stream in the target area is indispensable. In order to clarify the difference between with and without M/P the case of the future waste stream for the continuation of the present technical system is prepared for a reference (baseline data) of the SWM M/P. Although it is not realistic, the case bases on the present waste stream and assumes its factor such as self-disposal rate, source recycling rate, etc. will not change in future. The outcomes of forecast are described as below.

a.1 Waste Discharge Amount

Waste discharge amount for the year 2005, 2012 and 2020 is referred to 4.2.2, *Waste Discharge Amount Forecast*. The future waste discharge amount is summarised as follows;

Year 2005

- Whole MSW 644 ton/day
- Other Waste 22 ton/day

Year 2012

- Whole MSW 946 ton/day
- Other Waste 33 ton/day

Year 2020

- Whole MSW 1,321 ton/day
- Other Waste 46 ton/day

a.2 Bulky Waste

As stated before, bulky waste is recycled and is not disposed of at the landfill at present. The study team believed that it will be discharged and need to be disposed in future. It is, however, very difficult to forecast when and how much it will be discharged. Therefore, the future amount of bulky waste is not available.

a.3 Self-disposed Waste Amount

Self-disposed waste amount for the year 2005, 2012 and 2020 is estimated based on the present conditions as described earlier, as follows;

- *9% of total population have not received collection service. Among these people (no refuse collection service), 24% disposed their waste by themselves such as burned/ buried in their premises or vacant lot.*

The study team estimated future self-disposed waste amount as shown below;

Year 2005

Self-disposed Waste Amount = 788,999 x 0.09 x 0.24 x 533 g/day

= 9.1 ton/day

Year 2012

Self-disposed Waste Amount = 982,499 x 0.09 x 0.24 x 633 g/day
= 13.4 ton/day

Year 2020

Self-disposed Waste Amount = 1,249,940 x 0.09 x 0.24 x 697 g/day
= 18.8 ton/day

a.4 Illegally Dumped Waste Amount

Future illegally dumped waste amount for the year 2005, 2012 and 2020 is estimated based on the present conditions as described in 2.1.6, *Waste Stream in Mersin*, as follows;

- *31% among 9% of total population which have not received collection service dumped their waste in the vacant lot or river.*

Therefore, the study team estimated future illegally dumped waste amount as shown below;

Year 2005

Illegally Dumped Waste Amount = 788,999 x 0.09 x 0.31 x 533 g/day
= 11.7 ton/day

Year 2012

Illegally Dumped Waste Amount = 982,499 x 0.09 x 0.31 x 633 g/day
= 17.4 ton/day

Year 2020

Illegally Dumped Waste Amount = 1,249,940 x 0.09 x 0.31 x 697 g/day
= 24.3 ton/day

a.5 Recycled Waste Amount

Future recycled waste amount for the year 2005, 2012 and 2020 is estimated based on the present conditions as described in 2.1.6, *Waste Stream in Mersin*, as follows;

- *Recycled waste amount by generation sources per capita is estimated at 23.6 g.(15 ton ÷ 634,850).*
- *Recycled waste amount by street waste pickers is estimated at 15.8 g per capita (10 ton ÷ 634,850).*
- *Recycled waste amount by scavengers at composting plant is estimated at 0.6 g per capita (0.35 ton ÷ 634,850).*
- *Recycled waste amount by scavengers at dump site is estimated at 2.4 g per capita (1.5 ton ÷ 634,850).*

Therefore, the study team estimated recycled waste amount in each component of waste stream as shown below;

Year 2005

Recycled waste amount by generation sources = 788,999 x 23.6 g/day
= 18.6 ton/day

Recycled waste amount by street waste pickers = 788,999 x 15.8 g/day
= 12.5 ton/day

Recycled waste amount by scavenger at composting plant = 788,999 x 0.6 g/day
= 0.5 ton/day

Recycled waste amount by scavengers at dump site = 788,999 x 2.4 g/day
= 1.9 ton/day

Year 2012

Recycled waste amount by generation sources = 982,499 x 23.6 g/day
= 23.2 ton/day

Recycled waste amount by street waste pickers = 982,499 x 15.8 g/day
= 15.5 ton/day

Recycled waste amount by scavenger at composting plant = 982,499 x 0.6 g/day
= 0.6 ton/day

Recycled waste amount by scavengers at dump site = 982,499 x 2.4 g/day
= 2.4 ton/day

Year 2020

Recycled waste amount by generation sources = 1,249,940 x 23.6 g/day
= 29.5 ton/day

Recycled waste amount by street waste pickers = 1,249,940 x 15.8 g/day
= 19.7 ton/day

Recycled waste amount by scavenger at composting plant = 1,249,940 x 0.6 g/day
= 0.7 ton/day

Recycled waste amount by scavengers at dump site = 1,249,940 x 2.4 g/day
= 3 ton/day

a.6 Waste Collection Amount

Future collected waste amount for the year 2005, 2012 and 2020 is estimated as follows;

Collected Waste Amount = Waste Discharge Amount - Illegally Dumped Waste Amount - Recycled Waste Amount by Street Waste Pickers

Therefore, the study team estimated future collected waste amount as shown below;

Year 2005

Collected Waste Amount = 635 - 11.7 - 12.5 ton/day
= 610.8 ton/day

Year 2012

Collected Waste Amount = 933 - 17.4 - 15.5 ton/day
= 900.1 ton/day

Year 2020

Collected Waste Amount = 1,302 - 24.3 - 19.7 ton/day
= 1,258.0 ton/day

a.7 Compost Plant

Future amount of each component of waste stream concerning with operation of compost plant such as waste amount transported to compost plant, quantity of compost produced and rejected waste from year 2005 up to year 2020 is forecasted as same amount at the time being. Therefore, the amount of the above-mentioned components are clarified as follows;

Year 2005, 2012 and 2020

Waste Amount transported to compost plant = 40 ton/day

Quantity of compost produced = 20 ton/day

Rejected Waste from compost plant = 10 ton/day

a.8 Final Disposal Amount

Future final disposal amount for the year 2005, 2012 and 2020 is simply calculated according to the following formula;

Final Disposal Amount = Collected Waste Amount - Waste Amount Transported to Compost Plant + Rejected Waste + Other Wastes - Recycled Waste Amount by Scavengers at dump site

Therefore, the study team estimated final disposal amount as shown below;

Year 2005

Final Disposal Amount = 610.8 - 40 + 10 + 24 - 1.9 ton/day
= 602.9 ton/day

Year 2012

Final Disposal Amount = 900.1 - 40 + 10 + 36 - 2.4 ton/day
= 903.7 ton/day

Year 2020

Final Disposal Amount = 1,302.0 - 40 + 10 + 51 - 3 ton/day
= 1,320.0 ton/day

Therefore, amount of each component of waste stream is summarised in the following table.

Table 5-26: Summary of Future Waste Stream Component for Mersin GM

Waste Stream Component	Ton/day

	2005	2012	2020
Waste Generation Amount	662.7	969.6	1,350.3
Recycling by Generation Sources	18.6	23.2	29.5
Self-Disposed Waste Amount	9.1	13.4	18.8
Waste Discharge Amount	635.0	933.0	1,302.0
Recycling by Street Waste Pickers	11.7	15.5	19.7
Waste Collection Amount	610.8	900.1	1,258.0
Illegally Dumped Waste Amount	11.7	17.4	24.3
Waste Amount Transported to Compost Plant	40.0	40.0	40.0
Quantity of Compost Produced	20.0	20.0	20.0
Recycling by Scavengers at Compost Plant	0.5	0.6	0.7
Rejected Wasted from Compost Plant	10.0	10.0	10.0
Recycling by Scavengers at Dump site	1.9	2.4	3.0
Other Waste	24.0	36.0	51.0
Final Disposal Amount	602.9	903.7	1,320.0

b. Future Waste Stream Diagram

In conclusion, the study team presented the future waste stream diagram for Mersin

