LIST OF FIGURES

H.1 Planning Frameworks

H.1.1 Goal, Targets and Strategies

H.1.1.1 Goal

In order to formulate a draft Master Plan for the municipal solid waste management for the Study area, the goal of the Master Plan is proposed as follows:

DEVELOPMENT AND REALIZATION OF A BEAUTIFUL AND CLEAN LIVING ENVIRONMENT IN THE ASUNCION METROPOLITAN AREA TOWARDS THE 21ST CENTURY.

The goal of the Solid Waste Management Master Plan is achieved through:

- **Citizens' Participation and**
- **Establishment of Self-sustainable Solid Waste Management**

H.1.1.2 Targets

In order to realize the goal, the targets for 15 municipalities are set up and tabulated in Table H.1.1.2a.

Table H.1.1.2a Targets of Collection, Street Sweeping and Final Disposal Services

Services / Municipality	Collection Coverage Ratio(%)			Street Sweeping Distance(km)			Sanitary Landfill Level		
	1993	2000	2006	1993	2000	2006	1993	2000	2006
1.Highly Urbanized Muni.									
1-1 Asuncion	70	85	100	264	300	300	Level 1	Level 3	Level 3
1-2 F.Mora	67	85	100	?	20	40	Level 1	Level 3	Level 3
2.Urbanized Muni.									
2-1 M.R.Alonso	18	45	70	0	6	10	Open	Level 2	Level 3
2-2 Luque	11	45	70	?	9	18	Level 1	Level 2	Level 3
2-3 Capiata	11	45	70	?	6	12	Open	Level 2	Level 3
2-4 San Lorenzo	18	45	70	5	21	32	Level 1	Level 2	Level 3
2-5 Lambare	65	80	100	2	17	25	Level 1	Level 2	Level 3
2-6 Villa Elisa	49	65	85	0	9	20	Open	Level 2	Level 3
3.Less Urbanized Muni.									
3-1 Nemby	8	45	70	0	3	12	Open	Level 1	Level 2
3-2 J.A.Saldivar	0	25	50	0	1	2	None	Level 1	Level 2
3-3 Ita	16	45	70	0	5	9	Open	Level 1	Level 2
3-4 Aregua	0	25	50	0	5	7	None	Level 1	Level 2
3-5 Limpio	1	25	50	0	3	8	None	Level 1	Level 2
3-6 Villa Hayes	11	45	70	0	5	9	Open	Level 1	Level 2
3-7 Aceval	0	25	50	0	6	11	None	Level 1	Level 2

H.1.1.3 Strategies for the Attainment of the Goal

The proposed strategies for the attainment of the Goal is detailed in the six paragraphs as follows:

a. **Provision of facilities and equipment to apply to the basic objective for the execution of MSWM:**

- MSWM must be able to control or mitigate the adverse impacts of waste on the environment and human health.
- Solid waste is a resource to be utilized through appropriate means.

b. **Provision of solid waste services and facilities to comply with the following priorities:**

- Minimization of solid waste production
- Minimization of the need for landfill
- Development of Sanitary Landfills

c. **Provision of appropriate and scheduled services to the citizens for the proper storage, collection and reception of solid waste. Illegal dumping must be eliminated.**

- The offered solid waste services must comply with the generation of waste.
- The offered solid waste services should make it relatively easy for the citizens to get rid of their waste.
- The offered solid waste collection services must follow a strict and regular schedule on a routine basis, so to develop the good habits on the population.

d. **Self-financed solid waste management through the increase of citizens' burden.**

- The "polluter pays principle" will be advocated, but where appropriate (to minimize administration), general principles for financing will be employed, and as occasion demands (to eliminate non-collection area), "cross subsidy" will be established.
- All costs (also capital costs) must be covered by fees and charges being

admitted so that a capital seed is provided for take off.

e. **Increase in public involvement in environmental protection and increase in public attention on environmental matters.**

- The citizens must be made responsible for/aware of his own role in the production of pollutants and the proper handling of waste (however, everybody should have the right to receive solid waste services, provided they pay).
- The citizens must participate actively in the solid waste services (eg. proper discharge).

f. **Full control over activities related to MSWM and the cleanliness of the Asuncion Metropolitan Area.**

- Involvement of private enterprises will be encouraged when appropriate and feasible.
- Private enterprises will be invited to participate through competitive bidding.
- Private cooperation will be supervised and controlled by the municipality. The municipality will maintain full contact with the citizens on matters related to payment, complaints and exemption.

H.1.1.4 Strategy Elements

In concrete terms, the Goal is to be obtained through:

i. Establishment of a self-sustainable solid waste management system;

ii. Provision of collection services in the urban area of the Asuncion Metropolis and establishment of a reliable collection system under which regular services can be provided;

iii. Construction of sanitary disposal sites which employs sufficient measures for protection of environment and human health;

iv. Establishment of efficient street sweeping and public area cleansing systems;

v. Establishment of Beneficiary-Pay-Principle under which service recipients pay waste collection fee(tax) and tipping fee according to the capability of each household owner;

vi. Establishment of proper legislation and regulations through the modification and revision of the existing ones;

vii. Establishment of proper roles of the organizations involved in solid waste management;

viii. Strengthening of the management and administration system;

ix. Development of public participation and education programs;

x. Development of the human resources involved in solid waste management; and

xi. Securing funds for capital investment for the equipment and facilities necessary for the realization of the goal, specially during the time of take off.

H.1.2 Target Year and Population

H.1.2.1 Target Year

The master plan shall cover a long period from 1994 to 2006. Upon consideration of the limited resources for MSWM in the Metropolitan Area, the goal of the master plan shall be achieved in a stepwise manner. The period of the plan is divided into the following three stages.

Table H.1.2.1a Target Year

Category of Plan	Target Year
Master Plan	1994 - 2006
Medium Term Improvement Plan	2001 - 2006
Short Term Improvement Plan for F/S	1996 - 2000
Immediate Improvement Plan	Present - 1995

H.1.2.2 Population Forecast for the Urban Area

Since there is neither an urban area development master plan nor an official population forecast for the Study area. The population forecast, therefore, was carried out by the Study Team.

Growth rates to project the future population in the Study Area were estimated considering the population census data of 1962, 1972, 1982 and 1992. Also, growth trends, urban development potentiality such as areas proximity to Asuncion city, land availability (open spaces), cost of land, employment opportunities, etc. were examined for the estimation of the population growth rates as shown in Table H.1.2.2a.

Based on past population growth rates (refer to Table H.1.2.2b Urban Area Population and Growth Rate of the Study Area), the future population is projected and tabulated in Table H.1.2.2c.

Table H.1.2.2a Classification of Growth Rates

Municipality	Growth Rate, according to the last Census Increase /Decrease	Proximity to Asuncion	Land Availability (%)	Cost of Land	Employment Opportunity	Future Housing Development (%)	Current Growth Rate (%)	Adopted Growth Rate (%)
Highly Urbanized Mu.								
Asuncion	Decrease	—	—	high	high	—	1.00	0.80
F.Mora	Decrease	contiguous	—	high	high	—	3.62	2.00
Urbanized Mu.								
Lambare	Decrease	contiguous	10	average	average	—	4.06	4.00
San Lorenzo	Decrease	near	20	average	high	10	5.99	5.00
Capiata	Increase	near	50	average	average	30	6.26	6.00
Luque	Increase	contiguous	50	average	average	30	13.04	8.00
M.R.Alonso	Increase	contiguous	10	average	average	10	10.42	8.00
Villa Elisa	Decrease	near	30	average	low	10	9.53	8.00
Less Urbanized Mu.								
Nemby	Decrease	near	50	below ave.*	low	20	8.55	6.00
J.A.Saldivar *	—	far	70	below ave.	low	20	N.A.	6.00
Ita	Increase	far	70	below ave.	low	10	4.37	4.00
Aregua	Decrease	near	50	below ave.	low	30	2.04	2.00
Limpio	Decrease	near	50	low	low	10	5.11	5.00
Villa Hayes	Increase	far	90	low	low	—	4.79	4.00
Benjamin Aceval	Increase	far	90	low	low	—	4.66	4.00

Source: JICA Study Team

* Same rate as Capiata is adopted

** below average

Table H.1.2.2b Urban Area Population and Growth Rate of the Study Area

Municipality/ Urban Area	Population				Average Annual Growth Rate (%)		
	1962	1972	1982	1992	1962–1972	1972–1982	1982–1992
Highly Urbanized M.							
1.Asuncion	288,882	388,958	454,881	502,426	3.02	1.58	1.00
2.F.Mora	14,519	36,892	66,810	95,349	9.77	6.12	3.62
Subtotal	303,401	425,850	521,691	597,775	3.45	2.05	1.37
Urbanized M.							
3.Lambare	20,778	31,732	67,168	99,990	4.33	7.79	4.06
4.San Lorenzo	18,573	36,811	74,552	133,405	7.08	7.31	5.99
5.Capiata	20,892	26,417	45,716	83,898	2.37	5.64	6.26
6.Luque	11,008	13,921	24,917	84,885	2.38	5.99	13.04
7.M.R.Alonso	5,686	7,388	14,636	39,422	2.65	7.08	10.42
8.Villa Elisa	3,214	4,774	12,038	29,918	3.97	9.76	9.53
Subtotal	80,151	121,013	239,027	471,518	4.21	7.04	7.03
Less Urbanized M.							
9.Nemby	796	861	11,994	27,234	0.79	30.14	8.55
10.J.A. Saldivar				2,016			
11.Ita	6,265	7,069	9,311	14,275	1.21	2.79	4.37
12.Aregua	3,699	3,916	5,177	6,335	0.57	2.83	2.04
13.Limpio	1,438	2,232	16,036	26,396	4.49	21.80	5.11
14.Villa Hayes	4,712	4,795	7,420	11,843	0.17	4.46	4.79
15.Benjamin Aceval	3,463	2,881	3,935	6,203	-1.82	3.17	4.66
Subtotal	20,373	21,754	53,873	94,302	0.66	9.49	5.76
Total :	403,925	568,617	814,591	1,163,595	3.48	3.66	3.63

Source: Dirección General de Estadística, Encuestas y Censos. Secretaria Tecnica de Planificación

* The following Municipalities were considered populated districts:
1962: (F.Mora, Lambare, San Lorenzo, Capiata, M.R. Alonso and Villa Elisa)
1972: (Capiata, M.R. Alonso, and Villa Elisa);
1982: (Capiata and M. R. Alonso)

** Estimated urban population (Nemby and Limpio)

Table H.1.2.2c Urban Area Population Projections for Selected Years Within the Study Area (1992–2006)

No	Urban Area	Population			Average Annual Growth Rate % (1992–2002)
		1992	2002	2006	
	Highly Urbanized M.				
1	Asuncion	502,426	544,098	561,720	0.80
2	F.Mora	95,349	116,230	125,811	2.00
	Sub-total	597,775	660,328	687,531	1.00
	Urbanized M.				
3	Lambare	99,990	148,010	173,150	4.00
4	San Lorenzo	133,405	217,303	264,133	5.00
5	Capiata	83,898	150,249	189,685	6.00
6	Luque	84,885	183,260	239,801	8.00
7	M.R.Alonso	39,422	85,109	115,790	8.00
8	Villa Elisa	29,918	64,591	87,875	8.00
	Subtotal	471,518	848,521	1,070,434	6.05
	Less Urbanized M.				
9	Nemby	27,234	48,772	61,573	6.00
10	J.A. Saldivar	2,016	3,610	4,558	6.00
11	Ita	14,275	21,230	24,720	4.00
12	Aregua	6,335	7,722	8,359	2.00
13	Limpio	26,396	42,996	52,262	5.00
14	Villa Hayes	11,843	17,531	20,508	4.00
15	Benjamin Aceval	6,203	9,182	10,742	4.00
	Subtotal	94,302	150,944	182,722	4.82
	Total :	1,163,595	1,659,793	1,940,687	3.62

Source : Projection was done by the JICA Study Team. Projections for the period 2002–2006 were estimated using the 1992–2002 rates.

a. Highly Urbanized Municipalities

According to the Statistic, Survey and Census Bureau, the population growth rates of Asunción and Fernando de la Mora has decreased from 3.02 % (1962–1972) to 1.00 % (1982–1992) and 9.77 % (1962–1972) to 3.62 % (1982–1992) respectively (refer to Table 2.2.2b). According to this trend, and due to its small area (117 km2 for Asunción and only 20 km2 for Fernando de la Mora), the high cost and the shortage of land, the future growth rate will be expected to reduce to about 0.80 % (Asunción) and about 2.00 % (Fernando de la Mora), for the next ten years (1992–2002).

The population projections for 2006 were prepared using the same growth rates as for the period 1992–2002. Accordingly, the population for 2002 and 2006 is expected to reach 544,098 and 561,720 (Asunción) and 116.230 and 125,811 (Fernando de la Mora) respectively.

The Population of the Highly Urbanized Municipalities will occupy 35.43 % of the total population of the Study area in 2006.

b. Urbanized Municipalities

The population growth of these municipalities are very much influenced by the increase in the number of migrants from rural areas. Among the Urbanized Municipalities, Luque (13.04 %), Mariano Roque Alonso (10.42 %) and Villa Elisa (9.53 %) showed high growth rates during the period 1982–1992 (refer to Table H.1.2.2b). However, by 2002, it is expected decline to about 8.00 % for those municipalities which is still significantly high, the population growth rates of these municipalities is expected to gradually become stable.

For the same period (1982–1992), Lambare, San Lorenzo and Capiata showed 4.06 %, 5.99 % and 6.26 % growth rates respectively (refer to Table H.1.2.2b). By 2002, these municipalities will only have minor changes, declining to 4.0 % (Lambaré), 5.0 % (San Lorenzo) and 6.0 % (Capiata) remaining at almost the same growth level as the 1982–1992 period.

In 1992, the population of the Urbanized Municipalities showed 40.52 % of the total population of the Study area, less than the 51.37 % reflected in the Highly Urbanized Municipalities. However, by 2006, it is projected to reverse; 55.16 % for the Urbanized Municipalities and 35.43 % for the Highly Urbanized Municipalities (refer to Table H.1.2.2c).

Some of the consequences of such rapid population growth in the Urbanized Municipalities are the increase in number of migrants from rural areas, cheaper land cost compared to Asunción, availability of lands, locations of new housing settlements by the National Housing Council (CONAVI), etc.

c. Less Urbanized Municipalities

Among the Less Urbanized Municipalities, the highest growth rates are found in Ñemby (30.14 %) and Limpio (21.80 %) during 1972–1982, declining to 8.55 % and 5.11 % in 1982–1992 respectively. By 2006, it is expected to decline to 6.00 % (Ñemby) and 5.00 % (Limpio), (refer to Table H.1.2.2c).

Itá, Areguá, Villa Hayes and Benjamín Aceval show slight increase reaching to 4.37 %, 2.04 %, 4.79 % and 4.66 % respectively (refer to Table H.1.2.2b). However, the number of persons is estimated to stabilize at just 4.00 %, 2.00 %, 4 % and 4 % for the same municipalities by 1992–2006 (refer to Table H.1.2.2c).

Recently, the municipality of J.A. Saldívar was separated from Capiatá, therefore the population growth rate is considered 6 % as well as Capiatá to estimate the future population for the next 14 years.

The population growth of the Less Urbanized Municipalities is expected to decline slightly, however the number of persons is still growing. The total population is expected to reach 182,722 people by the 2006, accounting for 9.41 % of the total population of the Study area.

The projected urban area population growths are shown in Figures H.1.2.2a, H.1.2.2b, H.1.2.2c and H.1.2.2d.