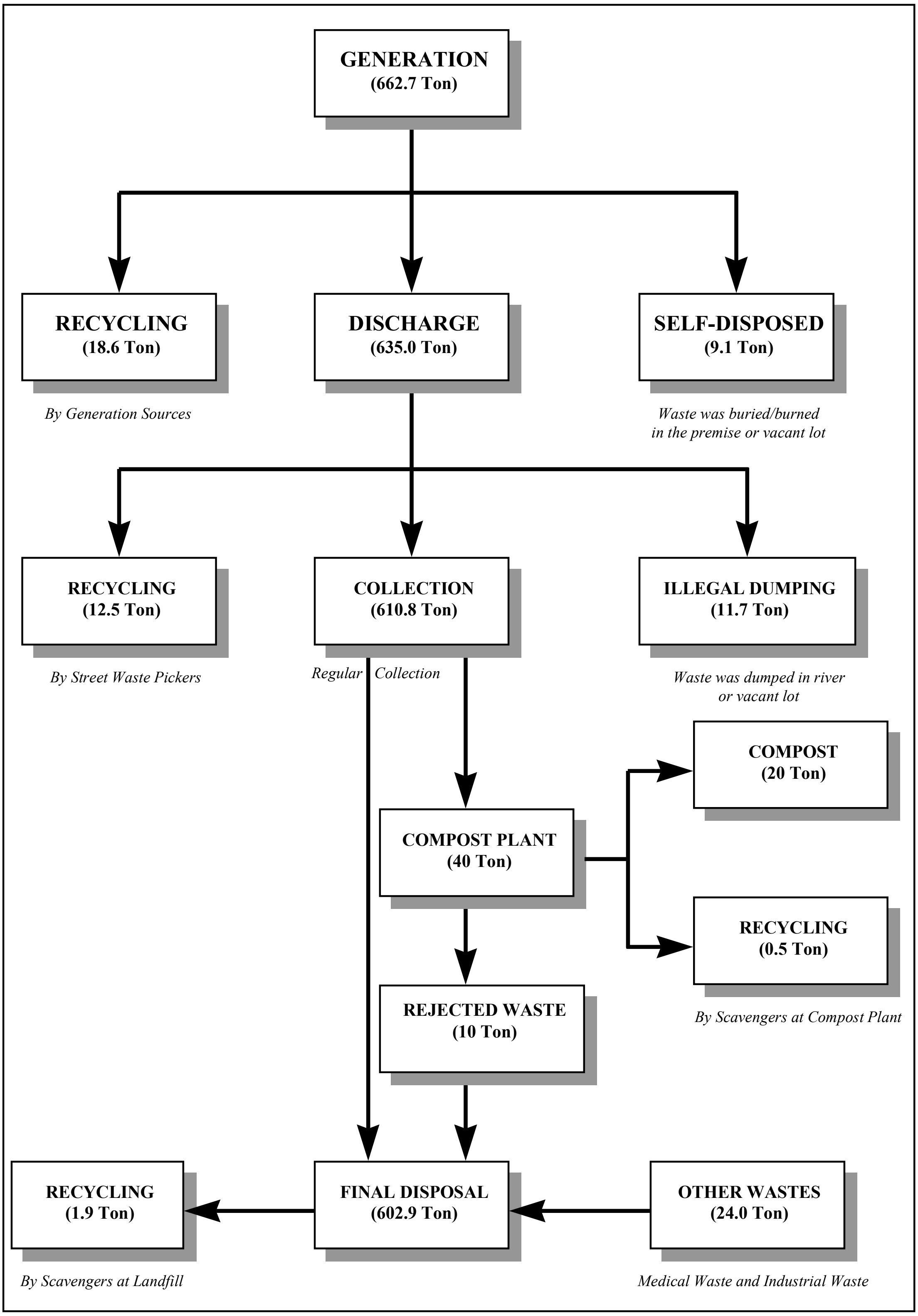

Figure 5-14: Waste Stream Diagram for Mersin in Year 2005

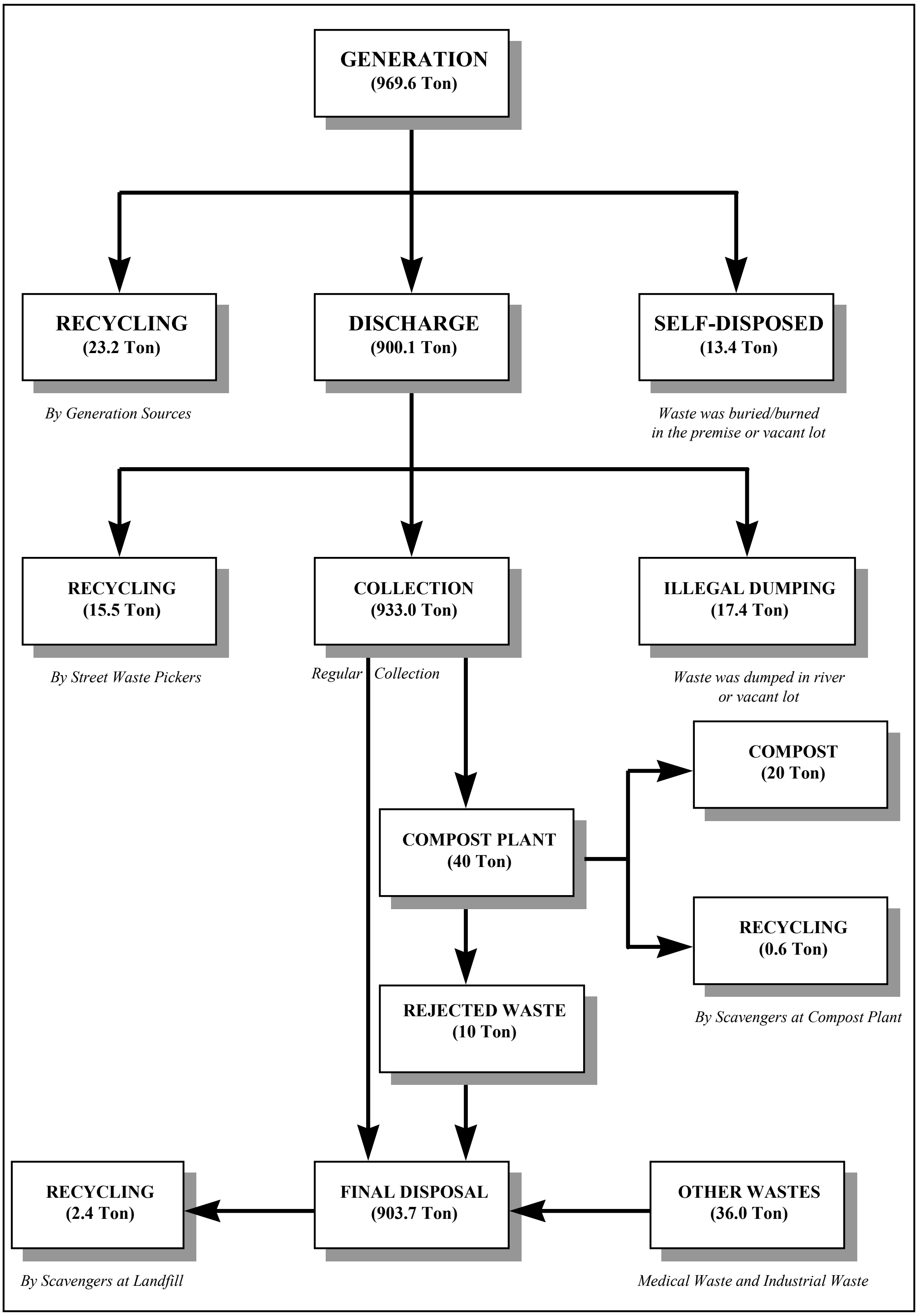

Figure 5-15: Waste Stream Diagram for Mersin in Year 2012

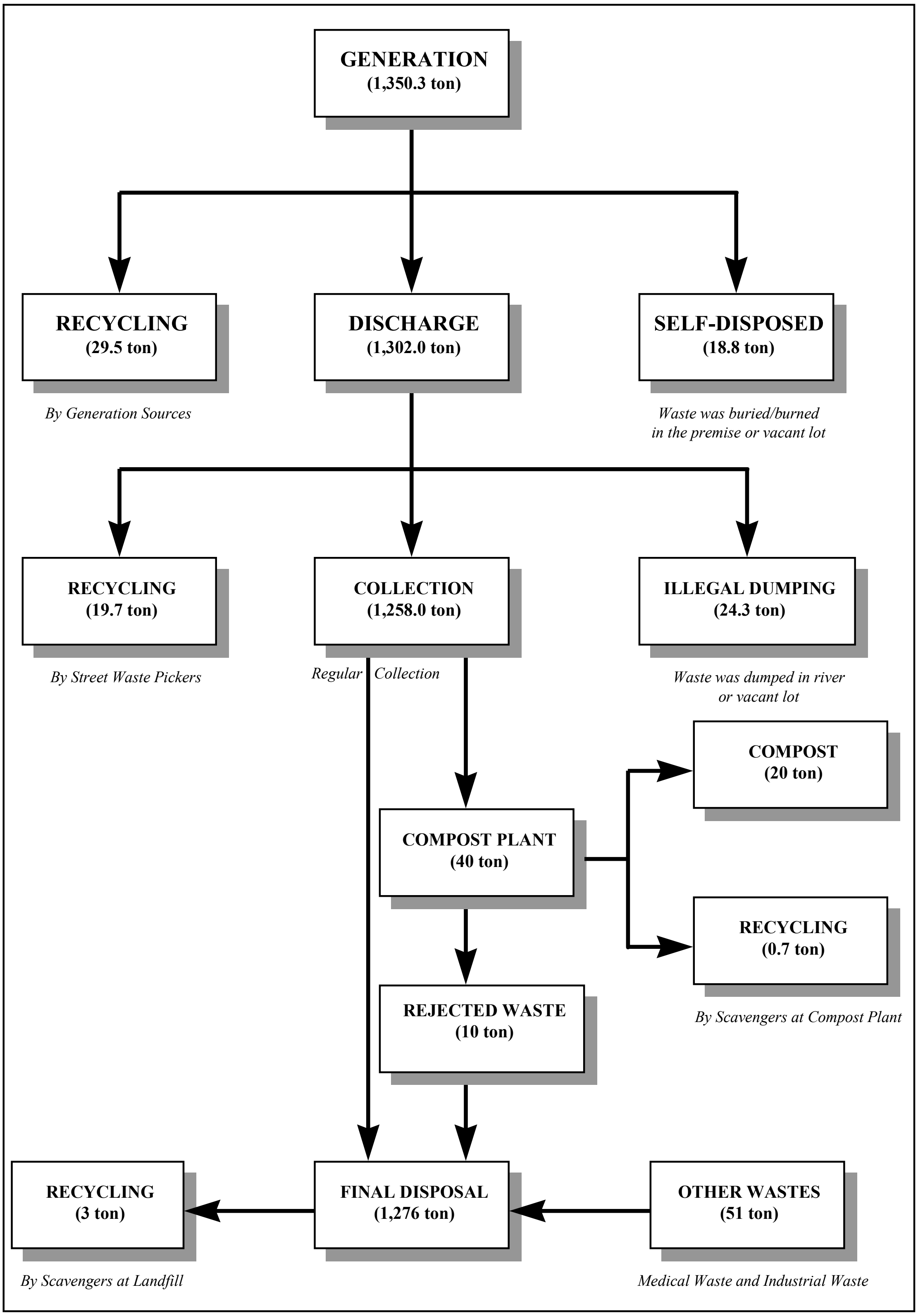

Figure 5-16: Waste Stream Diagram for Mersin in Year 2020

b. Collection and Haulage

The collection and haulage system is basically associated with the final disposal and intermediate treatment systems. The collection and haulage systems for Mersin will be improved within a phased program as given below.

Phase	Target Year	Aim
Phase 1	1999-2005	• The direct haulage of wastes will be continued. • In Toroslar DM wheeled container system will put into operation gradually due to the operation of communal storage/collection system. • Usage of wheeled containers will be extended gradually within the city. • A pilot stage source separation system will be initiated in the high-income mahalle(s). • The new landfill site is presumed to be constructed at a farther location. Therefore, the introduction of a transfer station(s) will be examined to cope with the haulage of the waste to landfill site, which will be far from the city centre.
Phase 2	2006-2012	• Part of the transfer station(s) will be in operation. • The whole storage system will be changed with wheeled container system • The pilot stage source separation will be extended to other mahalles of city, therefore separate collection will start.
Phase 3	2013-2020	• The transfer station(s) will be in full operation. • The source separation will be in full operation

b.1 Storage and Discharge in Mersin

The following main policies will be applicable for Mersin;

- The type of containers used will be regulated, standard wheeled container system will be extended.
- A source separation system will be initiated for discharging the non-compostable (recyclable) and compostable wastes in a controlled manner, in order to give provision for a composting/recycling scheme.
- The usage of litter bins will be extended, especially starting from high-income and middle-income areas.

b.2 Collection and Haulage in Mersin

- The usage of compactor trucks will be extended. Satellite collection vehicles will be introduced for the collection in narrow streets.
- Communal container collection system will be applied in order to increase the collection efficiency.
- It is assumed that the existing collection equipment will be used in Phase 1, and gradually they will be replaced with the new vehicles, after they exceed the life span of 7 years.

- Collection frequency will be daily, 6 days a week for residential and commercial and market waste for compostable waste.
- Collection frequency for source separated non-compostable waste (recyclable materials) will be once or twice a week.
- Direct hauling of collected waste will be achieved in the Phase 1, but whenever the new landfill site will be in operation, there will be a need of transfer station(s) in Mersin.
- The remaining economic life of collection vehicles in Mersin is given below.

Production Year	Yenisehir DM	Akdeniz DM	Toroslar DM
1991	-	17	12
1992	12	-	-

The economical lifespan of collection equipment is given below.

1) Communal containers : 7 years
2) Waste collection vehicles and heavy equipment : 7 years
3) Machinery : 15 years
4) Buildings and civil works : 30 years

As can be understand from the tables, the equipment that was produced in 1991 and 1992 has already exceeded its lifespan but still in function in Mersin DM. It is unrealistic to propose the replacement of all these equipment at once because the present solid waste management systems rely heavily on them. It is, therefore, proposed that all the existing equipment would be operational until the end of 2005 (beginning of Phase 2), requiring higher maintenance costs and should be replaced gradually in Phase 2.

The type of collection equipment and collection methods proposed for each type of area is summarised below.

Area	Collection Equipment	Collection Method
Standard residential areas and commercial areas	Compactor truck (12 - 16 m^3)	Communal container collection
Narrow streets, old town	Satellite vehicles (4 m^3)	Communal container collection
Source separated non-putrescible waste (recyclables)	Collection truck	Separate collection
Street waste	Compactor truck (12 - 16 m^3)	Communal container collection

b.3 Haulage/Transfer Stations

As mentioned before, the direct haulage of wastes to the disposal site in Mersin will be accomplished by the existing collection vehicles and no transfer station will be necessary due to the location of the disposal site by 2002.

Transfer station option in Mersin, especially siting of transfer station has been discussed with the municipal officials of Mersin, but unfortunately it was not possible for Akdeniz, Yenisehir and Toroslar DM's to propose alternative sites for selection. Although the investment and operation of the transfer stations are under the responsibility of Greater Municipality, they are going to be located in DM grounds and therefore have to be discussed internally by the municipal authorities, and selected through the sites which has been proposed by DM's.

Due to these arguments, the study team was not able to locate the transfer station in Mersin at this stage of the project, and therefore highlighted the issue in a theoretical - desk study - approach, by discussions with the metropolitan municipal officials. The proposed site by the Metropolitan Municipality for desk study, is a site located in Toroslar DM in Portakal Mahalle, which is almost 27 km far from the new selected landfill site of Cimsa.

The alternative locations for the transfer station have to be recommended by DM's municipal officials, and the Greater Municipality of Mersin must plan the most feasible site for transfer system.

b.3.1 Siting Issues for Transfer Stations

It is worth at this stage to give some idea how to locate the transfer station. Several criteria determine where a transfer station should be located. Some of these are more obvious than others, as given below;

- First of all, the transfer station should be as near as possible to weighted centre of the individual collection area, since the minimisation of travel distances is the whole purpose of the transfer station.
- In addition to proximity to the collection routes, access to major haul routes is also important in optimising transfer vehicle productivity.
- Access roads must be able to handle heavy truck traffic, and truck routes should be designed to minimise the impacts of the vehicles on neighbourhoods.
- Aside from the routing issues, the land on which the facility will be built should provide adequate isolation.
- Siting the facility will also involve garnering neighbourhood and community acceptance, where there will be minimum of public and environmental objection, which in many cases is the most difficult task.
- Transfer station should be located to where the construction and operation will be most economical.
- Additionally, if the transfer station site is to be used for processing operations involving recycling/material recovery, requirements and as well as the environmental conditions for those operations must also be assessed.

Transfer Stations

In the field of solid waste management, the functional element of transfer and transport refers to the means, facilities, and appurtenances used to effect the transfer of waste from one location to another, usually more distant, location. Typically, the contents of relatively small collection vehicles are transferred to larger vehicles that are used to transport the waste over extended distances either to waste treatment facilities or to disposal sites. In some cases, transfer and transport operations are also used in conjunction with waste treatment facilities to transport recovered materials to markets or to other intermediate waste facilities and to transport residues to landfills.

b.3.2 The Need for Transfer Operations

Transfer and transport operations become a necessity when haul distances to available processing centres or disposal sites increase so that direct hauling is no longer economically feasible. Transfer stations are centralised facilities where waste is unloaded from several small capacity collection vehicles and loaded into a larger capacity vehicle for hauling. This tends to increase the efficiency of the system, as collection vehicles and crews remain closer to the routes, while larger vehicles, designed for transfer, make the trip to the disposal facility.

Because of siting problems, and the lack of available spaces, landfills and other disposal facilities are being sited in more remote areas, away from municipal waste sources or generation points. Consequently, the costs associated with transporting the waste from the collection route to the disposal facility are increasing. Transfer stations are becoming a more attractive alternative for controlling these rising costs.

In addition, transfer station operation may be integrated with other waste management options, such as recycling programs and waste - to - energy facility operation, which further enhances the attractiveness of transfer stations.

Despite the benefits associated with transfer stations, significant capital and operating costs may remove them as feasible options.

Additionally, operating a transfer station can have significant impacts on other elements of integrated solid waste management system and, if properly planned, these impacts can be extremely positive and cost effective.

Transfer operations can be used successfully with all types of collection vehicles and conveyor systems. Additional factors that tend to make the use of transfer operations attractive include;

- The occurrence of illegal dumping due to the excessive haul distances,
- It gives provision to locate the disposal sites far from collection routes,
- The use of small capacity collection vehicles,
- The existence of low-density residential service areas,
- The use of a hauled container system (if needed) with relatively small capacity containers for the collection of wastes from commercial sources.

Although the specific details vary with size, important factors that must be considered in the design of transfer stations are given below:

- The type of transfer operation to be used
- Storage and throughput capacity requirements
- Equipment and accessory requirements
- Sanitary requirements

- Transfer station cost and benefits.

b.3.3 Transfer Station Planning and Design Requirements:

Although the specific details vary with size, important factors that must be considered in the design of transfer stations are given below:

- The type of transfer operation to be used
- Storage and throughput capacity requirements
- Equipment and accessory requirements
- Sanitary requirements
- Transfer station cost and benefits.

Type of Transfer Station:

Transfer stations are used to accomplish transfer of solid wastes from collection and other small vehicles to larger transport equipment. Depending on the method used to load the transport vehicles, transfer stations may be classified into three general types:

(1) Direct-load
(2) Storage-load
(3) Combined direct-load and storage-load

On the other hand, transfer stations may be classified with respect to throughput capacity (the amount of material that can be transferred and hauled) as follows:

(1) Small, less than 100 ton/day
(2) Medium, between 100 – 500 ton/day
(3) Large, more than 500 ton/day.

Transfer station categories, based on the method used are briefly outlined in Figure 5-17, and some of the associated advantages and disadvantages are also included.

Table 5-27: Transfer Station Design Alternatives

Design Option	Advantages	Disadvantages
Direct-Load • Collection vehicle dump load directly into a open-top trailer via large hopper • Waste is gravity-fed to the trailer	• No intermediate handling of waste, increasing efficiency • Facility shutdown rare because no complicated equipment involved • Easy to operate	• Additional tipping floor/storage space may be required in order to operate in efficient way
Storage-Load • Large tipping pit/floor/hopper where the collection vehicles unload • Mobile plant/crane organise and push the waste into open trailer/container	• Requires little site work • Involves relatively low building costs • Recyclables can be separated • Floor/pit acts as storage area during peak arrival	• Usually insanitary /unaesthetic conditions • Operation cost are higher than direct-loading method • Sometimes complicated mechanical systems are used
Combined Direct-Load and Storage-Load • Usually a multipurpose facility • Materials recovery	• Can achieve resource recovery and recycling • Can handle big capacities of waste	• Higher investment/operation and maintenance costs • Very complicated to operate

b.3.4 Selection of Type of Mersin Transfer Stations

For DMs of Mersin, direct-load is the most cost effective and efficient type of transfer station because it possesses simple operation conditions, low investment/operation and maintenance costs, and non-complicated mechanical systems.

Transfer Station Capacity Requirement

A fundamental transfer station design factor is the communities waste volume estimate. Practices show that estimates are often inaccurate, resulting in oversized or undersized facilities faced with operating losses and high tipping fees. Accurate waste stream assessment data and estimating the changes in the waste stream due to recycling or other waste management program are the only way to avoid this problem. This issue has seriously been taken into consideration in the project studies and accurate values have been identified.

Both the throughput and storage capacity requirements must be evaluated carefully in planning and designing transfer stations. The throughput capacity of a transfer station must be such that the collection vehicles do not have to wait too long to unload. In most cases, it will not be cost-effective to design the station to handle the ultimate peak number of hourly loads. Ideally, an economic trade-off analysis should be made.