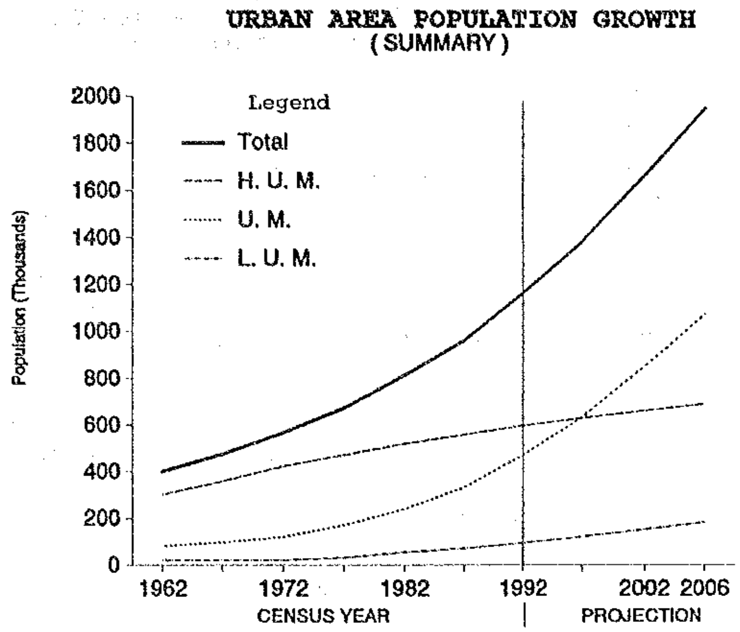


Figure H.1.2.2a Urban Area Population Growth (Summary)

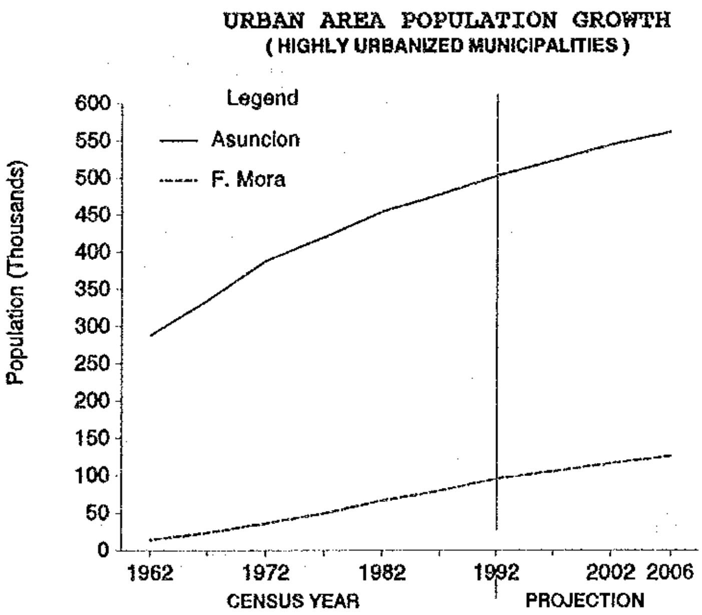


Figure H.1.2.2b Urban Area Population Growth (Highly Urbanized Municipalities)

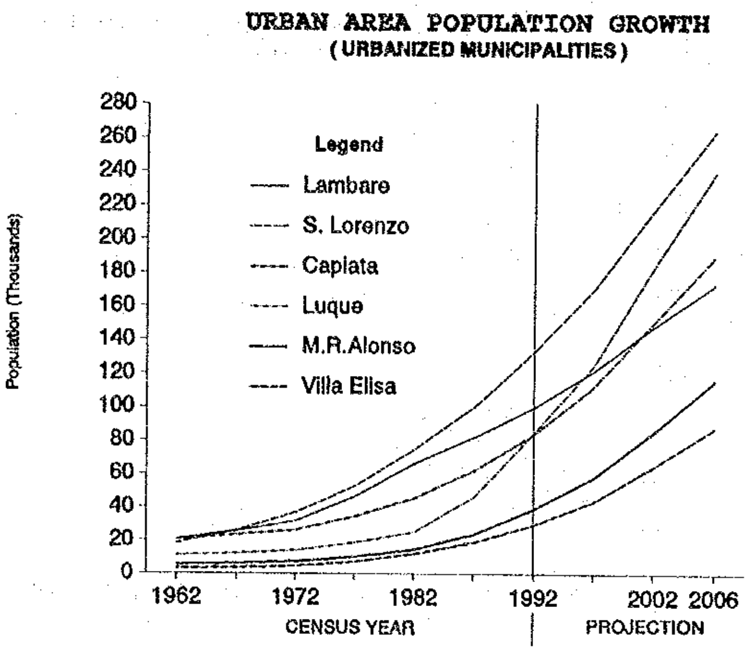


Figure H.1.2.2c Urban Area Population Growth (Urbanized Municipalities)

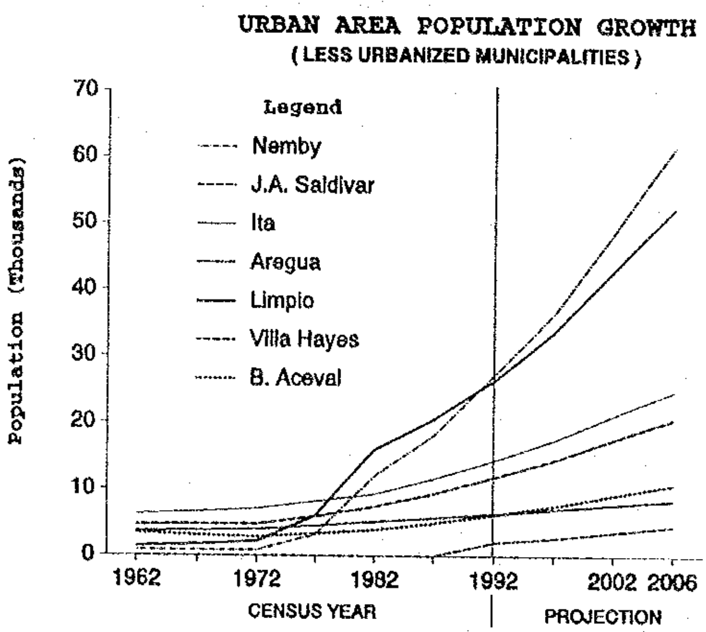


Figure H.1.2.2d Urban Area Population Growth (Less Urbanized Municipalities)

H.1.3 Forecast on Waste Amount and Composition

H.1.3.1 Forecast on Future Waste Amount

a Forecast Model

The Waste Amount and Composition Survey (WACS) carried out by the JICA Study Team was used as a reference in the elaboration of the MSW amount estimate of the Study area.

The forecast model will include interim estimates for the years 1994, 1998 and 2006 of the planning period. The types of waste to be forecast are:

i. MSW

- Household waste
- Commercial waste
- Market waste
- Institutional waste
- Street sweeping waste
- Hospital waste (non-infectious waste)
- Bulky waste

ii. Other wastes

b. Factors influencing waste increase and composition

The following factors will have an influence on the future generation of waste and its composition:

- The social welfare and the financial capacity of the single consumers/families
- Industrial technology
- Import of goods

Forecasts are difficult to conduct in Paraguay due to the lack of the past data regarding waste amount and composition. From a financial viewpoint (e.g., the GDP), the wastes of Paraguay should identify with the developing state of the country.

c. Methodology for the Forecast-Model

The forecast-model covers two (2) items. The first item is the forecast of the total amount of waste and its composition. The forecast of the total waste amount requires a study on the relation between GDP and the generation of waste.

For the type of wastes to be forecasted, the following assumptions were made:

ca. Household waste

The weighed result for the residential areas will be used. Waste generation will be projected based on the number of inhabitants, with a margin for the increase in generation ratio as a result of a GDP increase. However, the ratio of garden waste (grass and wood, and others) will not increase.

cb. Commercial waste

Waste generation will be forecasted based on the number of shops which will increase in accordance with the increase in population, with a margin for the increase in generation ratio as a result of a GDP increase.

cc. Market waste

Waste generation will be forecasted based on the number of shops in the market which will also increase with the population, with a margin for the effects of a GDP increase.

cd. Institutional waste

Waste generation will be forecasted based on the number of employees which will also increase with the population, with a margin for the effects of a GDP increase.

ce. Street sweeping

Waste generation ratio will not change and generation will be projected based on the length of the street for sweeping services.

cf. Hospital waste (non-infectious waste)

Waste generation will be projected based on the number of beds, with a margin for the increase in generation ratio as a result of GDP increase.

cg. Bulky waste

Bulky waste was not observed at the Cateura landfill. The generation of bulky waste shall be examined in future.

ch. Other wastes

Waste generation was forecasted based on the population, with a margin for the effects of a GDP increase.

d. Increase in Population

The most direct influence on waste generation is the change in population, and the estimated annual population growths in the Study area for the planning period are tabulated in Table H.1.2.2c.

e. Relation between GDP and Waste Generation

To determine the relationship between GDP and the generation of waste, the increased amount of welfare was taken into account. A strict relation is not expected in advance, but some indication for further analysis may be identified.

An increase in the GDP is expected to have a big impact on the generation of waste per capita of developing countries than of developed countries. Also, at a certain welfare level, increase in GDP will remarkably change the composition of waste.

Japan has fine statistics allowing for the analysis of the relation of GDP and waste generation in a developing economy (1963 – 1970) and a developed economy (1975 – 1988). The years 1970 – 1975 are excluded due to fluctuations in data resulting from a new treatment law and economic recession and instability caused by the oil crisis.

Based on the data of Japan for the period 1963–1970, a developing economy can be characterized as follows:

– Average increase in waste generation per capita: 5.789 %/year
– Average increase in GNP *: 10.438 %/year

* GNP was used due to the unavailability of a GDP.

Based on this figure, we assume that the change in GDP will affect waste generation as follows:

- Flexibility for a developing economy: 0.55 of GDP-change in %

The GDP of Paraguay (taken from the 1993 constant) is supposed to develop as follows:

- 1994 - 1998 + 3.5 %
- 1999 - 2006 + 3.0 %

The annual increase in GDP would result to increase in waste generation due to increased welfare. The increase in waste generation per capita per year is, therefore, estimated as:

- 1994 - 1998 3.5 x 0.55 = 1.925 %/year →Say 1.9 %/year
- 1999 - 2006 3.0 x 0.55 = 1.65 %/year →Say 1.7 %/year

Accordingly, a 1.8% increase in waste generation per capita per year can be constantly observed in the planning period 1994-2006.

On the other hand, garden wastes such as grass, wood, and soils shares about 40% of MSW due to houses with large gardens, unpaved roads, etc.. Garden wastes should not increase in future because of urbanization and improvement of roads. We concluded, therefore, the increase in waste generation per capita per year in the planning period is **1.1%** (1.8% x 0.6 = 1.08% →say 1.1%).

f. Forecast on Waste Amount

Based on the above-mentioned assumption, the forecast on MSW and other wastes are presented. A temporary forecast on waste generation ratio in the Study area was done based on the generation ratio in 1993 and tabulated in Table H.1.3.1a. In addition, a temporary forecast on the increase of the number of generation source in the Study area was also carried out based on that in 1993 and tabulated in Table H.1.3.1b. The results of the forecast are shown in Table H.1.3.1c to H.1.3.1q.

Table H.1.3.1a Forecast on Waste Generation Ratio

	Unit	1993	2000	2006
1. MSW				
Household	g/pers/day	876	946	1,010
Shop	g/shop/day	2036	2,198	2,347
Restaurant	g/shop/day	26,119	28,198	30,111
Market	g/shop/day	3422	3,694	3,945
Institutional	g/empl/day	81	87	93
Street Sweeping	g/km/day	242,424	242,424	242,424
Hospital	g/bed/day	5255	5,673	6,058
2. Other Wastes*	g/pers/day	32	35	37

Note : * Other waste will be generated only in Asunción.

Table H.1.3.1b Forecast on the Number of Generation Sources

(in 1993)

Category	Population	Shop		Market	Public Officer	Street Swept	Coverage Ratio
		Restaurant	Others				
	persons	nos.	nos.	shops	persons	km	%
Highly Urbanized M.							
Asuncion	506,445	454	17,102	4,676	19,974	264	83.0
Fernando de la Mora	97,256	179	2,480	0	1,741	0	67.0
Sub-total	603,701	633	19,582	4,676	21,715	264	
Urbanized M.							
Lambare	103,990	55	1,600	0	1,827	0	65.0
San Lorenzo	140,075	73	3,000	700	2,398	0	18.0
Capiata	88,932	47	1,571	0	1,476	0	11.0
Luque	91,676	48	2,190	0	2,124	0	10.9
M.R.Alonso	42,576	22	800	0	720	0	17.5
Villa Elisa	32,311	17	456	0	546	0	49.0
Sub-total	499,560	262	9,617	700	9,091	0	
Less Urbanized M.							
Nemby	28,868	15	1,054	0	708	0	8.0
J.A.Saldivar	2,137	1	58	0	350	0	0.0
Ita	14,846	8	464	150	605	0	16.0
Aregua	6,462	3	321	0	425	0	0.0
Limpio	27,716	15	1,340	60	648	0	1.0
Villa Hayes	12,317	6	121	0	478	0	11.0
Benjamin Aceval	6,451	3	168	0	202	0	0.0
Sub-total	98,797	52	3,526	210	3,416	0	

(in 2000)

Category	Population	Shop		Market	Public Officer	Street Swept	Coverage Ratio
		Restaurant	Others				
	persons	nos.	nos.	shops	persons	km	%
Highly Urbanized M.							
Asuncion	535,496	473	17,833	4,876	20,828	300	100
Fernando de la Mora	111,717	206	2,849	0	2,000	20	85
Sub-total	647,213	679	20,682	4,876	22,828	320	
Urbanized M.							80
Lambare	136,843	94	2,105	0	2,404	17	45
San Lorenzo	197,100	145	4,221	985	3,374	21	45
Capiata	133,721	105	2,362	0	2,219	6	45
Luque	157,116	141	3,753	0	3,640	9	45
M.R.Alonso	72,967	66	1,371	0	1,234	6	65
Villa Elisa	55,376	50	782	0	936	9	
Sub-total	753,123	602	14,595	985	13,808	68	
Less Urbanized M.							
Nemby	43,407	34	1,585	0	1,065	3	45
J.A.Saldivar	3,213	3	87	0	526	1	25
Ita	19,536	13	611	197	796	5	45
Aregua	7,422	4	369	0	488	5	25
Limpio	38,999	29	1,886	84	912	3	25
Villa Hayes	16,208	11	159	0	629	5	450
Benjamin Aceval	8,489	6	221	0	266	6	25
Sub-total	137,274	101	4,197	282	4,682	28	

(in 2006)

Category	Population	Shop		Market	Public Officer	Street Swept	Coverage Ratio
		Restaurant	Others				
	persons	nos.	nos.	shops	persons	km	%
Highly Urbanized M.							
Asuncion	561,720	491	18,485	5,054	21,589	300	100
Fernando de la Mora	125,811	232	3,208	0	2,252	40	100
Sub-total	687,531	722	21,693	5,054	23,841	340	
Urbanized M.							
Lambare	173,150	151	2,664	0	3,042	25	100
San Lorenzo	264,133	261	5,657	1,320	4,522	32	70
Capiata	189,685	212	3,351	0	3,148	12	70
Luque	239,801	342	5,956	0	5,776	18	70
M.R.Alonso	115,790	165	2,176	0	1,958	10	70
Villa Elisa	87,875	125	1,240	0	1,485	20	85
Sub-total	1,070,434	1,257	21,044	1,320	19,932	117	
Less Urbanized M.							
Nemby	61,573	69	2,248	0	1,510	12	70
J.A.Saldivar	4,558	5	124	0	747	2	50
Ita	24,720	22	773	250	1,007	9	70
Aregua	8,359	6	415	0	550	7	50
Limpio	52,262	52	2,527	113	1,222	8	50
Villa Hayes	20,508	18	201	0	796	9	70
Benjamin Aceval	10,742	9	280	0	336	11	50
Sub-total	182,722	180	6,568	363	6,168	58	