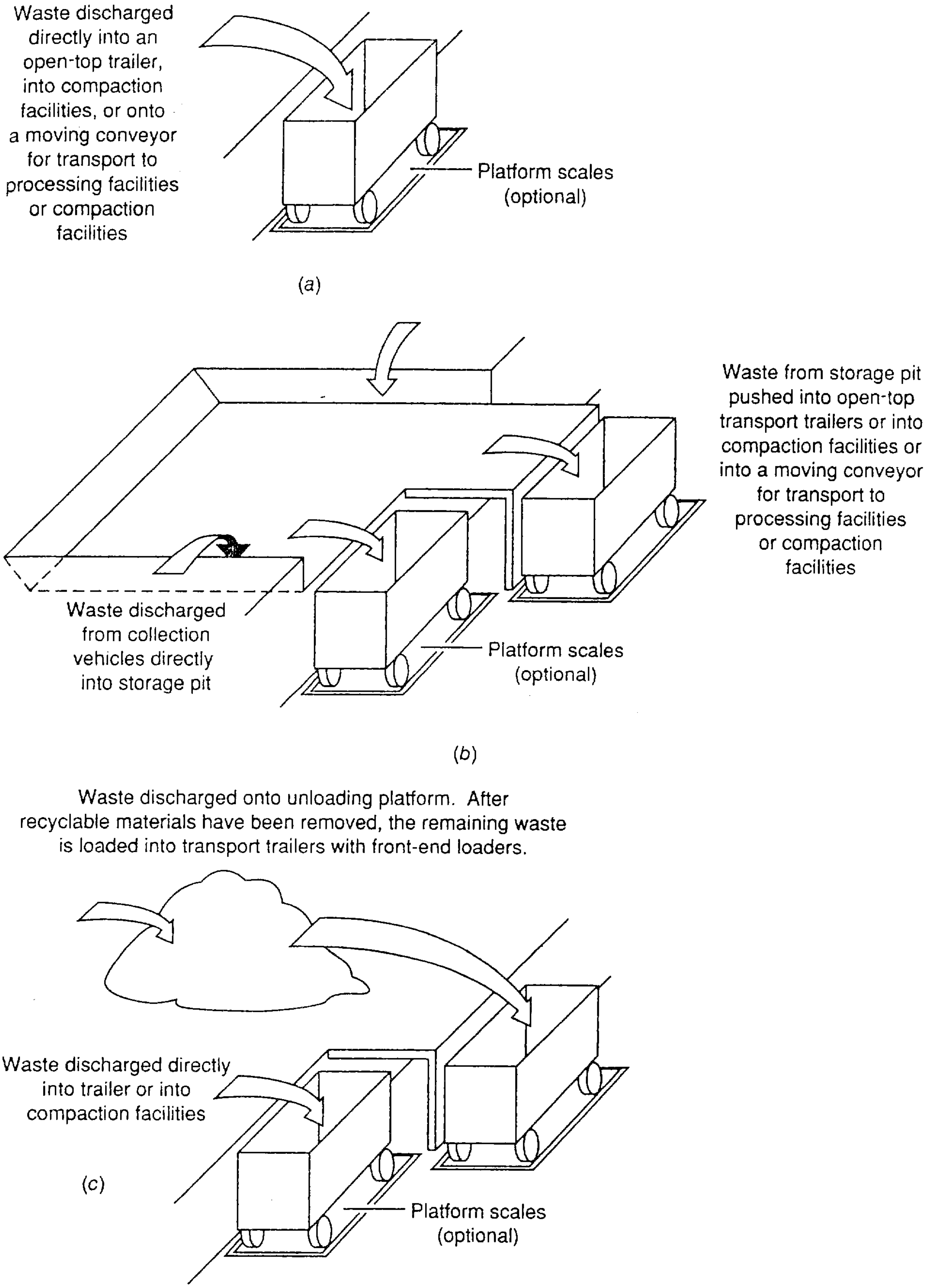

Figure 5-17: Types of Transfer Operations

b.3.5 Selection of the Capacity of Mersin Transfer Station

The estimated future collected waste amount in Mersin for the year 2005, 2012 and 2020 are given below:

Year	Collected Waste Amount
2005	637 ton/day
2012	942 ton/day
2020	1,321 ton/day

The transfer stations in Mersin will need to be put into operation when current compost landfill be closed and new Cimsa landfill open. Basing on the estimated future collected waste amounts and transfer station capacity requirements, the capacity of Mersin transfer stations is given below, which will illustrate the operational capacity for the years 2005, 2012 and 2020.

Year	Operational Capacity		
	Yenisehir	Akdeniz	Toroslar
2005	160 ton/ 8 hr shift	250 ton/ 8 hr shift	250 ton/ 8 hr shift
2012	270 ton/14 hr shift	330 ton/11 hr shift	370 ton/12 hr shift
2020	390 ton/ 20 hr shift	430 ton/14 hr shift	540 ton/18 hr shift

<u>Equipment and Accessory Requirements</u>

The equipment and accessories used in conjunction with a transfer station depend on the function of the transfer station in the waste management system. The types and amounts of equipment required also vary with the capacity of the station. Additional equipment is required to distribute the waste and equalise the loads. Scales should be provided at all medium and large size transfer stations, both to control and monitor the operation and to develop meaningful engineering data.

If the transfer station is to be used as a dispatch centre or district headquarters for a solid waste collection operation, a more complete facility should be constructed. For headquarters facility, fuel depot, a lunchroom, meeting room, offices, locker rooms, showers, and toilets should be provided. Facilities for providing equipment maintenance may also be incorporated.

One of the most important equipment in transfer stations is the transfer vehicle. Transfer vehicles come in two basic varieties:

- Open-top trailers
- Enclosed trailers

Where the point of final disposition can be reached by motor vehicle, the most common means used to transport solid wastes from transfer stations are trailers, semitrailers and compaction vehicles.

In general, vehicles used for hauling on highways should satisfy the following requirements:

(1) Wastes must be transported at minimum cost

(2) Wastes must be covered during haul

(3) Vehicles must be designed for highway traffic

(4) Vehicle capacity must be such that the allowable weight limits are not exceeded, and

(5) The methods for loading and unloading must be simple and dependable.

The decision-makers should consider the factors given below, which would be affecting transfer vehicle selection:

(1) Capital costs

(2) Capacity of the trailer

(3) Type of transfer station

(4) Distance of haul to disposal site

(5) Hours of haul/day

(6) Quantity of waste to be transported, and

(7) Weight limits.

Sanitary Requirements

Environmental Requirements

By proper design, construction and operation, the objectionable problems of transfer stations can be minimised. Most of the modern, large transfer stations are enclosed and are constructed of materials that can be maintained and cleaned easily. To eliminate inadvertent emissions, enclosed facilities should have air-handling equipment that creates a negative pressure within the facility. In most cases, fireproof construction is used for direct-loading transfer stations with open loading areas if necessary. Special attention should be given to the problem of blowing paper. The best way to maintain overall sanitation of a transfer station is to monitor the operation continually. Spilled wastes should be picked up immediately or in any case should not be allowed to accumulate for more than 1 or 2 hour. The area should also be washed in reasonable intervals. The produced wastewater in the facility should also be handled in a sanitary manner, if necessary should be treated.

Health and Safety

Health and safety issues in transfer stations are related to dust and vapour inhalation. Overhead water sprays are used to keep the dust down in the facility. To prevent inhalation, workers should wear dust masks. For reasons of safety, the public should not be allowed to discharge wastes directly into the facility, but to containers at the reception area of vehicles.

Transfer Station Benefits

Developing and operating transfer stations involves significant capital costs, including land acquisition, construction of buildings, purchase of equipment, and haul vehicles. Cost of design, site preparation, and construction are also significant.

Substantial benefits, however, can also be realised. Cost savings resulting from transfer station implementation may include;

(1) Reduced nonproductive time of collection crew

(2) Reduced collection truck mileage

(3) Reduced maintenance costs of collection trucks, and

(4) Increased use of lighter duty collection vehicles.

b.3.6 Cost Comparison Between Direct Haul/Transfer Station - (Short-range transfer)

To understand the advantages and cost/benefits of transfer stations, it is fair at this stage to give an example on direct haul to disposal site verses transfer station in case of Mersin, depending on the actual findings of surveys held during the project, which we think will be more explanatory.

From an area, which has a population of 30,000, and a solid waste production rate of 0.44 kg/capita/day, it is planned to collect the solid waste with compaction vehicles. The loading capacity of the collection vehicle is 16 m^3. (Full load in every trip). Collection team is composed of 1 driver and 2 collection labour. The density of the waste is 290 kg/m^3. The time spend for one trip collection is 100 minutes. The disposal site is 27 km and transfer station is 2.5 km away from the collection site and the average speed of the vehicle is 40 km/hr on highway and 20 km/hr in the city. The time spend for disposing of waste on the disposal site and transfer station is 25 minutes and 10 minutes respectively. The fuel consumption of the vehicle is 0.24 l/km and the cost of the fuel is 288,000 TL/l. The length of the collection area is 2 km. The gross salary of the labour is 120,000,000 TL/month.

Cost comparison for the direct haul to the disposal area verses short-range transfer (use of transfer station option) are calculated as follows.

<u>Direct Haul to the Disposal Site:</u>

Population	: 30,000 capita
Waste generation amount	: 0.44 kg/capita/day
Daily waste amount	: 13,200 kg/day
Daily volumetric waste amount	: 45.5 m^3/day
Collection vehicle capacity	: 16 m^3
Labour	: 1 driver + 2 collector
Duration of one collection trip	: 100 minutes

Haul time to disposal site
(27 km / 40 km/hr) x 60 min/hr : 40.5 min

Duration of disposal : 25.0 min
Duration of coming back to collection area : 40.5 min

Total duration of one collection trip
(100+40.5+25+40.5) = 206 min / 60 min/hr : 3.43 hr / trip

Number of trips per day (for 8 working hours/day)
(8 hr/day) / (3.43 hr/trip) : 2.33 trip/day

Waste collected per day
(16 m^3) x (2.33 trip/day) : 37.3 m^3/day

Daily length of drive
(27km x 2 x 2.33 trip) + (2 km x 2.33 trip) : 130.5 km/day

Total fuel cost per day
130.5 km x 0.24 lit./km x 288,000 TL/lit. : 9,020,160 TL/day

Daily labour cost
3 x 120,000,000 TL/month / 30 day/month : 12,000,000 TL/day

Total cost per day : 21,020,160 TL/day

Cost of per ton of solid waste
(21,020,160 TL/day) / (37.3 m^3/day) = 563,543 TL/m^3
(563,543 TL/m^3 / 0.29 m^3/ton) : **1,943,252 TL/ton**

<u>Short-range Transfer (Use of Transfer Station Option):</u>

Population : 30,000 capita
Waste generation amount : 0.44 kg/capita/day
Daily waste amount : 13,200 kg/day
Daily volumetric waste amount : 45.5 m^3/day
Collection vehicle capacity : 16 m^3
Labour : 1 driver + 2 collector
Duration of one collection trip : 100 minutes

Haul time to transfer station
(2.5 km / 20km/hr) x 60 min/hr : 7.5 min

Duration of disposal : 10.0 min
Duration of coming back to collection area : 7.5 min

Total duration of one collection trip
(100+7.5+10+7.5) = 125 min / 60 min/hr : 2.1 hr / trip

Number of trips per day (for 8 working hours/day)
(8 hr/day) / (2.1 hr/trip) : 3.8 trip/day

Waste collected per day
(16 m^3) x (3.8 trip/day) : 60.8 m^3/day

Daily length of drive
(2.5 km x 2 x 3.8 trip) + (2 km x 3.8 trip) : 26.6 km/day

Fuel cost per day

26.6 km x 0.24 lit./km x 288,000 TL/lit. : 1,838,590 TL/day

Labour cost per day
3 x 120,000,000 TL/month / 30 day/month : 12,000,000 TL/day

Total cost per day : 13,838,590 TL/day

Cost of per ton of solid waste
(13,838,590 TL/day) / (60.8 m^3/day) = 227,608 TL/m^3
(227,608 TL/m^3 / 0.29 m^3/ton) **: 785,000 TL/ton**

Cost of Transfer from Transfer Station to Disposal Site:

A trailer of 25 ton loading capacity, with 0.34 lit./km fuel consumption will transfer the waste that is disposed to the transfer station, with a work force of only one driver. The disposal area is 27 km from the transfer station.