Table H.1.3.1c Forecast on Waste Generation in Asunción

(in 1993)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	876	g/person/day	506,445	persons	444
1.2 Commercial (Food)	26,119	g/shop/day	454	shops	12
1.3 Commercial (Others)	2,036	g/shop/day	17,102	shops	35
1.4 Market Waste	3,422	g/shop/day	4,676	shops	16
1.5 Institutional Waste	81	g/employee/day	19,974	employees	2
1.6 Street Sweeping Waste	242,424	g/km/day	264	km	64
1.7 Hospital Waste	5,255	g/bed/day	3,330	beds	17
1.8 Bulky Waste	0	ton/day			0
Sub-total					589
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	32	ton/day			32
Sub-total					0
Total					589

(in 2000)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	946	g/person/day	535,496	persons	506
1.2 Commercial (Food)	28,198	g/shop/day	473	shops	0
1.3 Commercial (Others)	2,198	g/shop/day	17,833	shops	39
1.4 Market Waste	3,694	g/shop/day	4,876	shops	18
1.5 Institutional Waste	87	g/employee/day	20,828	employees	2
1.6 Street Sweeping Waste	242,424	g/km/day	300	km	73
1.7 Hospital Waste	5,673	g/bed/day	3,472	beds	20
1.8 Bulky Waste	0	ton/day			0
Sub-total					658
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	35	ton/day			35
Sub-total					0
Total					658

(in 2006)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	1,010	g/person/day	561,720	persons	567
1.2 Commercial (Food)	30,111	g/shop/day	491	shops	15
1.3 Commercial (Others)	2,347	g/shop/day	18,485	shops	43
1.4 Market Waste	3,945	g/shop/day	5,054	shops	20
1.5 Institutional Waste	93	g/employee/day	21,589	employees	2
1.6 Street Sweeping Waste	242,424	g/km/day	300	km	73
1.7 Hospital Waste	6,058	g/bed/day	3,599	beds	22
1.8 Bulky Waste	0	ton/day			0
Sub-total					742
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	37	ton/day			37
Sub-total					0
Total					742

Table H.1.3.1d Forecast on Waste Generation in F.Mora

(in 1993)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	876	g/person/day	97,256	persons	85
1.2 Commercial (Food)	26,119	g/shop/day	179	shops	5
1.3 Commercial (Others)	2,036	g/shop/day	2,480	shops	5
1.4 Market Waste	3,422	g/shop/day	0	shops	0
1.5 Institutional Waste	81	g/employee/day	1,741	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	0	km	0
1.7 Hospital Waste	5,255	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					95
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	32	ton/day			0
Sub-total					0
Total					95

(in 2000)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	946	g/person/day	111,717	persons	106
1.2 Commercial (Food)	28,198	g/shop/day	206	shops	6
1.3 Commercial (Others)	2,198	g/shop/day	2,849	shops	6
1.4 Market Waste	3,694	g/shop/day	0	shops	0
1.5 Institutional Waste	87	g/employee/day	2,000	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	20	km	5
1.7 Hospital Waste	5,673	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					123
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	35	ton/day			0
Sub-total					0
Total					123

(in 2006)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	1,010	g/person/day	125,811	persons	127
1.2 Commercial (Food)	30,111	g/shop/day	232	shops	7
1.3 Commercial (Others)	2,347	g/shop/day	3,208	shops	8
1.4 Market Waste	3,945	g/shop/day	0	shops	0
1.5 Institutional Waste	93	g/employee/day	2,252	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	40	km	10
1.7 Hospital Waste	6,058	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					151
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	37	ton/day			0
Sub-total					0
Total					151

Table H.1.3.1e Forecast on Waste Generation in Lambare

(in 1993)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	876	g/person/day	103,990	persons	91
1.2 Commercial (Food)	26,119	g/shop/day	55	shops	1
1.3 Commercial (Others)	2,036	g/shop/day	1,600	shops	3
1.4 Market Waste	3,422	g/shop/day	0	shops	0
1.5 Institutional Waste	81	g/employee/day	1,827	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	0	km	0
1.7 Hospital Waste	5,255	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					96
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	32	ton/day			0
Sub-total					0
Total					96

(in 2000)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	946	g/person/day	136,843	persons	129
1.2 Commercial (Food)	28,198	g/shop/day	94	shops	3
1.3 Commercial (Others)	2,198	g/shop/day	2,105	shops	5
1.4 Market Waste	3,694	g/shop/day	0	shops	0
1.5 Institutional Waste	87	g/employee/day	2,404	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	17	km	4
1.7 Hospital Waste	5,673	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					141
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	35	ton/day			0
Sub-total					0
Total					141

(in 2006)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	1,010	g/person/day	173,150	persons	175
1.2 Commercial (Food)	30,111	g/shop/day	151	shops	5
1.3 Commercial (Others)	2,347	g/shop/day	2,664	shops	6
1.4 Market Waste	3,945	g/shop/day	0	shops	0
1.5 Institutional Waste	93	g/employee/day	3,042	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	25	km	6
1.7 Hospital Waste	6,058	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					192
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	37	ton/day			0
Sub-total					0
Total					192

Table H.1.3.1f Forccast on Waste Generation in San Lorenzo

(in 1993)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	876	g/person/day	140,075	persons	123
1.2 Commercial (Food)	26,119	g/shop/day	73	shops	2
1.3 Commercial (Others)	2,036	g/shop/day	3,000	shops	6
1.4 Market Waste	3,422	g/shop/day	700	shops	2
1.5 Institutional Waste	81	g/employee/day	2,398	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	0	km	0
1.7 Hospital Waste	5,255	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					133
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	32	ton/day			0
Sub-total					0
Total					133

(in 2000)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	946	g/person/day	197,100	persons	186
1.2 Commercial (Food)	28,198	g/shop/day	145	shops	4
1.3 Commercial (Others)	2,198	g/shop/day	4,221	shops	9
1.4 Market Waste	3,694	g/shop/day	985	shops	4
1.5 Institutional Waste	87	g/employee/day	3,374	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	21	km	5
1.7 Hospital Waste	5,673	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					209
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	35	ton/day			0
Sub-total					0
Total					209

(in 2006)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	1,010	g/person/day	264,133	persons	267
1.2 Commercial (Food)	30,111	g/shop/day	261	shops	8
1.3 Commercial (Others)	2,347	g/shop/day	5,657	shops	13
1.4 Market Waste	3,945	g/shop/day	1,320	shops	5
1.5 Institutional Waste	93	g/employee/day	4,522	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	32	km	8
1.7 Hospital Waste	6,058	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					301
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	37	ton/day			0
Sub-total					0
Total					301

Table H.1.3.1g Forecast on Waste Generation in Capiata

(in 1993)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	876	g/person/day	88,932	persons	78
1.2 Commercial (Food)	26,119	g/shop/day	47	shops	1
1.3 Commercial (Others)	2,036	g/shop/day	1,571	shops	3
1.4 Market Waste	3,422	g/shop/day	0	shops	0
1.5 Institutional Waste	81	g/employee/day	1,476	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	0	km	0
1.7 Hospital Waste	5,255	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					82
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	32	ton/day			0
Sub-total					0
Total					82

(in 2000)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	946	g/person/day	133,721	persons	126
1.2 Commercial (Food)	28,198	g/shop/day	105	shops	3
1.3 Commercial (Others)	2,198	g/shop/day	2,362	shops	5
1.4 Market Waste	3,694	g/shop/day	0	shops	0
1.5 Institutional Waste	87	g/employee/day	2,219	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	6	km	1
1.7 Hospital Waste	5,673	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					136
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	35	ton/day			0
Sub-total					0
Total					136

(in 2006)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	1,010	g/person/day	189,685	persons	192
1.2 Commercial (Food)	30,111	g/shop/day	212	shops	6
1.3 Commercial (Others)	2,347	g/shop/day	3,351	shops	8
1.4 Market Waste	3,945	g/shop/day	0	shops	0
1.5 Institutional Waste	93	g/employee/day	3,148	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	12	km	3
1.7 Hospital Waste	6,058	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					209
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	37	ton/day			0
Sub-total					0
Total					209

Table H.1.3.1h Forecast on Waste Generation in Luque

(in 1993)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	876	g/person/day	91,676	persons	80
1.2 Commercial (Food)	26,119	g/shop/day	48	shops	1
1.3 Commercial (Others)	2,036	g/shop/day	2,190	shops	4
1.4 Market Waste	3,422	g/shop/day	0	shops	0
1.5 Institutional Waste	81	g/employee/day	2,124	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	0	km	0
1.7 Hospital Waste	5,255	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					86
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	32	ton/day			0
Sub-total					0
Total					86

(in 2000)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	946	g/person/day	157,116	persons	149
1.2 Commercial (Food)	28,198	g/shop/day	141	shops	4
1.3 Commercial (Others)	2,198	g/shop/day	3,753	shops	8
1.4 Market Waste	3,694	g/shop/day	0	shops	0
1.5 Institutional Waste	87	g/employee/day	3,640	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	9	km	2
1.7 Hospital Waste	5,673	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					163
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	35	ton/day			0
Sub-total					0
Total					163

(in 2006)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	1,010	g/person/day	239,801	persons	242
1.2 Commercial (Food)	30,111	g/shop/day	342	shops	10
1.3 Commercial (Others)	2,347	g/shop/day	5,956	shops	14
1.4 Market Waste	3,945	g/shop/day	0	shops	0
1.5 Institutional Waste	93	g/employee/day	5,776	employees	1
1.6 Street Sweeping Waste	242,424	g/km/day	18	km	4
1.7 Hospital Waste	6,058	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					271
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	37	ton/day			0
Sub-total					0
Total					271

Table H.1.3.1i Forecast on Waste Generation in M.R.Alonso

(in 1993)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	876	g/person/day	42,576	persons	37
1.2 Commercial (Food)	26,119	g/shop/day	22	shops	1
1.3 Commercial (Others)	2,036	g/shop/day	800	shops	2
1.4 Market Waste	3,422	g/shop/day	0	shops	0
1.5 Institutional Waste	81	g/employee/day	720	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	0	km	0
1.7 Hospital Waste	5,255	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					40
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	32	ton/day			0
Sub-total					0
Total					40

(in 2000)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	946	g/person/day	72,967	persons	69
1.2 Commercial (Food)	28,198	g/shop/day	66	shops	2
1.3 Commercial (Others)	2,198	g/shop/day	1,371	shops	3
1.4 Market Waste	3,694	g/shop/day	0	shops	0
1.5 Institutional Waste	87	g/employee/day	1,234	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	6	km	1
1.7 Hospital Waste	5,673	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					75
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	35	ton/day			0
Sub-total					0
Total					75

(in 2006)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	1,010	g/person/day	115,790	persons	117
1.2 Commercial (Food)	30,111	g/shop/day	165	shops	5
1.3 Commercial (Others)	2,347	g/shop/day	2,176	shops	5
1.4 Market Waste	3,945	g/shop/day	0	shops	0
1.5 Institutional Waste	93	g/employee/day	1,958	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	10	km	2
1.7 Hospital Waste	6,058	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					130
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	37	ton/day			0
Sub-total					0
Total					130

Table H.1.3.1j Forecast on Waste Generation in Villa Elisa

(in 1993)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	876	g/person/day	32,311	persons	28
1.2 Commercial (Food)	26,119	g/shop/day	17	shops	0
1.3 Commercial (Others)	2,036	g/shop/day	456	shops	1
1.4 Market Waste	3,422	g/shop/day	0	shops	0
1.5 Institutional Waste	81	g/employee/day	546	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	0	km	0
1.7 Hospital Waste	5,255	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					30
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	32	ton/day			0
Sub-total					0
Total					30

(in 2000)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	946	g/person/day	55,376	persons	52
1.2 Commercial (Food)	28,198	g/shop/day	50	shops	1
1.3 Commercial (Others)	2,198	g/shop/day	782	shops	2
1.4 Market Waste	3,694	g/shop/day	0	shops	0
1.5 Institutional Waste	87	g/employee/day	936	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	9	km	2
1.7 Hospital Waste	5,673	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					58
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	35	ton/day			0
Sub-total					0
Total					58

(in 2006)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	1,010	g/person/day	87,875	persons	89
1.2 Commercial (Food)	30,111	g/shop/day	125	shops	4
1.3 Commercial (Others)	2,347	g/shop/day	1,240	shops	3
1.4 Market Waste	3,945	g/shop/day	0	shops	0
1.5 Institutional Waste	93	g/employee/day	1,485	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	20	km	5
1.7 Hospital Waste	6,058	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					100
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	37	ton/day			0
Sub-total					0
Total					100

Table H.1.3.1k Forecast on Waste Generation in Nemby

(in 1993)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	876	g/person/day	28,868	persons	25
1.2 Commercial (Food)	26,119	g/shop/day	15	shops	0
1.3 Commercial (Others)	2,036	g/shop/day	1,054	shops	2
1.4 Market Waste	3,422	g/shop/day	0	shops	0
1.5 Institutional Waste	81	g/employee/day	708	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	0	km	0
1.7 Hospital Waste	5,255	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					28
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	32	ton/day			0
Sub-total					0
Total					28

(in 2000)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	946	g/person/day	43,407	persons	41
1.2 Commercial (Food)	28,198	g/shop/day	34	shops	1
1.3 Commercial (Others)	2,198	g/shop/day	1,585	shops	3
1.4 Market Waste	3,694	g/shop/day	0	shops	0
1.5 Institutional Waste	87	g/employee/day	1,065	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	3	km	1
1.7 Hospital Waste	5,673	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					46
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	35	ton/day			0
Sub-total					0
Total					46

(in 2006)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	1,010	g/person/day	61,573	persons	62
1.2 Commercial (Food)	30,111	g/shop/day	69	shops	2
1.3 Commercial (Others)	2,347	g/shop/day	2,248	shops	5
1.4 Market Waste	3,945	g/shop/day	0	shops	0
1.5 Institutional Waste	93	g/employee/day	1,510	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	12	km	3
1.7 Hospital Waste	6,058	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					73
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	37	ton/day			0
Sub-total					0
Total					73

Table H.1.3.11 Forecast on Waste Generation in J.A.Saldivar

(in 1993)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	876	g/person/day	2,137	persons	2
1.2 Commercial (Food)	26,119	g/shop/day	1	shops	0
1.3 Commercial (Others)	2,036	g/shop/day	58	shops	0
1.4 Market Waste	3,422	g/shop/day	0	shops	0
1.5 Institutional Waste	81	g/employee/day	350	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	0	km	0
1.7 Hospital Waste	5,255	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					2
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	32	ton/day			0
Sub-total					0
Total					2

(in 2000)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	946	g/person/day	3,213	persons	3
1.2 Commercial (Food)	28,198	g/shop/day	3	shops	0
1.3 Commercial (Others)	2,198	g/shop/day	87	shops	0
1.4 Market Waste	3,694	g/shop/day	0	shops	0
1.5 Institutional Waste	87	g/employee/day	526	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	1	km	0
1.7 Hospital Waste	5,673	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					4
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	35	ton/day			0
Sub-total					0
Total					4

(in 2006)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	1,010	g/person/day	4,558	persons	5
1.2 Commercial (Food)	30,111	g/shop/day	5	shops	0
1.3 Commercial (Others)	2,347	g/shop/day	124	shops	0
1.4 Market Waste	3,945	g/shop/day	0	shops	0
1.5 Institutional Waste	93	g/employee/day	747	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	2	km	0
1.7 Hospital Waste	6,058	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					6
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	37	ton/day			0
Sub-total					0
Total					6

Table H.1.3.1m Forecast on Waste Generation in Ita

(in 1993)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	876	g/person/day	14,846	persons	13
1.2 Commercial (Food)	26,119	g/shop/day	8	shops	0
1.3 Commercial (Others)	2,036	g/shop/day	464	shops	1
1.4 Market Waste	3,422	g/shop/day	150	shops	1
1.5 Institutional Waste	81	g/employee/day	605	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	0	km	0
1.7 Hospital Waste	5,255	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					15
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	32	ton/day			0
Sub-total					0
Total					15

(in 2000)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	946	g/person/day	19,536	persons	18
1.2 Commercial (Food)	28,198	g/shop/day	13	shops	0
1.3 Commercial (Others)	2,198	g/shop/day	611	shops	1
1.4 Market Waste	3,694	g/shop/day	197	shops	1
1.5 Institutional Waste	87	g/employee/day	796	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	5	km	1
1.7 Hospital Waste	5,673	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					22
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	35	ton/day			0
Sub-total					0
Total					22

(in 2006)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	1,010	g/person/day	24,720	persons	25
1.2 Commercial (Food)	30,111	g/shop/day	22	shops	1
1.3 Commercial (Others)	2,347	g/shop/day	773	shops	2
1.4 Market Waste	3,945	g/shop/day	250	shops	1
1.5 Institutional Waste	93	g/employee/day	1,007	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	9	km	2
1.7 Hospital Waste	6,058	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					31
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	37	ton/day			0
Sub-total					0
Total					31

Table H.1.3.1n Forecast on Waste Generation in Aregua

(in 1993)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	876	g/person/day	6,462	persons	6
1.2 Commercial (Food)	26,119	g/shop/day	3	shops	0
1.3 Commercial (Others)	2,036	g/shop/day	321	shops	1
1.4 Market Waste	3,422	g/shop/day	0	shops	0
1.5 Institutional Waste	81	g/employee/day	425	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	0	km	0
1.7 Hospital Waste	5,255	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					6
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	32	ton/day			0
Sub-total					0
Total					6

(in 2000)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	946	g/person/day	7,422	persons	7
1.2 Commercial (Food)	28,198	g/shop/day	4	shops	0
1.3 Commercial (Others)	2,198	g/shop/day	369	shops	1
1.4 Market Waste	3,694	g/shop/day	0	shops	0
1.5 Institutional Waste	87	g/employee/day	488	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	5	km	1
1.7 Hospital Waste	5,673	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					9
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	35	ton/day			0
Sub-total					0
Total					9

(in 2006)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	1,010	g/person/day	8,359	persons	8
1.2 Commercial (Food)	30,111	g/shop/day	6	shops	0
1.3 Commercial (Others)	2,347	g/shop/day	415	shops	1
1.4 Market Waste	3,945	g/shop/day	0	shops	0
1.5 Institutional Waste	93	g/employee/day	550	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	7	km	2
1.7 Hospital Waste	6,058	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					11
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	37	ton/day			0
Sub-total					0
Total					11

Table H.1.3.1o Forecast on Waste Generation in Limpio

(in 1993)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	876	g/person/day	27,716	persons	24
1.2 Commercial (Food)	26,119	g/shop/day	15	shops	0
1.3 Commercial (Others)	2,036	g/shop/day	1,340	shops	3
1.4 Market Waste	3,422	g/shop/day	60	shops	0
1.5 Institutional Waste	81	g/employee/day	648	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	0	km	0
1.7 Hospital Waste	5,255	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					28
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	32	ton/day			0
Sub-total					0
Total					28

(in 2000)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	946	g/person/day	38,999	persons	37
1.2 Commercial (Food)	28,198	g/shop/day	29	shops	1
1.3 Commercial (Others)	2,198	g/shop/day	1,886	shops	4
1.4 Market Waste	3,694	g/shop/day	84	shops	0
1.5 Institutional Waste	87	g/employee/day	912	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	3	km	1
1.7 Hospital Waste	5,673	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					43
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	35	ton/day			0
Sub-total					0
Total					43

(in 2006)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	1,010	g/person/day	52,262	persons	53
1.2 Commercial (Food)	30,111	g/shop/day	52	shops	2
1.3 Commercial (Others)	2,347	g/shop/day	2,527	shops	6
1.4 Market Waste	3,945	g/shop/day	113	shops	0
1.5 Institutional Waste	93	g/employee/day	1,222	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	8	km	2
1.7 Hospital Waste	6,058	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					63
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	37	ton/day			0
Sub-total					0
Total					63

Table H.1.3.1p Forecast on Waste Generation in Villa Hayes

(in 1993)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	876	g/person/day	12,317	persons	11
1.2 Commercial (Food)	26,119	g/shop/day	6	shops	0
1.3 Commercial (Others)	2,036	g/shop/day	121	shops	0
1.4 Market Waste	3,422	g/shop/day	0	shops	0
1.5 Institutional Waste	81	g/employee/day	478	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	0	km	0
1.7 Hospital Waste	5,255	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					11
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	32	ton/day			0
Sub-total					0
Total					11

(in 2000)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	946	g/person/day	16,208	persons	15
1.2 Commercial (Food)	28,198	g/shop/day	11	shops	0
1.3 Commercial (Others)	2,198	g/shop/day	159	shops	0
1.4 Market Waste	3,694	g/shop/day	0	shops	0
1.5 Institutional Waste	87	g/employee/day	629	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	5	km	1
1.7 Hospital Waste	5,673	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					17
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	35	ton/day			0
Sub-total					0
Total					17

(in 2006)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	1,010	g/person/day	20,508	persons	21
1.2 Commercial (Food)	30,111	g/shop/day	18	shops	1
1.3 Commercial (Others)	2,347	g/shop/day	201	shops	0
1.4 Market Waste	3,945	g/shop/day	0	shops	0
1.5 Institutional Waste	93	g/employee/day	796	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	9	km	2
1.7 Hospital Waste	6,058	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					24
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	37	ton/day			0
Sub-total					0
Total					24

Table H.1.3.1q Forecast on Waste Generation in Benjamin Aceval

(in 1993)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	876	g/person/day	6,451	persons	6
1.2 Commercial (Food)	26,119	g/shop/day	3	shops	0
1.3 Commercial (Others)	2,036	g/shop/day	168	shops	0
1.4 Market Waste	3,422	g/shop/day	0	shops	0
1.5 Institutional Waste	81	g/employee/day	202	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	0	km	0
1.7 Hospital Waste	5,255	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					6
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	32	ton/day			0
Sub-total					0
Total					6

(in 2000)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW			8,489		
1.1 Household Waste	946	g/person/day	6	persons	8
1.2 Commercial (Food)	28,198	g/shop/day	221	shops	0
1.3 Commercial (Others)	2,198	g/shop/day	0	shops	0
1.4 Market Waste	3,694	g/shop/day	266	shops	0
1.5 Institutional Waste	87	g/employee/day	6	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	0	km	1
1.7 Hospital Waste	5,673	g/bed/day		beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					10
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	35	ton/day			0
Sub-total					0
Total					10

(in 2006)

Items	Generation Ratio		Generation Source		Generation Amount (ton/day)
	Ratio	Unit	Ratio	Unit	
1. MSW					
1.1 Household Waste	1,010	g/person/day	10,742	persons	11
1.2 Commercial (Food)	30,111	g/shop/day	9	shops	0
1.3 Commercial (Others)	2,347	g/shop/day	280	shops	1
1.4 Market Waste	3,945	g/shop/day	0	shops	0
1.5 Institutional Waste	93	g/employee/day	336	employees	0
1.6 Street Sweeping Waste	242,424	g/km/day	11	km	3
1.7 Hospital Waste	6,058	g/bed/day	0	beds	0
1.8 Bulky Waste	0	ton/day			0
Sub-total					14
2. Other Waste					
2.1 Industrial Waste	0	ton/day			0
2.2 Others	37	ton/day			0
Sub-total					0
Total					14

H.1.3.2 Forecast on Waste Composition

a. Forecast on Waste Composition

A change in the composition of waste is expected due to new products and a different consumption pattern.

In Table H.1.3.2a, results for household waste and MSW (excluding street sweeping and bulky wastes) composition from WACS are compared with the data of Rio de Janeiro in Brazil provided by the Applied Research Center of COMLU-RB (Rio de Janeiro Municipal Public Cleansing Company), Pinang in Malaysia in 1987 and Tokyo in Japan in 1972.

Table H.1.3.2a Comparison of Waste Composition Data for MSW

unit:%

	Household Waste from WACS	MSW * from WACS	Pinang ** Malaysia 1987	Tokyo Japan 1972	Rio de Janeiro 1991
1. Combustibles	**70.9**	**71.8**	**88.1**	**89.0**	**79.1**
Kitchen Wastes	38.8	39.2	32.8	25.9	33.9
Paper	7.8	10.3	25.5	35.6	27.1
Textile	2.0	1.8	3.4	3.2	2.7
Plastic	2.5	2.9	11.2	6.9	12.7
Grass and Wood	19.0	16.8	14.4	–	2.0
Leather and Rubber	0.9	0.8	0.8	0.8	0.7
Others	–	–	–	16.6	–
2. Non-Combustibles	**29.1**	**28.2**	**12.0**	**11.0**	**20.4**
Metal	1.2	1.1	2.6	3.7	3.1
Glass	4.4	4.7	1.4	7.3	2.2
Ceramic and Stone	2.1	2.0	0.2	–	0.4
Others(soils, etc.)	21.4	20.4	7.8	–	14.7
Total	100	100	100	100	99.5
Apparent Specific Gravity (kg/m^3)	180	180	190	N.A.	209

Note: WACS : Waste Amount and Composition Survey
* : The figure shows the composition of MSW other than street sweeping and bulky waste.
** Source : "Solid Waste Management Study for Pulau Pinang and Seberang Perai Municipalities, August 1989, JICA"

There is no existing data available in the Study area. The analysis was, therefore, focused on the comparison of the data provided by WACS and Brazil assuming that changes in waste composition would result to wastes' characteristic of a developed economy.

Brazil was chosen for its reliable waste data and its geographical and demographic features which is similar to Paraguay.

The ratios of papers, plastics, grass and wood, and others (soils, etc.) necessitate considerations on the carrying out of forecast. Development on the other hand will only be considered as a minor change.

As referred to in Table H.1.3.2a, the frame of the waste composition in 2006 is set as follows:

- Paper and plastic ratios will increase up to 24% and 7% respectively as seen in Malaysia and Brazil.
- Ratio of grass and wood will decrease to 10% due to the reduction of vegetation in the urban area.
- Soils (others) ratio will decrease to 11% due to the increase in the number of paved roads.
- Other fractions would only be considered as minor changes.

Table H.1.3.2b shows the forecast on waste composition of MSW excluding street sweeping and bulky wastes in the Study area.

Table H.1.3.2b Forecast on Composition of MSW unit:%

Composition	1993	2000	2006
1. Combustibles	**71.8**	**75**	**79**
Kitchen waste	39.2	36	34
Paper	10.3	18	24
Textile	1.8	2	3
Plastic	2.9	5	7
Grass and Wood	16.8	13	10
Leather and Rubber	0.8	1	1
2. Non-Combustibles	**28.2**	**25**	**21**
Metal	1.1	2	3
Glass	4.7	5	5
Ceramic and Stone	2.0	2	2
Others (Soils, etc.)	20.4	16	11
Total	100.0	100.0	100.0

Note: MSW here excludes street sweeping and bulky waste.

b Forecast on Calorific Value

ba. LCV of each physical composition item

The following calorific values were measured in the WACS:

- for mixed combustibles of 7 generation sources, i.e. residential areas (high, middle and low income), markets, commercial areas (restaurants and others) and institutions
- for each combustible items of the middle income residential area.

The calorific value of waste differs according to physical composition and three content, moisture content, combustible waste and ash. The ratio of combustible waste and ash depends on the change in physical composition. Table H.1.3.2c shows our survey data on mixed combustibles and the data of Japan in 1972.

Table H.1.3.2c Comparison of Three Contents and LCV

		1993 JICA Study		Japan in 1972
		Household	MSW	
Moisture content	(%)	39.8	40.3	54.1
Combustible	(%)	25.2	26.6	31.4
Ash	(%)	35.0	33.1	14.5
Measured Lower calorific value	(kcal/kg)	1,120	1,179	1,165

Note: MSW excludes street sweeping and bulky waste.

The above 1993 data by the JICA Study Team are weighing average figures of mixed wastes, taking the waste generation ratio by each generation category into account. The moisture content of each data ranges between 25% and 60 %. The lower calorific value was determined only taking into account the possibility that the physical composition may vary, because the moisture content is forecast to remain constant.

The higher calorific values (HCVs) in dry base of each combustible components of the middle income residential area were also measured. Based on the higher calorific values the lower calorific values (LCVs) were calculated. These results are tabulated in Table H.1.3.2d.

Table H.1.3.2d HCVs in Dry Base and LCVs in Wet Base of Each Combustible Waste

	Higher Calorific Value in Dry Base (Kcal/Kg)	Lower Calorific Value in Wet Base (Kcal/Kg)
Kitchen Wastes	4,830	1,100
Paper	4,371	2,600
Textile	3,917	2,300
Plastic	9,617	6,500
Grass & Wood	3,445	1,400
Leather & Rubber	5,056	3,500

Based on Table H.1.3.2d, the LCVs of wastes can be calculated by the following formula.

$$LCV = (RGa^{*1} * 1,100 + RPa^{*2} * 2,600 + RT^{*3} * 2,300 + RPl^{*4} * 6,500 + RGr^{*5} * 1,400 + RL^{*6} * 3,500) / 100$$

RGa^{*1} ; Ratio of kitchen wastes in wet weight (%)
RPa^{*2} ; Ratio of paper in wet weight (%)
RT^{*3} ; Ratio of textile in wet weight (%)
RPl^{*4} ; Ratio of plastic in wet weight (%)
RGr^{*5} ; Ratio of grass and wood in wet weight (%)
RL^{*6} ; Ratio of leather and rubber in wet weight (%)

bb. Lower calorific value forecast

With the above mentioned formula the future LCV of MSW is estimated by multiplying the LCV in Table H.1.3.2d by the ratio of the future physical composition shown in Table H.1.3.2b.

In case a separate collection system will not be introduced, the LCV of mixed waste is estimated in Table H.1.3.2e.

Table H.1.3.2e Forecast on Lower Calorific Value

Year	Lower Calorific Value (kcal/kg)
	Mixed
1993	1,192
2000	1,452
2006	1,697

Note: MSW excludes street sweeping and bulky waste.

H.1.3.3 Future Waste Stream

The waste streams for the 15 municipalities in the year 2006 were forecasted.

a. Conditions of the Forecast

aa Source recycling

The food waste recycling rate (54g/person/day) at generation sources will be kept by 2006.

ab. Self-disposal (collection service area)

Since the dominant housing style (detached houses) will not change in future. The self-disposal rate (245g/person/day) will be kept by 2006. Consequently, self-disposal amount is calculated by the formula below.

$SA = 245(g/person/day) \times NP \times CCR \times 10^{-6}$

SA : Self-disposal amount (ton/day)
NP : Population (persons)
CCR : Collection coverage ratio (%)

ac. Self-disposal (non-collection service area)

Self-disposal amount in non-collection service area is derived from the following formula:

SA (non) = HWA x (1 - CCR/100)

SA (non)	: Self-disposal amount in non-collection service area (ton/day)
HWA	: Household waste amount (ton/day)

ad. Discharge

The waste discharge amount is obtained by the following formula:

DA = WGA - SRA - SA - SA (non)

DA	: Discharge amount (ton/day)
WGA	: Waste generation amount (ton/day)
SRA	: Source recycling amount (ton/day)

ae. Recycling other than at sources

The rate of recycling other than at sources (42g/person/day) will be kept by 2006.

af. Other waste

The rate of the other wastes, which is 32g/person/day in 1993 and only disposed of at the Cateura landfill, will change to 37g/person/day by 2006.

ag. Landfill

The landfill amount is calculated by the formula below.

LA = DA - RA + OWA

LA	: Landfill amount (ton/day)
RA	: Amount of recycling other than at sources (ton/day)
OWA	: Other wastes amount (ton/day)

ah. Incineration

Residues from incineration plants amount to 35 % with reference to the actual data in Japan. The incineration plant is 60% efficient in producing heat from waste with reference to the actual data in Japan.

The incineration plant starts operation in 2001 and all excluding street sweeping and bulky wastes will be incinerated.

ai. Apparent specific gravity

Apparent specific gravity of waste after compaction at the final disposal site is:

.	Residue of incineration:	1.1
.	Others:	0.8

b. Future Waste Stream

Future waste streams are prepared in accordance with each alternative and presented in H.4 and H.5.