Fuel cost
27 km x 0.34 lit./km x 288,000 TL/lit. **: 2,644,000 TL**

Labour cost
(1 x 120,000,000 TL/month) / (30 day/month) **: 4,000,000 TL**

Total Cost : 6,644,000 TL

Cost of per ton of solid waste
6,644,000 TL / 25 ton **: 266,000 TL/ton**

Total cost of short-range transfer and haul to disposal site

(785,000 TL/ton + 266.000 TL/ton) ***: 1,051,000 TL/ton***

CONCLUSION:

Due to the results of the desk study, it is clearly understandable that using transfer stations is almost 50 % more cost effective than direct haulage of solid wastes to the disposal area.

(In above example, for the both cases, daily vehicle costs do not include the maintenance, repair, wear-out and managerial costs).

c. Public Area Cleansing

c.1 Public Area Cleansing Basic Concepts

- In most mahalles of the city all streets sweeping work will be generally carried out manually.
- The existing mechanical street sweepers will be used for the cleaning of main roads and boulevards in the Phase 1 and Phase 2, renewing them when necessary. In Phase 3, the ratio of the mechanical sweeping operation will be increased if the labour cost will be increased and the road conditions will be

improved. If these labour and road condition allows, whole system for major road will be exchanged to fully mechanical system.

- An appropriate collection and transportation system for street waste will be introduced.
- The street waste, which is collected manually, will be stored in wheeled containers that are allocated only for this purpose and will be collected by the existing collection vehicles.
- Prevention of littering in the city will be achieved.
- The supervision system of labourers will be improved.

The present street sweeping work, mainly conducted manually, is deemed to be an appropriate method due to cheap labour costs and inferior road conditions that would hamper mechanical street sweeping equipment. However, the ratio of manual/mechanical sweeping work shall be examined and changed according to the labour cost increase and the improvement of road conditions.

c.2 Public Area Cleansing Master Plan Program

- **To install more litter boxes along streets**

More litter boxes will be installed to reduce the workload for street sweepers and preventing waste from scattering.

- **To increase the number of collection points**

In order to shorten the haulage distance of the collected waste, communal containers will be used as collection points, which will be placed in close proximity. The haulage distance will be controlled, which will be less than one km.

- **To use a new type of cart to carry litter collected**

A new type of cart with a larger haulage capacity will be introduced to improve the efficiency of the haulage work.

- **To set up site offices with space**

The municipalities will set up site offices with storage space in accordance with the increase in street sweeping area. These offices will function as a storehouse to stow carts, tools, etc., and to enable a foreman to supervise street sweepers.

- **Sweeping Frequency**

The street sweeping frequency in Mersin is proposed as follows:

Road Classification	Frequency
Commercial roads and market zones	Once a day
Main roads in the Central Zone	Once a day
Suburban commercial streets	4 times per week
Secondary streets	2 times per week
Residential Streets	2 times per week
Main roads (boulevards)	Once a day

d. Recycling

The following government related recycling systems will be established.

- An administration system that promote production of recyclable goods/products from the manufacturing stage, with government assistance, in order to minimise waste generation (generation control) to as much as possible.
- A system that enables recycling at source, in particular, separate discharge at source and promote the recycling of segregated waste materials.
- Recycling by the several intermediate treatment facilities.

e. Intermediate Treatment

In order to draw up waste streams for 3 scenarios, the team set up the following figures for each intermediate treatment facility. These figures are deduced from the waste composition forecasted by the team and various operational data which the consultants gained from Japan, Denmark, etc.

Items	Rates(%)
Separate Collection Amount	
- Non-putrescible Waste	58
- Putrescible Waste	42
Sorting Plant	
- Recycled Waste	24
- Residues	76
Biogas Plant	
- Water Content	70
- CH4, H2O, etc.	77
- Compost	18
- Residues	4
- Recycling	1
RDF (Refuse Derived Fuel)	
- RDF	60
- Residues	40
Compost Plant	
- Water Content	70
- CH_4, H_2O, etc.	77
- Compost	18
- Residues	4
- Recycling	1

f. Final Disposal

Since future final disposal site in 2020 is not identified, the team assumed a cavity in a mining quarry site as recommended in the previous chapter. The future landfill shall be designed in accordance with the design standard prepared by the MoE.

g. Operation and Maintenance of Vehicles and Equipment

District Municipalities has central workshops where general vehicle and equipment maintenance is undertaken on a regular basis in Mersin. The private companies are responsible of the big repairs and when ever needed, the vehicles are forwarded to the private workshops. The workshop area is also used for washing and parking the vehicles when they are not in use.

In future, it is proposed that, only preventive and daily maintenance as well as small repair services will be done at municipal workshops. The heavy repairs will be undertaken by the private sector.

g.1 Operation and Maintenance Plan Basic Concept

The number of people who are involved in SWM works in Mersin is currently more than 700 (municipal and private companies all together - 707) and it is expected to reach more than 1500 people by the year 2020. SWM works change on a day to day basis; to maintain the efficiency of operations, making a prompt decision and taking swift action are essential. Employing a large number of people is risky and is also difficult to maintain the level of management required, so it is recommended that the private sector participation in SWM works will be continuing in order to reduce the burden and work load on the authority responsible for SWM, and minimise the costs.

g.2 Operation and Maintenance Master Plan Program

Item	Program
Maintenance of Equipment	At present, the workshop owned by the municipalities only provides preventive maintenance service for equipment, and the major repairs are executed by the private workshops. The M/P proposes to continue this application till the end of Phase 2. That is; the preventive maintenance will be executed by the existing municipal facilities and major repairs be conducted at private garages. The reason for this is as follows: • It takes time for the municipal workshop to purchase spare parts. So spare parts only used frequently will be purchased and kept in storage. • Complex repair works will be consigned to the private sector although the cost is higher than if directly conducted at the municipal workshop because private garages are able to purchase spare parts much more readily. In the Phase 3, it is our recommendation that the whole repair and maintenance works will be privatised.
Operation of Collection Vehicles	To limit the burden and workload, currently experienced by the Cleansing Departments, various measures of private sector participation will be encouraged. The proposed measures are as follows: • The municipalities will own some compactor vehicles. The rest will be hired to or supplied by the private sector. The contract would include drivers, collection workers, fuel, and maintenance. • As for other collection vehicles, the municipalities can contract out most of the operation work to the private sector. The private collection company will be entrusted a small percentage of collection vehicles owned by the municipalities. Through the gradual expansion of this system, the municipality responsible for SWM can nurture the potential of the private section, in preparation for the future hand-over of all collection work.
Street Sweeping	Street sweeping workers will be employed in a contract base as at present, because it is very difficult for the DM to manage many street sweepers and employee cost will be high. The municipalities task is mainly to supervise contracted sweepers.

Item	Program
Source Separation and Recycling	In collaboration with DMs the Mersin GM will initiate a source separation scheme in pilot scale in the Phase 1. Additionally they will educate people and to promote recycling. At this phase the concrete plans for action are as follows: • The collection of the source-separated reusables from recycling points will be contracted out to the private sector. • The GM will construct a sorting plant and entrust the operation of it to the private sector. In Phase 2, GM and DM will extend the source separation schemes to other mahalles of Mersin. In Phase 3, the source separation program will be extended to the whole city and the private sector will be in charge of the actual recycling work.

5.3.2.1 Future Waste Stream for Each M/P Scenario

The future waste stream when the SWM M/P will be implemented is drawn up based on the following concepts:

1. Since the current self-disposal method such as open burning is not properly done and it gives adverse impacts on the surrounding. It should be eliminated by providing collection services by 2005.
2. The illegal dumping shall be also excluded by 2005, providing collection services and strict enforcement as well as control.
3. The current recycling rate (20.2 g/day/person) by waste generation sources will be kept until 2020
4. The recycling activities by street waste pickers will be gradually decreased and it will be disappeared by 2020.
5. The scavenging activities at the landfill shall be prohibited by January 2003 when a new recycling/composting plant will start operation.

The future waste stream for each scenario is drawn up based on the conceptual design described in the previous section. The following table is the summary of the future waste stream. For better understanding waste streams for 3 M/P scenarios are illustrated in the following Figures.