H.1.4 Other Pre-conditions

H.1.4.1 Economic and Financial Conditions

According to preliminary results from the 1992 population census, the population growth rate of the Central Department was much higher (5.7%) than the national average (3.1%), but Asuncion grew at only 1%. Within the Central Department, the population growth rates exceeded 10% in M.R. Alonso and Nemby, and ranged between 5% and 10% in Aregua, Capiata, Limpio, Luque, San Lorenzo and Villa Elisa.

The focus of the Project is on the urban population in the Study Area, which grew at a rate of 3.63% per year between 1982 and 1992. The urban population projection for the Project is based on an overall 3.62% annual growth rate in the Study Area, up to the target year.

On the other hand, the real growth rate of GDP is estimated at 3.5% for 1994 by the new administration of Paraguay inaugurated in August 1993. Since this is the only available official figure, in the absence of a medium or long-term national development plan, the initial goal of 3.5% real growth rate in GDP should be the base for estimating future economic conditions. Therefore, the initial target is assumed as the GDP growth rate for the term of this administration and beyond.

In reality, if the proposed measures are successful to reactivate the economy and make it less vulnerable to fluctuations in international prices of a few export commodities, then, higher growth rates can be expected in some of the future years.

Likewise, unexpected factors can bring about lower GDP growth rates. However, for the sake of facilitating projections, the GDP growth rate is assumed to average out at the initial target of 3.5%.

The 3.5% real growth rate of GDP may appear to be low in relation to the assumed overall population growth rate of 3.62% in the Study Area. However, the GDP growth rate refers to the whole economy, while the population growth rate refers to the urban population in the Study Area, where the concentration of economic activities is observed to be quite high.

Financially, the basic condition for a solid waste management system is that the service should be self-supporting. As public utilities, the service is legislated to be provided at real costs plus administrative expenses. This does not imply the right to run the service inefficiently. On the contrary, there is an obligation to render the service efficiently and to the satisfaction of the beneficiaries.

An interview survey was conducted to investigate the willingness to pay for solid wastes disposal services. Respondents were requested to answer the questions UNDER THE ASSUMPTION that solid wastes disposal services were SATISFACTORY. A comparison between the fee actually paid for solid wastes disposal services and the willingness to pay indicated that households were willing to pay significantly more than the fee actually paid, provided that the service is rendered at the satisfaction of beneficiaries.

Important conclusions from the interview survey are not only the determination of fees the beneficiaries are willing to pay, but also the indication on the good will and cooperative attitude of beneficiaries towards improved levels of solid wastes disposal services. It is therefore estimated that improvements in solid wastes disposal services can be implemented with reasonable certainty concerning the cooperation of beneficiaries in paying the necessary fees to finance such improvements.

H.1.4.2 Conditions for Cost Estimation

All cost estimates was conducted based on the following conditions:

- The prices and exchange rate are based on August 1993. The mean exchange rate in August 1993 is shown below.

  1 US$ = 1,756.52 Gs = 105.37 Japanese Yen

- Labor costs and investments for constructions and equipment available in Paraguay reflects Paraguayan price level. These prices are presented in Guarani(Gs). Table H.1.4.2a presents information on the unit prices in August 1993 in Paraguay.

- Prices for equipment not available in Paraguay reflects price level available in South America. These will be presented in CIF prices in US Dollar.

- All salaries are net salaries, which includes 9.5% tax and 41.47% social security charge.

- The inflation rate is not taken into account.

The information on typical unit prices for earthworks, concrete works, buildings, etc. were obtained from the Paraguayan Chamber of Construction Industry and Ministry of Public Works and Communication.

Table H.1.4.2a presents information on unit prices available in Paraguay in August 1993.

Table H.1.4.2a Information on Unit Prices Available in Paraguay

DESCRIPTION	UNIT	PRICE
1. Salary, including 42% Social Securities Charge		
- manager	Gs/month	> 3,000,000
- engineer & mechanic	Gs/month	1,000,000
- driver & operator	Gs/month	800,000
- worker	Gs/month	450,000
- clerk	Gs/month	300,000
2. Earthworks		
- Excavation and compaction; hauling distance = 0 to 50 m	Gs/m³	4,000
- Excavation, Hauling and compaction		
0 - 1 km	Gs/m³	5,500
1 - 5 km	Gs/m³	6,900
5 -10 km	Gs/m³	8,600
10 -15 km	Gs/m³	10,800
3. Drainage Works		
- Underground drains including excavation, supply & placing of gravel	Gs/m	7,800
- Underground drains with perforated pipes, including excavation, supply & placing of perforated pipes (D=diameter) and filter material		
D=100 mm	Gs/m	11,400
D=150 mm	Gs/m	14,200
D=300 mm	Gs/m	39,300
- Open Ditch w=3.0 m, including excavation and shaping	Gs/m	2,000
- Open Ditch w=1.5 m, including excavation, supply and facing of stones	Gs/m	54,600
- Concrete pipe D=600 mm, including excavation, foundation, supply & placing concrete pipe and back fill	Gs/m	123,000
- Concrete pipe culvert D=1,200 mm, including excavation, foundation, supply and placing concrete pipe and back fill	Gs/m	265,000
4. Pavement works		
- Surface Course, Dense-graded Asphalt Concrete	Gs/m³	200,000
- Base Course, Mechanical Stabilized Gravel	Gs/m³	53,000
- Sub-base Course, Gravel	Gs/m³	33,000
5. Concrete works, including material and works concerning form work, reinforcement work, concrete work		
- wall	Gs/m³	222,000
- slab	Gs/m³	235,000
- column	Gs/m³	235,000
- continuous footing foundation	Gs/m³	250,000
6. Building works		
- Steel Garage with steel cladding, including foundation and concrete floor	Gs/m²	68,500
- Office building of brickwork, including all works	Gs/m²	500,000
7. Miscellaneous		
- Fence, consisting of 2 m high galvanized wire mesh erected on galvanized steel posts each 2.5 m	Gs/m	35,900
- Gate, 8 m wide of gate	Gs/set	850,000
- Turfing, consist of supply of turf and soil and all works to be necessary	Gs/m²	7,600
8.Materials		
- Diesel Oil	Gs/l	480
- Gravel	Gs/m³	17,000
- Sand	Gs/m³	8,000
- Cement	Gs/50kg	11,690
- Ready Mixed-Concrete		
150 kg/cm²	Gs/m³	117,100
180 kg/cm²	Gs/m³	125,100
210 kg/cm²	Gs/m³	127,100
240 kg/cm²	Gs/m³	133,100
- Steel beam	Gs/kg	935
- Electric power	Gs/kwh	22.36

H.2 Work Flow of the Examination of Technical System Alternatives

H.2.1 System Components in MSWM

a. Technical System

The MSWM (Municipal Solid Waste Management) system consists of the technical and institutional systems. The technical system consists of the following sub-systems:

- discharge and storage;
- collection and haulage (transportation);
- street sweeping and public area cleansing;
- transfer;
- processing and recycling; and
- final disposal.

Some sub-systems are always necessary, while the necessity of the others such as processing depends on several factors with the local financial capability and the waste characteristics as decisive ones.

It is necessary to examine whether certain sub-systems are required, and if required, their types, methods, and facilities, too. The following table explains to what extent each technical sub-system is to be examined.

Table H.2.1a Scope of Examination

Sub-systems	Scope of Examination
- Discharge and Storage	B
- Collection and Haulage	B
- Street Sweeping and Public Area Cleaning	B
- Transfer	A
- Processing	A
. Incineration	A
. Composting	A
. Shredding	A
. Sorting	A
- Final Disposal	B

Note; A: Examination is to be made as to the sub-system is necessary or not
B: Examination is to be made on the type, method and facility to be used as the sub-system is absolutely necessary.

b. **Institutional System**

In addition to the above-mentioned technical sub-systems and to be considered parallel to this, MSWM system contains the following institutional sub-systems:

- organization and management;
- legislation and enforcement;
- finance (revenue source); and
- public cooperation.

H.2.2 Selection Method of an Optimum Technical System

An alternative to the MSWM system is a combination of various technical sub-systems such as discharge and storage system, collection and haulage system, street sweeping and public area cleansing system, processing system and final disposal system. Many alternatives can be made by the combination of possible sub-systems.

If all combinations of the above sub-systems were to be studied, the total number of combinations would be equal to hundreds of individual MSWM systems. Therefore, it can be deduced that a Master Plan study is a screening work concerning various alternative systems.

In view of the present MSWM in the Study area, a goal is set up to develop and realize a beautiful and clean living environment in the Asuncion Metropolitan Area. In addition, the creation of a cost-effective MSWM system is a main issue in the generation of alternatives because the implementation of MSWM may be very costly.

Generally, the following method is applied in the Study for the selection of an optimum alternative for the Master Plan.

a. Selection of the Optimum Technical System

aa. Examination of Technical Sub-systems

Possible sub-system alternatives for each technical sub-system will be examined and the optimum one will be selected. For example, as for the refuse containers, after the comparison of alternatives such as plastic bins, bamboo baskets, etc., an optimum bin will be selected.

ab. Examination of Combinations of Technical Sub-systems

A comparison study on the technical systems will be carried out by combining each technical sub-system.

ac. Selection of an Optimum Technical System

Upon consideration of the results of the above-mentioned alternative study, an optimum technical system will be selected by evaluating the following aspects:

i. technical points of view;
ii. economic and financial points of view;
iii. transactional facilitation points of view; and
iv. environmental points of view.

b. Selection of the Optimum Institutional System

After the selection of the optimum technical system, a study will also be made to generate alternatives for the organizational, institutional and financial aspects which will be suitable to the selected technical system. After the comparative study on the above-mentioned alternatives, an optimum MSWM system will be finally selected.

H.2.3 Selection Method of an Optimum Technical System

a. Selection Method

Generally, the selection of an optimum technical system alternative is carried out as the method described in the previous section H.2.2. The following method is applied in this study.

i. Primarily, the optimum technical system alternatives for Asuncion and Fernando de la Mora were examined, evaluated and selected.

ii. Secondarily, based on the above-mentioned work the optimum technical system alternatives for the other 13 municipalities were examined, evaluated and selected.

Selection of Optimum Technical System Alternatives for Highly Urbanized Municipalities

↓

Selection of Optimum Technical System Alternatives for the Other 13 Municipalities

The reasons, why we applied the method in this study, are as follows:

i. Regarding MSWM in the Study area, the most critical problem was the disposal of wastes from Asuncion and F.Mora; that was the issue of whether the Cateura landfill should close or not.

ii. Through the first study work in Paraguay, two candidate sites for the inter-municipal disposal operation were identified. It had the priority to select one inter-municipal disposal site from the two in the examination of technical system alternatives. Because the two candidate sites are located in the northern part of the Study area and in case the Cateura landfill should be closed, the construction and operation of a new inter-municipal disposal site was indispensable in the sound MSWM in the Study area.

iii. The use of the selected inter-municipal disposal site for Asuncion and F.Mora was one of the alternatives for MSWM in the other 13 municipalities.

b. **Work Flow Diagram of the Examination of Technical System Alternatives**

The examination and selection works of the optimum technical system alternative were divided into three stages, i.e., stage A for the examination of technical system components, stage B for the selection of the optimum technical system alternatives for Asuncion and Fernando de la Mora and stage C for the selection of them for the other 13 municipalities. The study flow diagram of these works are shown in Figure H.2.3a.

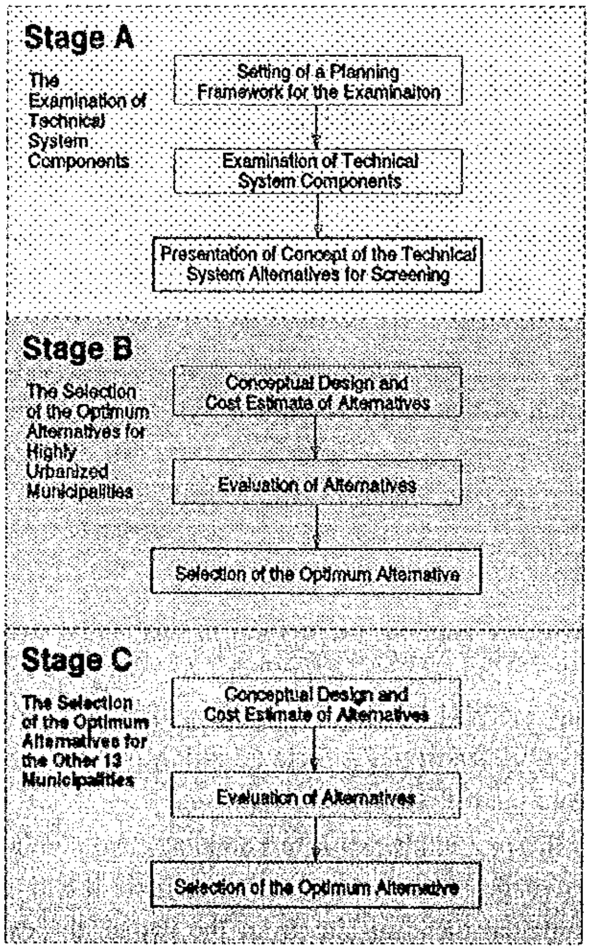


Figure H.2.3a Study Flow Diagram of the Examination of Technical System Alternatives

ba. Stage A : Examination of Technical System Components

baa. Setting up of a Planning Framework for the Examination

The planning framework, i.e. target year, future population, forecast on waste amount and composition, future economic and financial conditions, etc., was set up for the examination work. Based on additional data to be obtained during the progress of the study, the planning framework was partly modified for the preparation of the Master Plan.

bab. Examination of Technical System Components

The MSWM technical system consists of several sub-systems, i.e. collection, transfer, intermediate treatment, etc.. Each sub-system has various technical system components, e.g. incineration, composting, RDF (Refuse Derived Fuel), etc., for intermediate treatment. Various system components of sub-systems were examined and primarily screened for the comparison of the technical system alternatives.

bac. Presentation of technical system alternatives

After the examination of each technical system component, technical system alternatives for each municipality were presented combining the selected technical system components.

bb. Stage B : Selection of the Optimum Alternatives for the HUM(Highly Urbanized Municipalities)

bba. Conceptual Design and Cost Estimate of Alternatives

A suitable system of storage, collection, haulage, street sweeping, intermediate treatment and final disposal systems for each alternative were conceptually designed, and the cost incurred was estimated.

bbb. Evaluation of Alternatives

Evaluation of alternatives for selection was carried out by the least cost method. Because the implementability regarding the financial matter might have more priority than the other aspects if each alternative guarantees a certain level of environmental improvement. However, the approval of the optimum alternatives selected by the least cost method was subject to the decision done at the time of the IT/R (Interim Report) meeting. In the meeting, environmental, technical and social aspects of the alternative were be discussed.

bbc. Selection of the Optimum Alternative

As a result of the evaluation of alternatives including the policy making at the IT/R meeting, the optimum technical system alternatives for the MSWM master plan for Asuncion and F.Mora were selected.

bc. Stage C : Selection of the Optimum Alternatives for the Other 13 Municipalities

bca. Conceptual Design and Cost Estimate of Alternatives

Based on the results of the Stage B work, the suitable systems of storage, collection, haulage, street sweeping, and final disposal for each alternative were conceptually designed, and the cost incurred was estimated.

bcb. Evaluation of Alternatives

Evaluation of alternatives for selection was carried out by the least cost method as well as Stage B. The approval of the optimum alternatives was also subject to the policy making to be done at the time of the IT/R meeting.

bcc. Selection of the Optimum Alternative

As a result of the evaluation of alternatives including the policy making at the IT/R meeting, the optimum technical system alternatives for the MSWM master plan for the other 13 municipalities were selected.

H.3 Examination of Technical System Components

H.3.1 Discharge and Storage

The above said components of SWM system are closely related each other, and also they are closely related to the people's way of living. It is very difficult to replace an existing system with a new system, because there are too many factors to be taken into account for the formulation of the new system.

The system, which has been established already, generally comply with requirements of the Study area. As for the Metropolitan Area, the curb collection with the use of plastic bags (generally used ones) system, which has been established gradually, accumulating many minor adjustments appears to still function well. Consequently the examination is made for only applicability of various technologies.

a. Discharge

The waste discharge method is divided into two categories; mixed discharge and separate discharge.