Table 5-28: Future Waste Stream for Each M/P Scenario for Mersin

MERSIN Scenario1 2020year				(ton/day)	(ton/year)
Generation				1,350	
	Recycling			29	
	Discharge			1,321	
	Collection①			1,321	
	Non-Composatble	Sorting Plant(②=①×58%)		766	279,656
			Recycling(③=①×13.9%)	184	
			Residue(④=①×44.1%)	582	
		RDF Plant(=④)		582	212,430
			RDF(⑤=①×26.5%	349	
			Residue(⑥=①×17.	233	
	Compostable	Bio-Gas Plant(⑦=①×42%)		555	202,509
			Residue(⑧=①×1.7%)	22	
			Compost(⑨=①×7.6%)	100	
			CH_4,H_2O,CO_2(⑩=①×32.3%)	427	
			Recycling(⑪=①×0.4%)	6	
		Other Waste⑫		46	
		Final Disposal	(⑥+⑧)	255	93,075
			(⑥+⑧+⑫)	301	109,865

MERSIN Scenario2 2020year				(ton/day)	(ton/year)
Generation				1,350	
	Recycling			29	
	Discharge			1,321	
	Collection①			1,321	
	Non-Composatble	Sorting Plant(②=①×58%)		766	279,656
			Recycling(③=①×13.9%)	184	
			Residue(④=①×44.1%)	582	
	Compostable	Compost Plant(⑤=①×42%)		555	202,509
			Residue(⑥=①×1.7%)	22	
			Compost(⑦=①×7.6%)	100	
			CH_4,H_2O,CO_2(⑧=①×32.3%)	427	
			Recycling(⑨=①×0.4%)	6	
		Other Waste⑩		46	
		Final Disposal	(④+⑥)	604	220,460
			(④+⑥+⑪)	650	237,447

MERSIN Scenario3 2020year				(ton/day)	(ton/year)
Generation				1,350	
	Recycling			29	
	Discharge			1,321	
	Collection①			1,321	
	Non-Composatble	Sorting Plant(②=①×58%)		766	279,656
			Recycling(③=①×13.9%)	184	
			Residue(④=①×44.1%)	582	
	Compostable	Residue(⑤=①×42%)		555	202,509
		Other Waste⑥		46	
		Final Disposal	(④+⑤)	1,137	415,005
			(④+⑤+⑥)	1,183	431,795

MERSIN Continuation present system 2020year

Final Disposal = 1,386(ton/day) = 505,890 (t/year)

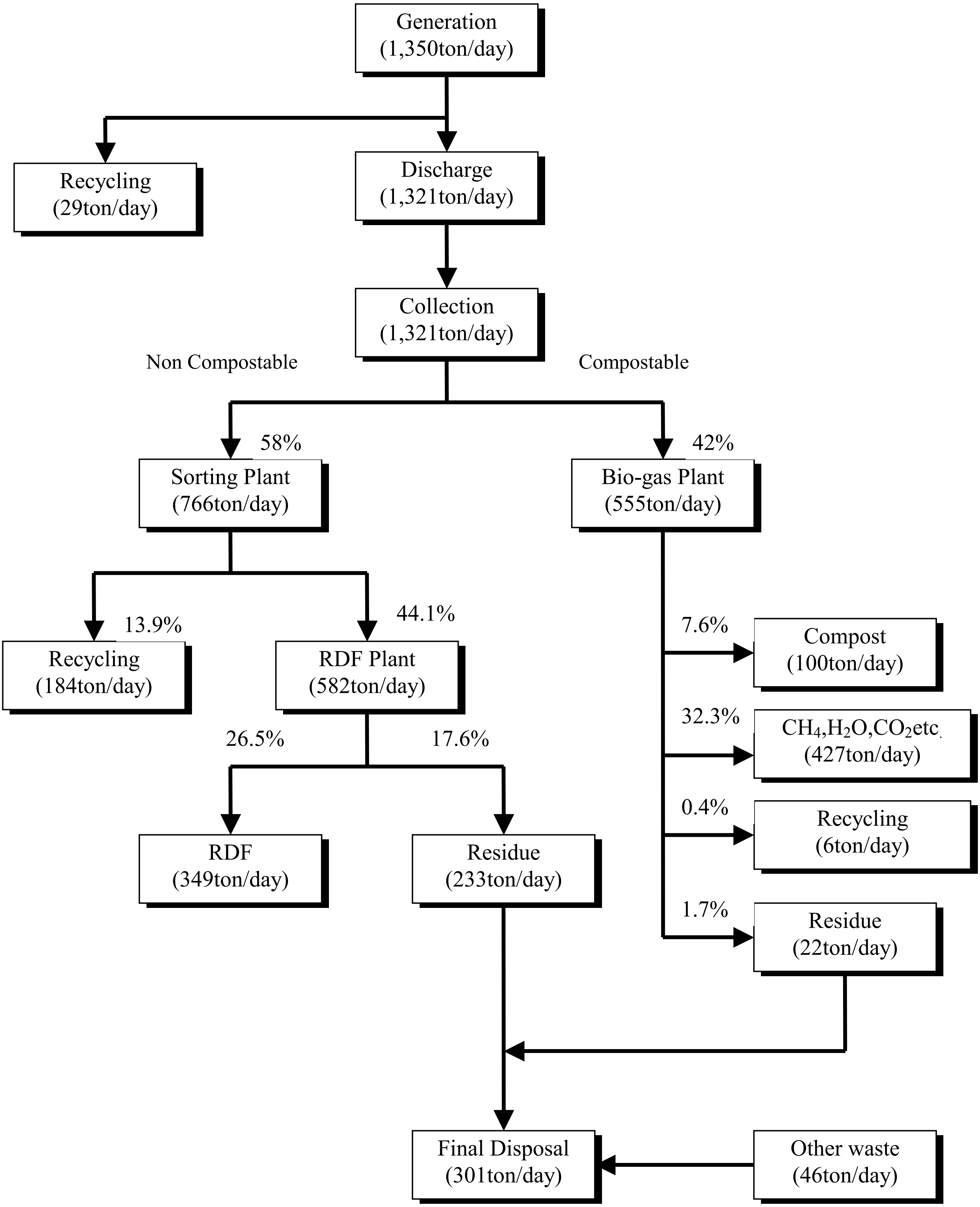

Figure 5-18: Waste Stream of M/P Scenario 1 for Mersin

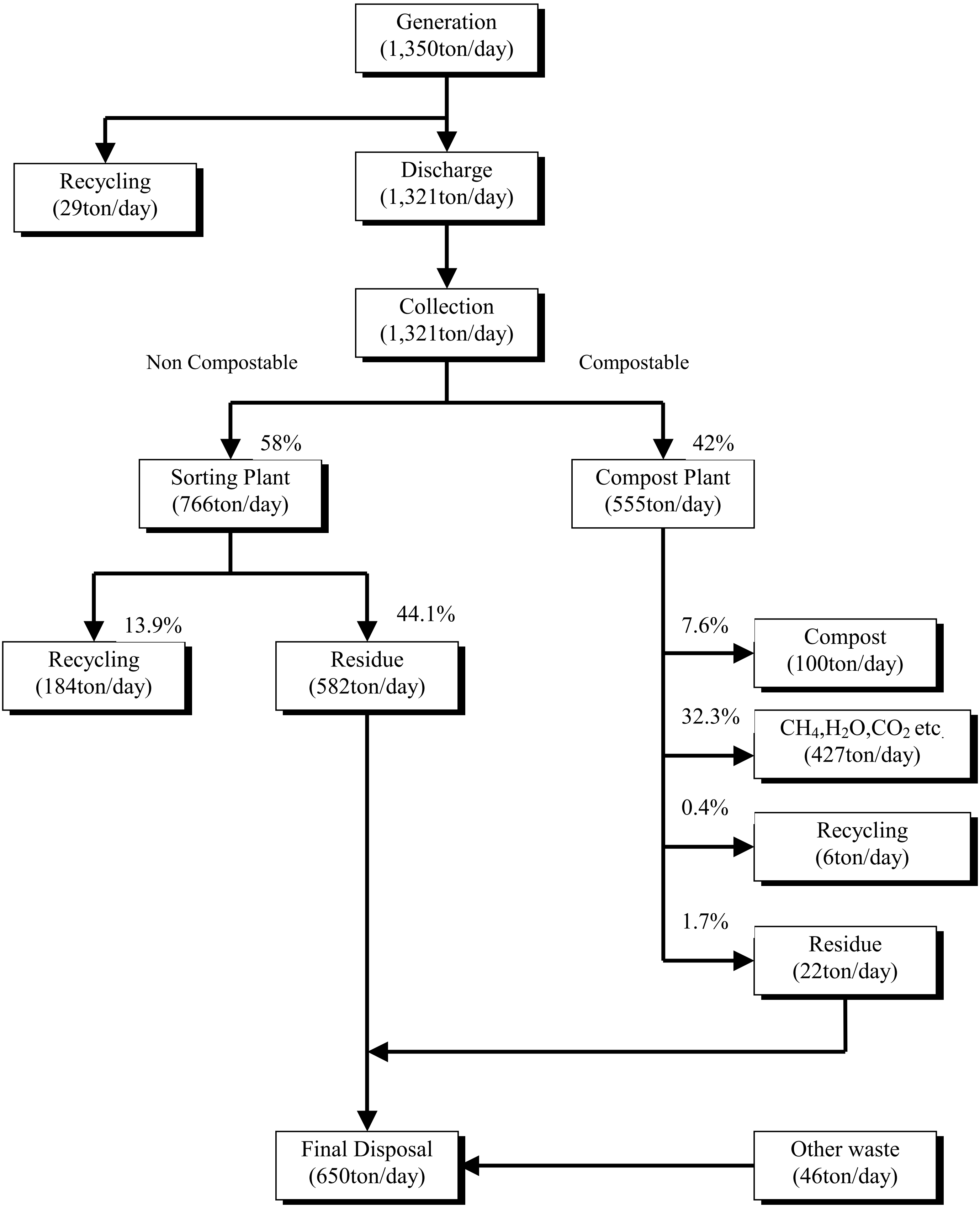

Figure 5-19: Waste Stream of M/P Scenario 2 for Mersin

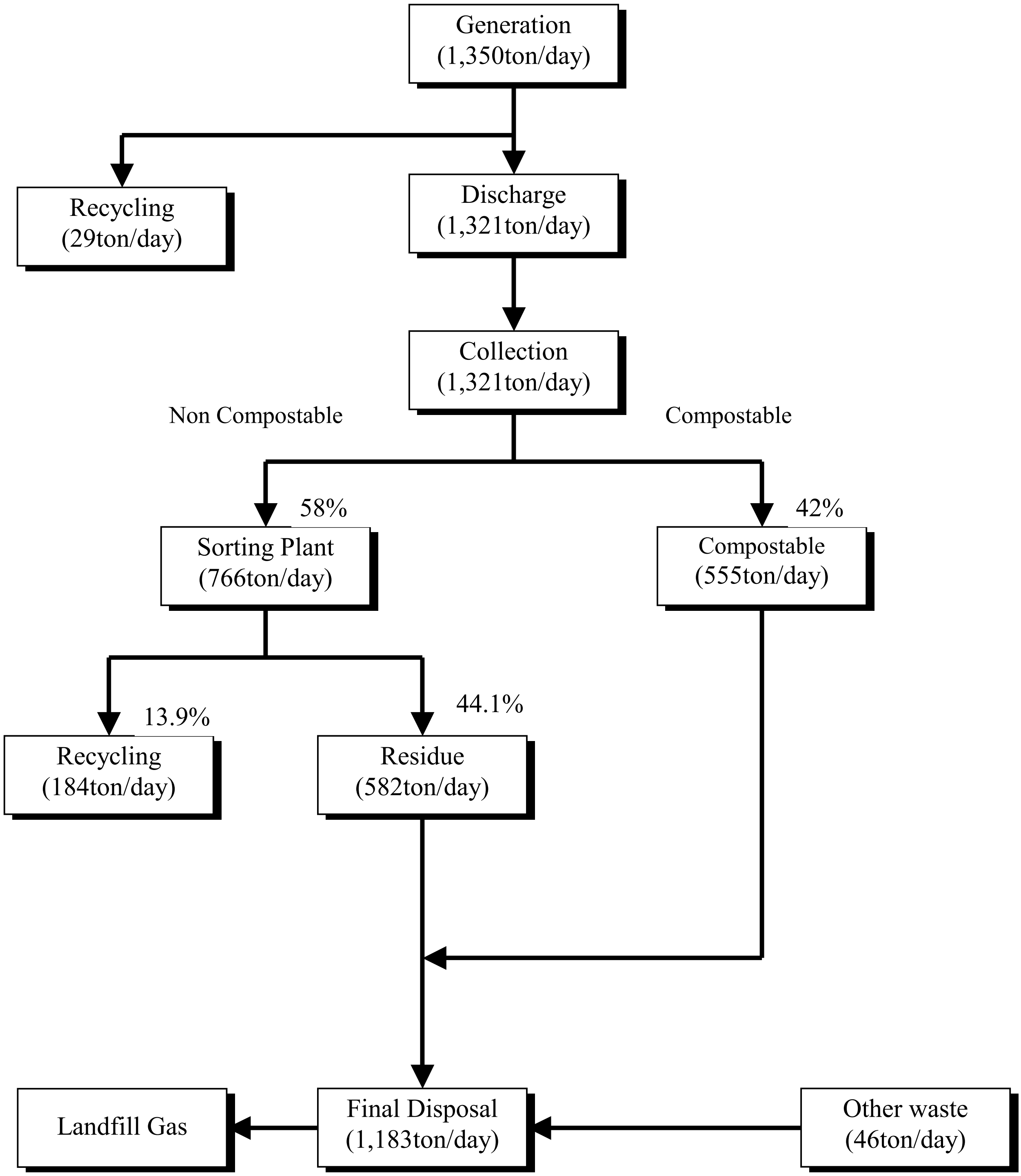

Figure 5-20: Waste Stream of M/P Scenario 3 for Mersin

5.3.3 Cost Estimation

a. Cost Estimation Items

Cost Estimation of Mersin GM in 2020 will be required for as follows;

- Refuse Collection & Transportation Cost
- Public Area Cleansing Cost
- Intermediate Treatment and Recycling Cost

Scenario1 -Sorting Plant
-RDF Plant
-Bio-Gas Plant

Scenario2 -Sorting Plant
-Compost Plant

Scenario3 -Sorting Plant

- Landfill Gas Collection Facility(Only Senario3)
- Final Disposal Cost

b. Unit Cost for Cost Estimation

US dollar is used for the calculation as fluctuation of Turkish Lira is sharp. Calculation is carried out using the May 1999 prices and at an exchange rate of US$ 1 = 407,000 Turkish Lira. Depreciation period for facility, heavy machinery and equipment, and the residual value are shown in Table 5-29.

Table 5-29: Depreciation Period of Facility and Equipment in Mersin

Items	Depreciation Period (Year)	Residual Value (%)
Vehicle and heavy machinery	7	10
Machinery	15	0
Building	30	0

Note: The life span of civil works and facilities other than building depends on the period of its operation.

Unit Cost of each items is shown in Table 5-30.

Table 5-30: Unit Cost in Mersin

Item		Unit Cost(US$/ton)
Refuse Collection & Transportation		19.3
Public Area Cleansing		221
Intermediate Treatment and Recycling	Sorting Plant	16.9
	RDF Plant	30.0
	Bio-Gas Plant	70.0
	Compost Plant	22.4
Landfill Gas Collection Facility		0.2
Final Disposal		10.6

c. Waste Amount for Each Items

c.1 Refuse Collection & Transportation and Public Area Cleansing Amount

Refuse collection and Public Area Cleansing Amount are shown in Table 5-31.

Table 5-31: Refuse Collection & Transportation and Public Area Cleansing Amount in Mersin

Item	Unit	MGM	YDM	TDM	ADM	Sub Total	Total
Refuse Collection & Transportation	ton/year	0	105,224	171,184	189,833	466,241	482,165
Public Area Cleansing	ton/year	2,734	3,015	4,868	5,307	15,924	

c.2 Recycling Intermediate Treatment Amount

Intermediate Treatment Amount are shown in Table 5-32.

Table 5-32: Recycling Intermediate Treatment Amount

Plant / Scenario	Unit	Sorting	RDF	Bio-gas	Compost	Landfill gas
Continuation of Present System	ton/year	-	-	-	-	-
Scenario 1	ton/year	279,656	212,430	202,509	-	-
Scenario 2	ton/year	279,656	-	-	202,509	-
Scenario 3	ton/year	279,656	-	-	-	431,795

d. Landfill Disposal Amount

Landfill Disposal Amount are shown in Table 5-33.

Table 5-33: Landfill Disposal Amount

Scenario	Unit	Landfill Disposal Amount
Continuation of Present System	ton/year	505,890
Scenario 1	ton/year	109,865
Scenario 2	ton/year	237,447
Scenario 3	ton/year	431,795

d. Comparison of Operation Cost of Each Scenario

The following table shows the operation cost, including depreciation costs, of each scenario in the year 2020. The operation cost in the table is calculated by subtracting revenues from selling materials and energy recovered by the recycling facilities. For reference, the operation cost of the continuation of present waste management system until 2020 was also calculated.

Table 5-34: Operational Cost of Each Scenario (Mersin)

Mersin Greater Municipality			Unit Cost (US$/ton)	Waste Amount (ton/year)	Cost (US$/year)	Unit Cost (US$/ton)	Waste Amount (ton/year)	Cost (US$/year)	Unit Cost (US$/ton)	Waste Amount (ton/year)	Cost (US$/year)	Unit Cost (US$/ton)	**Discharge Amount (ton/year)**	(US$/ton)	Population	(US$pc)
Continuation	Collection					19.3	105,224	2,030,823	19.3	171,184	3,303,851	19.3				
Present system	Road & Park		221.0	2,734	604,214	221.0	3,015	666,315	221.0	4,868	1,075,828	221.0				
	Plant	Compost	21.7	14,600	316,820											
	Landfill		10.6	505,890	5,362,434											
	Administration5%				314,173			134,857			218,984					
	Total				6,597,641			2,831,995			4,598,663		492,750	38	1,249,940	15
Scienario1	Collection					19.3	105,224	2,030,823	19.3	171,184	3,303,851	19.3				
	Road & Park		221.0	2,734	604,214	221.0	3,015	666,315	221.0	4,868	1,075,828	221.0				
	Plant	Sorting	16.9	279,656	4,726,186											
		Bio-gas	70.0	202,509	14,175,630											
		RDF	30.0	212,430	6,372,900											
	Landfill		10.6	93,805	994,333											
	Medical Waste		101.2	1,789	181,047											
	Administration5%				1,352,716			134,857			218,984					
	Total				28,407,026			2,831,995			4,598,663		492,750	83	1,249,940	33
Scienario2	Collection					19.3	105,224	2,030,823	19.3	171,184	3,303,851	19.3				
	Road & Park		221.0	2,734	604,214	221.0	3,015	666,315	221.0	4,868	1,075,828	221.0				
	Plant	Sorting	16.9	279,656	4,726,186											
		Compost	22.4	202,509	4,536,202											
	Landfill		10.6	237,447	2,516,938											
	Medical Waste		101.2	1,789	181,047											
	Administration5%				628,229			134,857			218,984					
	Total				13,192,816			2,831,995			4,598,663		492,750	52	1,249,940	21
Scienario3	Collection					19.3	105,224	2,030,823	19.3	171,184	3,303,851	19.3				
	Road & Park		221.0	2,734	604,214	221.0	3,015	666,315	221.0	4,868	1,075,828	221.0				
	Plant	Sorting	16.9	279,656	4,726,186											
		Gas-collectio	0.2	431,795	86,359											
	Landfill		10.6	431,795	4,577,027											
	Medical Waste		101.2	1,789	181,047											
	Administration5%				508,742			134,857			218,984					
	Total				10,683,575			2,831,995			4,598,663		492,750	47	1,249,940	19

5.3.4 Selection of the Best Technical System Scenario

The results of the comparison of the above 3 scenarios was presented to the counterparts for deliberation and the selection of the best scenario.

a. Comparative Analysis of Scenarios

The following table summarises the features of each of the 4 scenarios which include the scenario of continuation of the present system.