In the Study area, only mixed discharge is being executed. According to our public opinion survey, almost 100% of citizens agree to cooperate with separate discharge system for resource recovery. The result of the public onion survey also presents that most people are very interested in environmental protection activities. The introduction of the separate discharge system will be recommended in future in case the introduction of a processing facility and/or recycling plant is feasible.

b. Storage

ba. Consideration for Storage

There is a wide range of issues to be considered in order to select the most appropriate storage equipment for a certain area. The examples are as follows;

- the quantity and composition of the waste generated;
- the number and composition of the waste components which the waste should be separated into;

- the collection frequency, most often determined by the climate in combination with the waste composition;
- the space available near the source and the accessibility of the collection vehicles;
- environmental and occupational health aspects;
- the adaptability in the actual environment, i.e., the function is consistent with the user;
- the ability to stand misuse, rough climate and animals (rodents etc.);
- the total investment and operational costs over given period;
- the habits and traditions of the users and the collection crews.

bb. Type of Storage Equipment

The storage equipment which can be used in the Study area is listed in Table H.3.1a. At present 50 to 100 liters plastic bags are being used mainly, and all the containers are steel.

Table H.3.1a Storage Equipment for Solid Waste

Type	Material	Size	Wheels	Lid	Applicable for	Truck
Bag	Plastic	50-100 l	no		Detached house	All
Container						
Small	Steel	1.1 m^3	Yes	Yes	- Core area	- Compaction truck
Middle	Steel	5-10 m^3	No	Yes/No	- Large producer	- Hoist truck
Large	Steel	15-30 m^3	No	Yes/No	- Large Producer & Transfer Operation	- Roll-on roll-off trucks

bc. Capacity

- waste generation rate: 0.894 kg/person/day
- average person: 4.6 person/household

0.894 x 4.6 = 4.1 kg/household/day

4.1 kg x 7/3 day / 0.2(ASG) = 48.0 say 50 l /household/week.

ASG : Apparent Specific Gravity

An average household waste discharge, 50 l per one collection time, was obtained by the 1st phase study. The present 80 – 100 l plastic bag is thereby considered to be a suitable size for a household under the three times a week collection frequency.

bd. Sanitary Aspect

The following properties are required for the waste storage equipment in terms sanitary aspect:

- cover is required
- capacity
- little noise
- safe structure
- easiness to keep clean

c. Conclusions

ca. For Residential Area

- In order to improve the collection efficiency and avoid littering due to animal scavenging, the installation of the waste stand shall be promoted.

- Regarding non-collection service area (e.g. urban fringe area) due to the deficiency of the accessibility of the collection vehicles, the introduction of the public container collection system shall be examined. In this system collection from each household to the public container shall be done by the residents or their community.

cb. For Commercial Area

- For the cleanliness of the central area of the cities, the introduction of public containers (1.0 m^3 to 1.5 m^3), which comply with the present compactor trucks, shall be examined.

- For large waste generation sources such as markets, container collection system shall be examined.

H.3.2 Collection and Haulage

The collection and haulage system is mainly composed of the following items:

- collection frequency

- mixed or separate collection
- collection system
- collection time
- collection vehicle
- haulage method
- transfer system

a. Collection Frequency

The collection frequency is determined by the sanitary aspects and cost. Although six times a week collection is desirable in summer in order to maintain sanitary conditions, three time a week collection is acceptable considering cost.

Organic waste should be collected more frequently than inorganic waste. The collection frequency should be determined by the waste composition in case of separate collection will be introduced because the required collection frequency highly depends on the waste composition.

b Mixed or Separate Collection

Separate collection requires people to give more cooperation of source segregation and mixed collection does not give people any more endeavor. However, separate collection can contribute to make more effective recycling and resource recovery. The separate collection system is recommended in case the introduction of a recycling and/or processing facility is feasible. However, it must be reminded that the success of implementation of separate collection highly depends on public cooperation.

c. Collection Service

ca. Type of Collection Service

The following types of collection services for households can be applied to the Study area:

- curb collection;
- alley collection;
- setout–setback collection;
- setout collection;

– backyard collection; and
– bell collection.

The characteristics of these collection services are described as follows:

caa. Curb Collection

The householder is responsible for placing the containers at the curb on collection day and for returning the empty containers to their storage location until the next collection.

cab. Alley Collection

Where alleys are part of the basic layout of a city or a given residential area, alley storage of containers used for solid wastes is common.

cac. Setout-setback Collection

Containers are set out from the premises and set back after being emptied by additional crews that work in conjunction with the collection crew responsible for loading the collection vehicle.

cad. Setout Collection

Setout collection is essentially the same as setout-setback collection, except that the householder is responsible for returning the containers to their storage location.

cae. Backyard Collection

The collection crew enters the premises and collects the wastes form their storage location.

caf. Bell Collection

The collector calls out to the residents to discharge their waste when a collection vehicle arrives at a certain collection point.

cb. Selection of Collection Services

The curb collection with waste stand is very common in the Study area. However, the curb collection system with the use of plastic bags without waste stands causes animal scavenging and waste littering, thus creates unsanitary condition and ugly view. On the other hand, the curb collection gives high collection efficiency.

d. Collection Time

Traffic congestion is very common every weekday in the downtown area, and it is disturbing efficiency of waste collection work. Night collection is thereby carried out. The night work, however, should be limited within the commercial and business area.

e. Collection Vehicles

ea. Type of Waste Collection Vehicles

The 3 types of vehicles for waste collection services are as described below.

- compaction type;
- detachable container type (roll-on roll-off & hoist type); and
- standard type (dump truck and flat bed truck).

eb. Comparison of Waste Collection Vehicles

The three types of waste collection vehicles, as shown in Figure H.3.2a, are compared in Table H.3.2a in terms of their advantages and disadvantages.

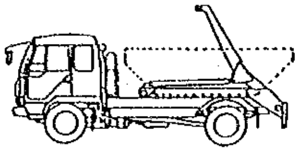
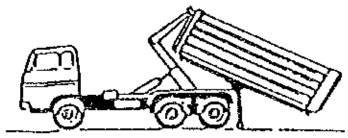
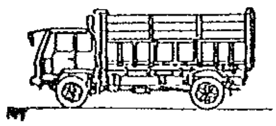
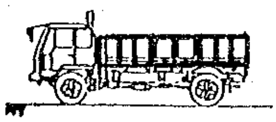
Type	Truck	
Compaction	Compactor Truck	
Detachable	Hoist Truck	
	Roll-on Roll-off Truck	
Standard	Dump Truck	
	Flat Bed Truck	

Figure H.3.2a Type of Waste Collection Vehicles

Table H.3.2a Comparison of Waste Collection Vehicles

Advantage	Disadvantage
Compaction Type	
- Highest waste loading factor - No waste scattering during transportation - Ease in discharge	- Complicated maintenance procedure - Most expensive - Incapable of loading bulky waste
Detachable Container Truck	
- Relatively easy maintenance - Ease in discharge - Container can be used as collection box - Highest collection and haulage efficiency	- Highest purchase cost due to large number of containers required - Wastes scattering possibility during transportation, if the open type container is used - Difficult to load bulky wastes
Standard Truck	
- Ease in maintenance - Ease in operation - Ease in discharge - Capable of collecting bulky waste - Cheapest - Compatible with present collection system, and relatively simple in operation - Multi-purpose	- Low waste loading factor - High possibility of waste scattering during transportation, if the open type truck is employed - Possibility of being used for other purposes

ee. Selection of Suitable Refuse Collection Vehicles

Although there are three types of vehicles in the Study area, the compaction type is very common in the highly urbanized municipalities and the regular type is common in the other municipalities. It is generally recommended that the suitable refuse collection vehicles are to be selected as follows:

i. For urbanized municipalities, the compactor type is recommended.
ii. For less urbanized municipalities, the regular type is useful due to the small collection amount, easy maintenance, flexibility of use and cheap price.
iii. For large generation sources, the detachable container type is suitable due to the efficiency of the collection and loading work.

f. Haulage Method

There are four kinds of haulage methods in principle as shown below;

- motor vehicle haulage,
- railway haulage,
- water haulage, and
- pneumatic and hydraulic methods.

In order to combine the above-mentioned methods, a transfer station is sometimes installed.

fa. Motor vehicle haulage

The motor vehicle is the most common means of transportation for solid wastes all over the world. The refuse trucks are classified into three categories as follows:

- compaction truck
- detachable container truck
- standard truck

The present motor vehicle haulage system has a very wide range of applicability. This applicability can be widened by combining various kinds of refuse trucks properly.

fb. Railway Haulage

Although railways were commonly used for the transport of solid wastes in the past, they are now used by only a few cities. However, renewed interest is again developing in the use of railways for hauling solid wastes, especially to remote areas where highway travel is difficult and railway lines now exist, and where railways own property or adjacent land for filling is available. As for the Study area, it is not possible to transport wastes to the Chaco area by using existing railway systems.

Advantages;

- large haulage capacity
- haulage cost per km is cheap

Disadvantages;

- two transfer stations are necessary at loading and unloading points.
- inter-municipal cooperation is essential.
- less flexibility.

fc. Water Haulage

Barges, scows, and special boats are being used to transport solid wastes. Wastes are gathered at a transfer station with refuse trucks and loaded on the boats for water haulage.

Advantage;

- large haulage capacity
- haulage cost per km is cheap

Disadvantage;

- two transfer stations are necessary at loading and unloading points
- difficulty under the bad weather
- less flexibility

This method is ordinarily used for sea transportation and for sea reclamation disposal site. Since there is a large river in Paraguay between Asuncion metropolitan area and the Chaco, it seems to be feasible to introduce a water haulage system. However, we do not recommend the water haulage system due to the following reasons:

- There is a good highway access including the bridge over the Rio Paraguay to the Chaco. This access is being improved by the Government.

- The candidate sites of the Chaco area selected by the Supervisory Committee was far from the river coast.

- The water haulage system requires loading and unloading facilities and transfer vehicles, thus it needs a certain amount of capital investment.

fd. Pneumatic and Hydraulic System

Both low-pressure air and vacuum conduit transport systems have been used to transport solid wastes. The most commonly used system is the transport of wastes from high density apartment or for loading into transport vehicles.

From a design and operational standpoint, pneumatic system are more complex than hydraulic systems because of the complex control valves and ancillary mechanisms that are involved. The necessity to use blowers or high speed turbines further complicates the installation from a maintenance standpoint. Because installation costs for such systems are quite high, they are most cost-effective when used in new facilities.

The concept of using water to transport wastes is not new. Hydraulic transport is now commonly used for the transport of a portion of food wastes (where home grinders are used). One of the major problems with this method is that ultimately the water used for transporting the wastes must be treated. As a result of solubilization, the organic strength of this waste water is considerably greater than that of other domestic waste water.

These methods have never been operated in the wide scale. The initial investment is very large and O & M cost is also high. This method should be limited to areas with high waste generation density.

g. Transfer Station

ga. Introduction

Transfer and transport operations become a necessity when haulage distances to available disposal sites or intermediate treatment plant increase to the point that direct hauling is no longer economically feasible. Transfer operations and the introduction of transfer stations are necessary in the case where the following is observed;

- The location of disposal sites is relatively far from collection routes (generally more than 20 km).
- The use of small-capacity collection trucks (generally under 15 m^3).
- The widespread use of medium-sized containers for the collection of wastes from commercial sources.
- The use of hydraulic of pneumatic collection systems.

gb. Necessity of Transfer System

The distance from the core collection area to the proposed disposal sites in the Chaco is more than 20 km. Therefore, it is dispensable to examine the introduction of the transfer system for motor vehicles.

h. Conclusions

ha. Collection frequency

Basically, the present frequency, i.e. everyday except Sunday for commercial area and three time a week for residential areas, shall be applied in future.

hb. Mixed or separate collection

The introduction of the separate collection system is recommended in case the introduction of a recycling and/or processing facility is feasible. The source separation for the recyclable materials is promoted. The collection of the recyclables from the sources, however, shall be done by private sectors.

hc. Collection service

The present curb collection with waste stands shall be continued in future. However, the introduction of the container collection shall be examined for the commercial area.

hd. Collection vehicles

The appropriate collection vehicles shall be selected basically according to the following criteria:

- For highly urbanized and urbanized municipalities, the compactor type is recommended.
- For less urbanized municipalities, the regular type is useful due to the small collection amount, easy maintenance, flexibility of use and cheap price.
- For large generation sources, the detachable container type is suitable due to the efficiency of the collection and loading work.

he. Haulage method

The present motor vehicle haulage method shall be applied in future.

hf. Transfer station

The introduction of the transfer system for motor vehicles shall be examined.

H.3.3 Street Sweeping

a. Introduction

Street cleaning is one of the most visible of all governmental activities. Consciously or not, residents allow their opinions of the effectiveness of street cleaning programs to influence their feelings toward their municipalities and local officials. Visitors may instinctively rate municipalities on this cleanliness before they learn anything else about them. Such opinions can help to shape a community's future. Street cleaning has been associated primarily with aesthetics.

The major goal of street cleaning programs has been to remove litter and dirt so that streets appear presentable and traffic will not create dust. In some areas particularly, regular street cleaning is necessary to prevent sewers from becoming clogged. Knowledgeable officials now recognize the pollution potential of particulate matter when washed into sewers.

Municipalities must balance the costs of adequate street cleaning and effective litter control programs, improved sewer operations, safety of pedestrians and vehicle occupants, reduction of air and water pollution, and economic development. Public education, however, will not eliminate all street litter. Debris also accumulates from air pollution fallout, animals, oil drippings, parts dropped from vehicles, spillage from solid waste collection and mud tracked onto pavements from this dirt and debris.

b. Street Cleaning Methods

As practiced today, street cleaning methods may be grouped conveniently under these general headings:

- manual cleaning.
- mechanical cleaning.
- vacuum cleaning.
- flushing.

ba. Manual Street Cleaning

Manual street cleaning is by far the oldest method. And although it has been widely replaced by mechanical methods, it still retains certain advantages, as follows:

Advantages;

- creation of a large number of job opportunities,
- low capital cost,
- great flexibility of operation,
- applicable to the work where the debris, accumulates most frequent ly,
- to clean beneath parked vehicles,
- to clean under subfreezing weather,
- to clean on rough cobble stone pavement,
- low operation noise.

Disadvantages;

- high labor cost,
- difficulty of supervision,
- danger under heavy traffic condition.

The equipment required for manual sweeping is simple and inexpensive. Sweepers use stiff bristled push brooms and wheeled carts carrying barrel-like containers, shovels, and possibly a few other tools for special tasks. Motor scooters have sometimes replaced push carts for certain manual cleaning assignments.

bb. Mechanical Cleaning

Mechanical cleaning is a cleaning method to utilize various sorts of machines as much as possible.

Advantages;

- great productivity,
- low manpower,
- safety on work.

Disadvantages;

- high capital cost,
- low flexibility of operation,
- difficulty of work in narrow areas,
- big operation noise,
- difficulty of work under heavy traffics.

bc. Vacuum Cleaning

Vacuum street sweeping appears to be increasingly attractive because it minimizes water pollution by removing more of the fine dust on the street as well as the larger debris. The flicking action of the broom is not as effective on fine materials as is the vacuum. Mechanical sweepers are designed to remove the larger debris; they do so in commendable fashion when the operator is capable and conscientious.

Vacuum units can also pick up larger debris, ranging from cigarette butts to beer bottles at operating speeds of 25 miles per hour. Vacuum units also use gutter brooms to loosen and deflect debris so it can be picked up. They also have an additional broom to withdraw the dirt which may or may not be used in picking up debris. 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 cleaning capability,
- no harm to sewage pipes by dust,
- less dust.

Disadvantages;

- high capital cost,
- low flexibility of operation,
- difficulty of work in narrow areas,
- big operation noise,
- difficulty of work under heavy traffic.

bd. Flushing

Street flushers hydraulically move debris from the street surface to the gutter. Since disposing of street dirt in sewers and catch basins is regarded with increasing disfavor because of its pollution effects, several municipalities now flush only to aid sweeping and not as the sole method of cleaning. Flushing before sweeping washes street dirt to the curb for collection by motorized sweepers. This type of flushing ordinarily employs smaller quantities of water and lower nozzle pressures, which also minimizes splashing pedestrians and vehicles, to keep the dirt from flowing into the inlets. The benefits of flushing after sweeping are that the entire pavement is made cleaner and that only small quantities of dirt are washed into inlets and catch basins.

Advantage;

- no dust.

Disadvantages;

- necessity of a large amount of water,
- clogging of sewage pipes,
- danger in winter,
- low flexibility of operation,
- difficulty of work in narrow areas,
- difficulty of work under heavy traffic.

c. Conclusions

It appears to be very attractive to introduce mechanical and/or vacuum cleaning machines. However, the present manual sweeping system is more suitable under the condition of high unemployment ratio in the study area. We did, therefore, not plan to introduce any mechanical and/or vacuum sweeping machine in this study.

H.3.4 Intermediate Treatment (Processing and Recycling)

a. Intermediate Treatment System

A technical system of MSWM consists of 3 main sub-system, i.e., collection and haulage system, intermediate treatment system and final disposal system. The intermediate treatment system requires not only the highest technology but also considerable amount of construction cost and O & M cost. In addition, the intermediate treatment system is not indispensable in MSWM, while the other two sub-systems are so. The construction of an intermediate treatment facility is often the biggest investment project in a local government. It is, therefore, very important to carefully examine the introduction of an intermediate treatment facility to a local government.

As for the intermediate treatment technology, there are various processing and resource recovery (including recycling) facilities as shown in Figure H.3.4a. In this section, the following intermediate technologies are examined and primarily screened for the comparison of the technical system alternative;

- incineration;
- composting;
- RDF;
- pyrolysis;
- ash solidification;
- biogas;
- size reduction (crushing and shredding); and
- sorting.

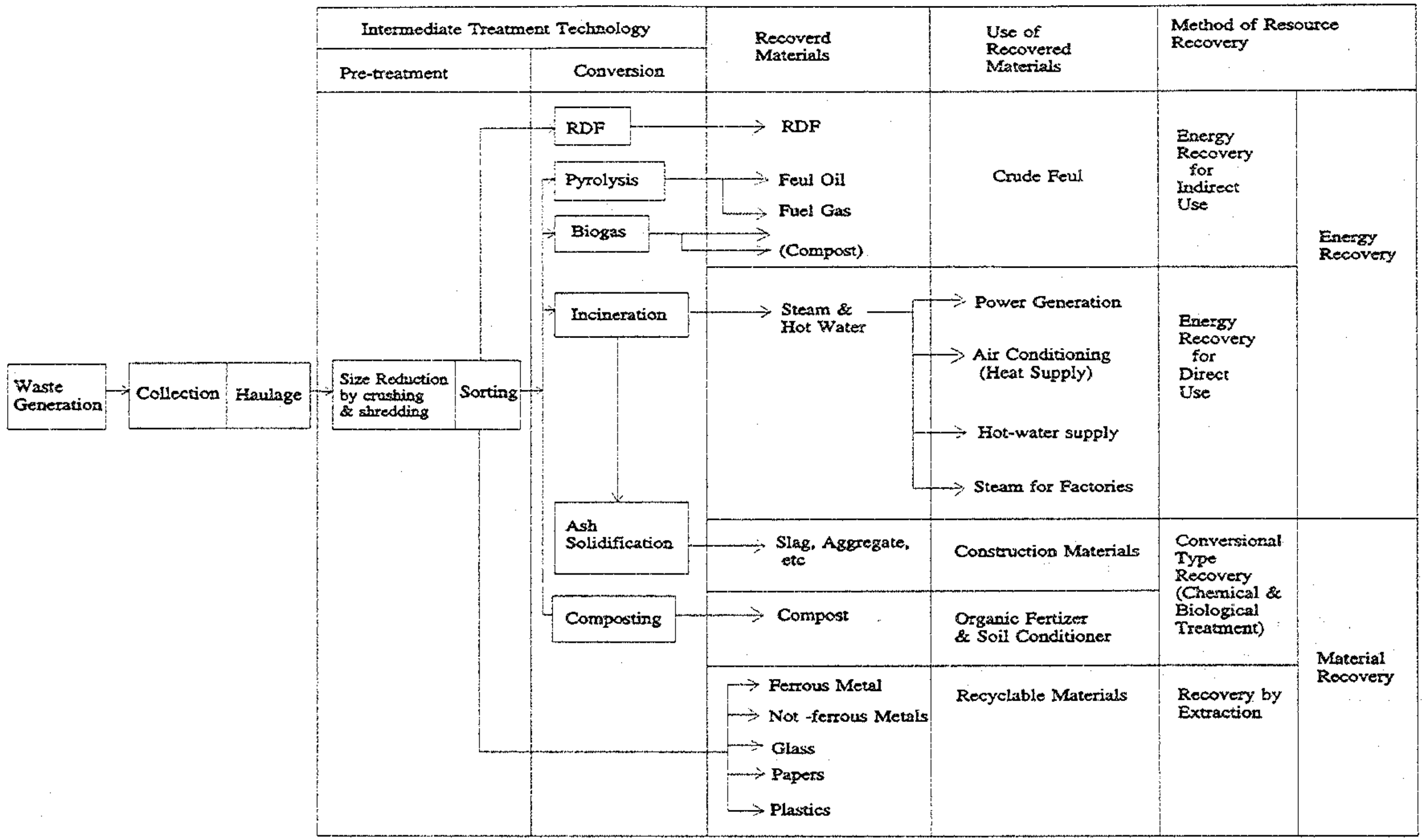


Figure H.3.4a Intermediate Treatment Technologies and Resource Recovery Methods

b. Characteristics of Each Technology

ba. Incineration

baa. Introduction

Incineration of municipal solid wastes is one of the most popular method for processing wastes in developed countries recently. The Waste is converted into mainly stable gaseous oxidizes and partly stable inorganic matters by the high temperature of combustion. Generally, incineration makes the biggest volume reduction of wastes among various intermediate treatment technologies and it also achieves stabilization of putrescible organic wastes.

A general observation would indicate that incinerators may be feasible where land available for landfilling is scarce, expensive or very remote from the actual solid waste generation center.

Modern incineration and flue gas cleaning technology makes waste incineration an environmentally acceptable form of waste treatment and makes it possible to locate plants even in densely populated areas.

bab. Components of an Incinerator

A modern incinerator consists of a number of basic components. Typical of these will 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 in recent years in favor of continuous feed methods.

bac. Movable grate (stoker) incinerator

A movable grate (stoker type) incinerator is the most widely used modern incinerator and the best tested technology for the thermal treatment of waste.

Various grate designs are in use for refuse burning. Each of these design functions to perform a number of tasks. A grate is designed to satisfy the following objec–

tives:

- to provide support for the refuse;
- to distribute air through grate openings;
- to transport the refuse from feed chute to ash quench;
- to agitate the bed to break up clumps; and
- to redistribute the burning mass.

bad. Fluidized bed incinerator

A major new development in refuse burning involves the application of fluidized–bed technology. Fluidized–bed incineration has been employed to some extent. High heat transfer and reaction rates achieved in such a unit have demonstrated favorable characteristics for the incineration of refuse with good burnout of residue. Construction cost and power consumption of this type incinerator are generally higher than other conventional types.

bae. Residue disposal

After combustion, there still will remain some residue, consisting of small fractions of both little combustible and non–combustible items.

Residue disposal is most generally accomplished by landfilling. When deposited at the landfill, cares should be taken in the same manner as raw wastes.

baf. Heat utilization

The heat utilization of municipal refuse incineration plants is very common and a significant element of waste incineration. The heat is used for power generation, district heating and cooling, hot water supply, followed by welfare facility for dwellings and direct steam supply to industries.

bag. Construction, maintenance and operating costs

A major factor contributing to the disfavor of incineration as an economical disposal solution is the high capital requirement. Total capital requirement per ton will generally decrease with increasing capacity, however, unit values are typically higher than other disposal alternatives, especially sanitary landfilling. Therefore, detailed cost evaluation have to be made on the construction cost, annual running and maintenance cost, versus expected income which could be obtained from the supply of electricity or heat.

bah. Advantages and disadvantages

Basic advantages are;

i. The system has wide range of availability. Almost all kind of waste except bulky inert materials can be treated.
ii. High reduction in bulk volume and weight and lower transportation costs due to possible location near cities and landfill requirements.
iii. Hygienic way of treating waste.
iv. Revenue will be expected from the sale of surplus electricity by means of power generation in the plant (in case of high calorific value of waste).

Disadvantages of incineration include:

i. Considerable investment costs and high operation and maintenance costs.

ii. Residues may have a higher concentration of heavy metals and other hazardous items.

bb. Composting

bba. Introduction

Waste composting is a method which achieves microbial degradation of organic matter, to produce a recycled organic product for use in gardens, parks, horticulture and so on.

Waste composting can be applied to household and vegetable wastes, garden wastes including branches and litter.

Composting technology is divided into two main categories, i.e., on-site composting and composting plants. These are the following composting plants.

- windrow type;
- high-rate composting type;
- modified landfill employing in-place composting; and
- biogas and compost production.

bbb. Composting technologies

i. on-site composting

On-site composting is the simplest possible composting technique and is carried out at each generation source (mainly each household) and it requires;

- the sorting of organic wastes in the kitchen; and
- the provision of a standard model compost container for each house hold.

Containers can be made of recycled plastics and constructed so as to allow air to enter in the bottom through simple holes, and with simple air outlets in the top.

ii. windrow type

Numerous windrow type plants were constructed throughout the world during this century, in which several types of turners have been designed to turn windrows or compost stacked over a wide area. In the last two decades, windrow composting has gained acceptance in Europe, especially for making compost from garden wastes.

Windrow composting is the conventional process of composting, used for unsorted or sorted and sieved organic wastes.

The process may be equipped with different pre-and post-treatment machinery devices to:

- prevent the input of undesirable metals, etc.;
- break large components into smaller fragments as to make it compostable;
- sort incoming materials depending on density;
- give a biological pre-treatment as mentioned above;
- aerate the windrows;
- sort the compost product, to recirculate larger fragments, or to send them for incineration; and
- fill up bags and sacks for sale.

iii. high-rate composting type

High rate composting system consists of various equipment, devices, etc., (with a unit operation) in order to perform the function of composting treatment, regardless of its method or size. This system has functions of feeding principally sorted and collected solid wastes, shredding, sorting and adjusting wastes in the equipment, fermentation, maturing and post-treatment then taking out refined compost and residue continuously and smoothly.

Composting operation must be kept at a constant condition so that oxygen amount, temperature, moisture, and C/N ratio, etc. can be easily controlled and secondary pollution especially offensive odor can be prevented securely. High-rate composting plants can be located at the urban areas with the environmental protection facilities such as a deodorant facility.

iv. modified landfill employing in-place composting

This process has been recommended as the lowest cost composting method yet available today. Essentially the process calls for pre-shredding of refuse and placing it in a sanitary landfill without cover. Composting may be conducted by the use of forced air blown through pre-laid, low-cost, four inch corrugated polyethylene pipes. Pre-shredding can be accomplished either centrally or with a rotor shredder on site. The cost of the stabilized refuse is approximately the same as or slightly more than a sanitary landfill, but there are the advantages of; (1) no cover, (2) less water pollution, and (3) approximately one-third of the landfill area required due to digestion and greater compaction. The end product can be dug out and sold if a market exists thus making room for more material. The filled area can be reused, making the pile deeper with a second and a third layer possible.

bbc. Value of organic matter, utilization and marketing.

Organic composts used as low-grade fertilizer or soil conditioner have a real benefit to most soils but particularly heavy clays or loose sand where its usage can increase crops.

The need for organic matter in the soil can be summarized as follows;

- improvement of physical character of soil;
- increase of moisture holding capacity;
- reduction of chemical fertilizer leaching especially nitrogen and phosphorous; and
- stimulation of healthy root growth.

bbd. Advantages and disadvantages

Composting system has several advantages and disadvantages. Advantages are as follows:

i. Compost product by waste are used as organic fertilizer and soil conditioner, i.e. recycling of nutrients.
ii. A certain quantity of reusable material can be recovered at the

pretreatment stage.

iii. A certain quantity of reduced waste volume at landfill is expected.

Disadvantages are as follows:

i. If composting is not preceded by any sorting, the compost produced will contain potentially polluted materials, making it less usable or even unusable for land and garden use.

ii. The recovery rate of compost product is not high (normally 35% of total waste weight). Rejected materials have to be hauled to the landfill site again.

iii. Reduction of waste volume can not be expected compare with incineration system.

iv. Quality of waste suitable for composting is very limited. Therefore in order to collect the above material for compost, modifications of existing systems for collecting and hauling may be required.

v. Efficiency of compost system is not enough, therefore:
   . It takes a long time for fermentation.
   . Wide stock yard for fermentation and storing the compost product will be required.

vi. Compared with chemical fertilizer, compost have the following inconveniences due to the amount of volume for the use of fertilizer.
   . high transportation cost.
   . difficulty for spreading in plantation.

vii. Generation of offensive odor has to be avoided.

bc. RDF (Refuse Derived Fuel)

bca. Introduction

RDF (Refuse Derived Fuel) is based on replacing e.g. coal in a conventional power or district heating plant by pellets made of waste.

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 trommel before shredding. This trommel 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 noncombustible 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 can be burned as a primary fuel in a specially designed boiler.

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

- Occupational health problems at the plants specially at manual sorting lines.
- 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.
- The need to alter the combustion conditions of conventional boilers and burners if a significant amount of RDF is to be burnt.

The following are different kinds of RDF:

- fluff-RDF
- densified-RDF
- dust-RDF
- wet-RDF

bcb. Advantages and disadvantages

- Advantage is:

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

- Disadvantages are:

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

bd. Pyrolysis

bda. Introduction

Recently, considerable attention has been given to pyrolysis in providing means of recycling municipal solid wastes. 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 total, 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–polluting intermediate system for wastes.

bdb. Advantages and disadvantages

Pyrolytic processing operations have certain advantages and disadvantages. Among the advantages are:

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

Basic disadvantages are;

i. Large capital investment and high operation cost.
ii. The nature of oil or gas obtained from the facility is still in insufficient for commercial use, therefore the market is limited to in–plant use only. For purifying the oil or gas, high cost have to be consumed, therefore it is not effective regarding their cost.

bdc. Notes

i. In Japan, the first commercial pyrolysis gasification plant which has 450 tons/day capacity commenced operation in 1983. However, due to several accidents caused during its operation, many revisions or improvement work were made to this plant. Although the plant is still in operation, it is said that a large scale basic improvement plan is now under way due to the unfavorable reasons, such as the lack of energy recovery benefit, complexity, high waste treatment cost, etc..

ii. The present situation on the pyrolysis technology in the United States indicates:

"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."

be. Ash Solidification

bea. Introduction

Besides increase in the quantity, refuse of the present day is diversified quality-wise. Even after complete incineration, there still remains a large quantity of substances which can not be treated such as incineration ash and sludge from discharged waste water treatment. For heavy metals, in particular, fundamental solution is desired because of the environmental problem at the places of disposal and difficulty to acquire a land for disposal.

Ash solidification technology is developed so as to dissolve and solidify such substances by high temperature or to change into solid concrete by using cements and other bonding agents.

bdb. Advantages and disadvantages

As for the melting treatment system, there are following advantages:

i. If the system is combined with an incineration, waste volume reduction in this system is 95 to 97%. Then, it is considered to have the best reduction effect compared with any other treatment systems.

ii. The fritted, glassy aggregate obtained from this plant is completely sterile, therefore, the problems of leachate from the landfill site for the residue of the plant is not to be considered.

Further efforts to develop a useful end-use are being followed as to concrete aggregate, building blocks, road way base and filter base.

iii. As heavy metals are sealed into slag under stable condition, there is no flow-out yet. Turning into a resource is also possible.