Table 5-35: Comparison of M/P Scenarios (Mersin)

Scenario Items	Without M/P Continuation of Present System	Scenario 1 Full Recycling	Scenario 2 Composting	Scenario 3 Landfill Gas Recovery
• **Technical**	• With the exclusion of sanitary landfilling, the adoption of this technical system is not forecast to incur problems because it is identical to the system currently in use. • On the other hand, the adoption of this system would incur no developments in the solid waste management technical system. • Since sanitary landfilling has already been introduced in some Turkish cities, the transfer of relevant technology can be satisfactorily carried out.	• To successfully produce biogas the separation of putrescible waste should be very strictly carried out. • The use of biogas plants to treat municipal SW is a relatively new approach, hence there is no assurance regarding its functions. Accordingly, the application in the target area, where even sanitary landfill is not conducted, is forecast to incur problems. • The operation of RDF facilities for waste treatment is only foreseen to incur minor problems. However, there is a need to consider the fact that recipients/users of RDF should adopt air pollution control measures. Hence sufficient considerations should be paid to the adoption of this technique.	• To successfully conduct composting, the separation of putrescible waste should be rigorously carried out. • As opposed to biogas plants, the technical problems that may arise in the composting of putrescible waste are minimal as long as separate collection is practised. • Nonetheless, difficulties are foreseen in view of the current manpower (skills) of Mersin GM.	• Separate collection is not stringently required for the sorting facility as it is for biogas production and composting. • Although not perceived as a difficult technique, landfill gas recovery is unheard of in Turkey. This would, therefore, require transfer of technology and training opportunity, etc. from other countries. • Of the three scenarios, this alternative is considered to incur the least technical problems.
• **Social**	• Since this scenario proposes the continued use of the current collection system, no social issues are forecast to arise. • On the other hand, site acquisition for the development of the final disposal site would be the most difficult as, of the 4 scenarios, this scenario requires the largest disposal site **(759,000m^3/year)**.	• Since this scenario requires separate collection to be very strictly carried out, proper education of and full co-operation from the public are important. • With the establishment of an highly advanced recycling system, public awareness regarding the importance of realising a closed-loop society on solid waste will be considerably heightened. • Site acquisition would be the easiest as, of the 4 scenarios, this scenario requires the smallest disposal site capacity **(165,000m^3/year)**.	• Since this scenario requires separate collection to be strictly carried out, proper education of and full co-operation from the public are important. • With the establishment of an advanced recycling system, public awareness regarding the importance of realising a closed-loop society on solid waste will be heightened. • Site acquisition would be relatively easy as it only requires a disposal site capacity of **356,000m^3/year**.	• Since this scenario requires separate collection, proper education of and co-operation from the public are important. • Except for the sorting facility, the disposal site is the most essential waste management facility, hence site acquisition is extremely important. • Because this scenario requires a huge disposal site capacity (**648,000m^3/year**), gaining the consensus of the residents is considered to become increasingly difficult by the year.
• **Environmental**	• Except for the conversion of the dump site into a sanitary landfill, problems brought about by current SWM, e.g., illegal dumping, scavenging, will remain unsolved.	• Excluding residues from the RDF plant and biogas production plant, the majority of the waste will be recycled into some form. • The rate of waste recycling activities is very high at **81%**. Accordingly, this scenario will	• All waste generated will be taken to the recycling facility (compost plant and sorting facility). • This will incur a **55%** recycling rate, thereby reducing the amount	• Of the waste generated, only non-putrescible waste types will be handled at the sorting facility. • This will only incur a **16%** recycling rate, thereby hardly

Scenario Items	Without M/P Continuation of Present System	Scenario 1 Full Recycling	Scenario 2 Composting	Scenario 3 Landfill Gas Recovery
	• The rate of waste recycling activities is very low at **5.4 %**. Accordingly, this scenario will hardly contribute to global environmental preservation.	highly contribute to global environmental preservation.	for final disposal. • This scenario will contribute less to global environmental preservation than biogas production (Scenario 1) due to the CO_2 emission levels the aerobic fermentation of putrescible waste for composting would emit.	reducing the final disposal amount. • The recovery of landfill gas (biogas) through the anaerobic fermentation of putrescible waste in the disposal site will curtail the emission of CH_4 which is believed to accelerate global warming four or five times more than CO_2. Accordingly, this scenario will highly contribute to global environmental preservation.
• **Economic**	• Through sanitary landfilling practices, waste disposal activities in the final disposal site will be environmentally-friendly.	• Maximum waste recycling will be achieved. Thermal recycling through biogas and RDF production, and improvement in compost quality will contribute to industrial development in the region. • Recovery of recyclable materials will be carried out in the sorting plant. • The disposal amount will be significantly reduced, and the landfill life span will be extended **5.4** times more than the case of continuation of present system.	• Recycling of organic waste is possible. Improvement in compost quality will contribute to industrial development in the region. • Recovery of recyclable materials will be carried out in the sorting plant. • The disposal amount will be reduced, and the landfill life span will be extended **2.3** times more than the case of continuation of present system.	• Thermal recycling through landfill gas recovery is possible. • Recovery of recyclable materials will be carried out in the sorting plant. • The disposal amount will be slightly reduced.
• **Financial**	• Will incur the smallest financial responsibility for SWM expenses: **US$15/person/year.** • Requires that the SWM expenses should be raised **2.21** times the expenses in 1998 (6.8 US$/person)	• The cleansing expenses will incur **2.18** times more than the case of continuation of present system. • Asking the residents to shoulder the SWM expenses is forecast to be difficult.	• The cleansing expenses will incur **1.37** times more than the case of continuation of present system. • Because this scenario will contribute to economic development in the region, the scenario could be realised, although it will depend on efforts exerted to gain resident consensus.	• The cleansing expenses will incur **1.24** times more than the case of continuation of present system. • Because this scenario will contribute to economic development in the region, the scenario could be realised, although it will depend on efforts exerted to gain resident consensus.

b. Selection of the Best Scenario

The team presented three (3) SWM M/P scenarios for Mersin GM in the IT/R and requested the C/P to carefully examine their advantages and disadvantages, problems to be encountered, issues to be solved, etc., and select by the end of the second study work in Turkey mid-April 1999. The team recommends Scenario 2: Composting based on the following reasons:

1. The revenues from the operation of the recycling facility will never exceed the depreciation cost and O&M (operation and maintenance) expenses. In general unless a tipping fee is imposed, the revenues will never outbalance the depreciation cost and O&M expenses.
2. Although scenario 1 presents an ideal recycling system, realising this system would require each resident to pay US$ 33 for the waste handling cost (4.85 times more than present costs estimated by the team).
3. Composting using the biogas plant is extremely favourable in terms of global environmental protection because the plant emits low CO_2 levels in the atmosphere. Nonetheless, it is still not a well-established technology. In particular, it is a very expensive system and quite difficult to strictly control the mixing of unsuitable waste types. In addition it requires a large amounts of wastewater treatment for the operation.
4. For RDF, the acquisition of users who have combustion facilities with air pollution countermeasures is of utmost importance.
5. Although scenario 3, which focuses on sanitary landfilling and the recovery of landfill gas, would require very little expenses, the system cannot be realised unless a large and appropriate sanitary landfill site is acquired.

The Mersin GM decided to select scenario 2 for this study. However, since year 2020, the M/P target year, is very far from now, they expressed they like to be free to change the scenario in accordance with socio-economic situation, technology progress, etc. in future.

5.3.5 Environmental Issues for EIA of F/S Projects

a. Selection of F/S Projects

If scenario 2 is selected, the projects to be covered by the F/S are as follows:

1. Introduction of the separate collection of two waste types
2. Construction of a sorting and composting plant

Construction of a sanitary landfill site

b. Environmental Issues for EIA of F/S Projects

EIA shall be conducted in accordance with EIA procedures in Turkey. In the phase of formulation of M/P, the priority projects for the F/S are selected and the items for EIA for the projects are decided. The priority projects are detailed below.

1. Introduction of separate collection system

2. Construction and operation of final disposal site
3. Construction and operation of sorting plant
4. Construction and operation of composting plant

The items to be subject to the EIA should have been as instructed by Ministry of Environment, but to proceed with the study, the items were selected by the study team based on the JICA guidelines for environmental considerations for the conduct of development studies and the result was approved by Ministry of Environment.

For Mersin, it was determined and agreed that the site for the F/S of the above-mentioned facilities 2, 3 and 4 is Cimsa site. The EIA for the use of this disposal site will cover the following items:

- Economic activities
- Traffic and public facilities
- Public health
- Hazards/risks
- Groundwater resource conditions
- Hydrological conditions
- Fauna and flora
- Landscape/aesthetics
- Air pollution
- Water pollution
- Soil contamination
- Noise and vibration
- Offensive odour

In accordance with the format of EIA prepared by Ministry of Environment, the following EIA issues need to be implemented.

Table 5-36: EIA issues to be Implemented for Priority Projects

Survey	Contents, Frequency, Points, etc.	Method
1. Economic Activities	① Halt in clay extraction ② Halt in scavenging activities ③ Construction & operation of sorting plant and composting plant	Hearing of quarry activities Hearing from scavengers Marketability of recyclable materials and compost
2. Traffic Volume	① Determination of current traffic volume ② Forecast of future traffic volume and impact (3points from 7 am to 7pm: large and small vehicle, motorbike, bicycle, pedestrian)	Field survey (hourly count)
3. Public Health	① Sanitary condition of residents ② Work environment at waste treatment and disposal facilities	Data from medical facilities Hearing from residents
4. Hazards /Risks	① Collapse of slope ② Gas explosions ③ Fire breakouts	Plans and design
5. Groundwater Resources	① Flow condition ② Possibility of diverting flow	Data from geological survey
6. Hydrological Conditions	Flow condition and runoff rate (Surface water; 2 times during one month x 2 points Groundwater; 2 times during three months x 3 points)	Flow rates are measured. Groundwater table Collection of well data
7. Fauna/Flora	① Endangered species ② Condition of ecosystem (An area of radius 1 km outside of the boundary of the proposed site)	Field survey
8. Landscape/ Aesthetics	① Determination of visibility area and representative view stations ② Preparation of a montage photo from two view stations on the vicinity land (An area of radius 1.5 km outside of the boundary of the proposed site)	Site survey Photographs
9. Air Quality	① Understanding of impact from the dumping site ② Forecast of impact from the sanitary landfill (2 times during one month x 2 points: Dust, SO_2, NOx, Cl_2, PM, Pb)	Method of Turkish standard or EU standard
10. Water Quality	Present situation and forecast of impact from sanitary landfill(Stream; 2 times x 3 points Groundwater; 2 times x 6 points Leachate; 2 times x 1 point Colour, pH, Total dissolved matter, DO, COD, BOD, Faecal Coliform, T-N, T-P, NH+4, Na+, Cl-, SO4, Cr6, Hg, Cd, Pb, As)	Method of Turkish standard or EU standard
11. Soil Contamination	Conjecture from the existing sanitary landfill	Qualitative
12. Noise/Vibration	Forecast of noise and vibration due to construction and operation of facilities	Calculation
13. Offensive Odour	Conjecture from the existing sanitary landfill	Quantitative
14. Land use	An area of radius 1 km outside of the boundary of the proposed site	Site survey and development plans
15. Water Use	Groundwater; within a radius of 5 km south of the site Surface water; from the site to the point of 5 km downstream	Hearing from residents
16. Meteorological data	Wind direction/velocity, precipitation, evaporation	Data collection and analysis