Disadvantages are;

i. Large capital investment cost.
ii. The technology at its developing stage.
iii. High operation cost. Inert materials contained in wastes have to be melted into molten slag, therefore, a large amount of additional fuel is required leading to high operation costs.
iv. Difficulty of operation. It is rather difficult to keep a stable and continuous operation. In this system, skilful operators are required.

bf. Biogas

bfa. Introduction

Biogas is produced when organic material decomposes under anaerobic circumstances. 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.

A biogas plant consists of a reception and pre-treatment part, a process part, and post-treatment part including stock facilities. In the process part the organic material is transformed into carbohydrate, 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 including hydrogen to methane.

Biogas can be utilized both for heat and power production. The residues are compost and can be utilized as soil improving agent.

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.

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

- organic wastes from households, including meat and vegetables
- flowers, including herbaceous 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

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

It has to be started, that this type of waste processing technology is rather new, which means, that it has not been possible to find experience from plants, which have been working for more than a few year. On the other hand, plants for agricultural and industrial purposes are well documented and reliable.

bfb. Advantages and disadvantages

Advantages are;

i. resource recovery of wastes into potentially useful products, i.e., methane gas and compost;
ii. minimal potential soil, water and ground water pollution; and
iii. possible location near urban areas.

Disadvantages are;

i. high investment cost;
ii. only few years operational experience of municipal wastes;
iii. transportation costs; and
iv. requirement of pre–sorting of organic wastes.

bg. Size Reduction (Crushing and Shredding)

bga. Introduction

A size reduction facility, which normally has crushing and shredding functions, is generally used as a pre–treatment facility for an incineration plant, composting plant and other intermediate treatment facilities, and also used in order to improve sanitary landfill operation.

As for shredding for sanitary landfill, it reduces the volume waste carried into the final disposal site. The shredded waste, as compared with the non-shredded one, will be settled more quickly when used for a sanitary landfill. The land users near the sanitary landfill make little complaint about the landfill, because the landfill work progresses sanitarily. In addition, fewer fires will break out during the landfill work. Fewer rodents and insect hatches will require less insecticides and rat poison.

The shredded wastes causes less damage to the landfill equipment and trucks for the sanitary landfill work than the non-shredded waste. The shredded waste settle less than non-shredded ones because of its high compaction ratio.

The term "crushed" has various meanings, i.e., shredding, milling, pulverizing, grinding, cutting, tearing, ripping, etc., for which appropriate machines are developed, respectively. For example, an ordinary hammer mill where 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 pulverized by shear force of the cutting board.

The grindability depends upon the substances to be crushed, and the size required for the purpose of each treatment system. The pulverizing process will be accompanied with sieving, if necessary.

bgb. Advantages and disadvantages

Several advantages can be described and they are as follows;

i. Shredding and crushing (size reduction) contributes to the work efficiency of the other intermediate treatment facilities;
ii. Shredding and crushing is well adapted to the local conditions and intended plans because (1) shredding reduces volume by about 50 percent thus making transportation by truck easier and more efficient, and (2) shredded waste spreads more easily. Shredded waste is compacted better in the sanitary landfill and thus takes up less space making the landfill area last longer.
iii. Shredding and crushing makes more compact and ultimately a more stable sanitary landfill and hence, the ultimate value of land after filling would be great.
iv. Since shredding and crushing facilitates more compaction of the waste,

here have been less fire on such operations particularly if solid waste disposed receives a final cover. In addition, problems of flies and rodents would be greatly minimized.

v. Shredding and crushing definitely increases compaction thus making landfills denser and reduces the percentage of settlement.

Shredding and crushing have the following disadvantages:

i. The use of the rotary type hammer crusher consumes large quantity of electricity as it usually requires a high power electric motor.

ii. Damages due to explosion caused by flammable matter contained in waste might occur frequently. Therefore, strict checking and sorting out of dangerous substances have to be done.

iii. According to tremendous wear of mechanical parts such as hammer beaters, shear blades, etc., frequent maintenance work, repairing or replacement of damaged parts shall be necessary.

bh. Sorting

bha. Introduction

An important point to be considered in both the treatment and disposal is that a system for recovery of resources such as paper, glass, metal, plastics, etc., must be provided in the early stage of planning. The most desirable method is a system which allows as many kinds of waste as possible at the lowest cost, and not causing any secondary environmental pollution.

The lay-out of sorting plants and the specific operational requirements vary between plants, but the plants in general serve one of two purposes;

- To salvage recyclable materials from the waste stream in order to increase the amount of recycling (Positive sorting). The reject is disposed of at a landfill or incinerated.

- To separate unwanted materials from the waste stream before further processing (recycling, incineration, composting etc.) (Negative sorting).

Furthermore, as the incoming waste usually has to be separated at source before coming to the plant, the plant will act as a control unit for the quality of the collection system and source separation.

Based on the above the following types of sorting plants are most relevant:

- Sorting of source separated wastes;
- Sorting of waste before incineration;
- Sorting of waste before composting;
- Sorting of building and demolition waste;
- Sorting of bottom ash from incineration.

However, it shall be stressed that the market price for the output material in combination with the quality of the input material are the determining factors for the economic viability of the plant.

bhb. Type of salvage process

The major purposes of salvaging are to recover valuables. For metal, nonferrous metal, paper, cardboard, glass, plastics, rag, leather, etc., to be recovered as valuables, a dry classifier which uses wind power, magnetic separator vibration, and human power are mainly used in accordance with each characteristic of the valuables. Dry classifying is usually performed in air. In addition to this method, available are the wet classification by means containing liquid and the semi-wet classification by means containing of less liquid. Both the dry classifier and the wet classification have a wide range of application in accordance with their characteristics. Various sorting methods are described in Table H.3.4a.

Table H.3.4a Sorting Methods

Mechanical or Manual	Dry or Wet	Classification	Sub-classification
Mechanical Sorting	Dry Classification	Mechanical Type	- Vibrating sieving - Trommel - Brush
		Wind Power Type	
		Magnetic Type	
		Electric Type	- Electrostatic Method (for non-ferrous metals)
		Optical Sorting (for glass)	
	Wet Classification	Mechanical Type (Semi-wet)	
		Water Power Type	
		Heavy Liquid Type	
Manual Sorting			

bhc. Advantages and disadvantages

Advantages of sorting systems are:

i. With the adoption of sorting devices such as pneumatic, mechanical, magnetic, etc., sorting out operation is executed effectively under hygienic environmental condition.
ii. Many sorting systems are relatively simple and easy to operate. Further-more, technically those devices are stable.
iii. Investment cost, utility cost and maintenance cost are usually cheaper than other systems.

Disadvantages are:

i. The suitable wastes to sort in this system are generally limited to such waste that are relatively dry and with rich inert material content. Therefore not so much contribution will be expected for waste volume reduction.
ii. Objects rejected after usable materials are sorted have to be hauled to landfill site again.
iii. Generally, quality or purity of materials which are obtained by mechanical separation device is insufficient, compared with manual sorting. For example, light fraction such as plastic films and papers are recovered as a mixture by pneumatic device. Each fraction can not be completely separated though because the specific gravity of both materials is almost equal to the specific weight, thus the market price will be reduced.
iv. As for manual sorting, a waste contaminated with other kinds of waste often will result in unacceptable working conditions for the personnel on a sorting plant.

c. Examination of System Components

Generally, the possibility of introducing appropriate intermediate treatment facilities must be examined because the acquisition of new disposal sites is becoming increasingly difficult and that better environmental conservation measures should be introduced.

ca. Selection criteria for intermediate treatment

The following criteria are considered in the selection of possible intermediate treatment

i. volume reduction of solid waste

The facility should be capable of reducing the solid waste volume for final disposal, thereby contributing to extend the life of disposal sites.

ii. resource recovery

The facility should assist the recycling of resources.

There are two ways of resource recovery from solid waste. One is the extraction of economically usable materials from solid waste, and the other is the extraction of energy from waste.

iii. protection of environmental pollution

The facility should contribute to the improvement of environmental conditions.

cb. Possible intermediate treatment

In response to the above-mentioned criteria, the following intermediate treatment systems are discussed in this report:

- incineration;
- composting;
- RDF;
- pyrolysis;
- ash solidification;
- biogas;
- size reduction (crushing and shredding); and
- sorting.

Each system can be employed independently or jointly, and has advantages and disadvantages. It is, therefore, important to select an optimum system or an optimum combination of systems, taking the following points into account:

- construction, operation, maintenance and repair cost
- acceptability of various kinds of wastes
- volume reduction effects for final disposal
- marketability and price stability in markets of recovered materials
- ease in operation

- reliability and stability of treatment plants (degree of technical development and operation results, etc.)
- impact on surroundings and its intensity
- simplicity in design of plants (pre–treatment, back–end treatment, etc.)

Table H.3.4b shows characteristics of possible processing systems.

cc. Relationship between intermediate treatment systems and solid waste quality

The processing systems should be selected according to qualities of waste. Table H.3.4c shows the general characteristics of various kinds of solid wastes (percentage of organic materials, water content, inorganic materials and calorific value), and types of wastes most effectively treated by the respective processing plants.

Each intermediate treatment technology and its characteristics are described below;

i. incineration

Suited for a wide variety of waste except for incombustible bulky waste. Waste from hospital and carcass are low in calorific values. However, they should be incinerated in a special furnace for sanitary purposes.

ii. composting

Generally, suited for domestic waste (especially garden wastes), other similar types of waste and some kinds of commercial waste.

iii. RDF

Commercial waste especially rich in paper content might be processable.

iv. pyrolysis

Limited only to waste with low moisture content and high calorific value.

v. ash solidification

Suited for ash including inert materials.

Table H.3.4b Examination of Intermediate Treatment Technologies

ITT	Recovered Material	Main Target of System	Contribution to Landfill			Special Cautions									Remarks
			Volume reduction	Harm-less	Stabi-lization	Stabil-ity of Tech-nology	Pretreatment	Post treatment	Rejected Sub-stances	Accept-ability of Refuse Quality	Construc-tion Cost (us$/ton)	Market-ability of recovered Material	Envi-ronmen-tal Impact	
Incineration	Heat/or Electric Power	Volume Reduction & Energy Conversion	B	B	B	A	Not Necessary	Not Necessary	Noncom-bustibles	A	82,200*1	(Electricity or Heat) C	B	-Initial/Running Cost -Possibility to find User of Heat
Composting	Compost	Conversation to Fertilizer	C	C	C	A	Necessary	Necessary	Glass, Stone, Plastic, etc.	C	46,000*2	C	C (Odor)	-Stability of Market for Products
RDF	Solid Fuel	Conversation to Fuel	C	C	C	C	Necessary	Necessary	Noncom-bustibles	C	N.A.	?	C (Noise & Dust)	-Marketability of Prod-ucts
Pyrolysis	Gas or Oil		B	B	B	C	Necessary	Necessary	Noncom-bustibles & Carbon	C	N.A.	X	B	-Incompletion of Technology -Initial/Running Cost
Ash Solidifica-tion	Slag	Volume Reduction & Prevention of Water Pollution	A	A	A	C	Occasionally Necessary	Not Necessary	None	B	N.A.	?	B	-Large Consumption of Supplemental Fuel -Difficulty of Operation
Biogas	Gas & Compost	Conversation to Fuel & Fertilizer	C	C	C	C	Necessary	Necessary	Glass, Stone, Plastic, etc.	C	97,500*3	C	B	-Stability of Market for Products
Crushing & Shredding	Ferrous etc.	Volume Re-duction of Bulky Waste	C	C	B	B	Extraction of Explosive Object	Necessary	Discarded Material	C	N.A.	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	C	A	Occasionally Necessary	Necessary	Discarded Material	C	N.A. 46,000*4	B	B	-Stability of Market for Salvaged Materials

Note: A: Excellent B: Good C: Fair or ( ) to be considered D: Poor and ( ) shows reason
ITT: Intermediate Treatment Technology
*1 : The cost for 30 ton/hour plant was estimated in the Study on the Solid Waste Management for Poznan City, May 1993 JICA (JICA Poland SWM Report)
*2 : The cost for 19,000 tonnes of garden waste per year from the JICA Poland SWM Report
*3 : The cost for 36,000 tonnes per year from the JICA Poland SWM Report
*4 : The cost from the JICA Poland SWM Report for 20,000 tonne/year

Table H.3.4c Kinds of Waste and Availability to Intermediate Treatment System

	3-Elements of Waste				Incineration	Composting	RDF	Pyrolysis	Ash Solidification*2	Biogas	Crushing & Shredding	Sorting
	Organic Substances B	Moisture Contents W	Inorganic Substances A	Calorific Value of Waste								
Municipal Waste												
.Domestic Waste	Much	Fair	Less	Middle	A	A	B	A	A	A	B	A
.Commercial Waste (mainly from officers and shops)	Fair	Less	Fair	High	A	-	A	A	A	-	B	A
.Commercial Waste (mainly from markets)	Much	Much	Less	Low	A	A	-	-	A	A	B	-
.Carcasses	Much	Much	Low	Low	A	-	-	-	A	-	-	-
.Other Waste (Street Sweeping and public area cleaning wastes)	Fair	Fair	Less	Low	B	B*1	-	-	A	-	-	-
Industrial Waste(Non-Toxic)	Less	Less	Fair	High	A	-	A	B	A	-	B	B
Bully Waste												
Combustible Bully Waste	Fair	Less	Less	High	A	-	B	B	A	-	A	B
Incombustible Bully Waste	Low	Less	Much	-	-	-	-	-	B	-	A	A
Hospital Waste (Infections)	Much	Much	Less	Low	A	-	-	-	A	-	-	-

Remarks :
A Suitable
B Processable
- Normally not for processing

Ranking System for 3-Elements of Waste:
.Much
.Fair
.Less
.Low

Ranking System for Calorific Values of Waste:
.High
.Middle
.Low

Note:
*1 : Only for garden wastes.
*2 : All evaluation is for the plant combined with an incineration.

vi. biogas

Limited only to organic wastes including paper and organic and sewage sludge.

vii. size reduction (crushing & shredding)

An independent plant is only for bulky waste. However, crushing and shredding devices are necessary for the other intermediate treatment systems.

viii. sorting

Suited for inert waste.

d. Conclusion

Upon consideration of the result of the examination and the present MSWM in the Study area, the following systems were redundant and omitted:

- composting;
- RDF;
- pyrolysis;
- ash solidification;
- biogas;
- size reduction; and
- sorting.

While the introduction of incineration for Asuncion and F.Mora, in case the present Cateura landfill would be used in future, was retained for further study;

The reasons are described as follows;

da. Composting

i. The market for the compost product from municipal solid waste is very limited in the Study area.
ii. The other competitive organic fertilizers derived from animal dung are easily obtained in the region.
iii. Due to high production cost, subsidies on the sale price will be necessary to make compost from municipal solid waste to compete in the fertilizer markets.
iv. High cost of transportation and labor for the utilization of compost.

v. Less volume reduction.
vi. Possibilities of occurrence of hazardous heavy metals accumulation in the soil and ecological system in case of mixed collection system.

db. RDF

i. Waste which can be converted to RDF is very limited.
ii. The technology is in its developing stage.
iii. The market for RDF product is limited.

dc. Pyrolysis

i. The waste quality is limited.
ii. The technology is under development.
iii. The operation of plant is very difficult.
iv. Large capital investment and high operational cost are required.

dd. Ash solidification

i. Large capital investment and high operational cost are required.
ii. The technology is in the developing stage.
iii. Land for final disposal is available in the Study area.
iv. Difficulty of operation.

de. Biogas

i. High investment cost.
ii. The technology is in the developing stage and only a few years operational experience regarding MSW.

df. Size reduction

i. Waste is limited to the bulky waste and the production of it is not very much.
ii. The bulky waste can be recycled manually.

dg. Sorting

i. The present recycling system (manual recycling system) mainly established by private sectors is well functioned.
ii. The introduction of the sorting facility may cause a conflict with the present private sectors concerned with recycling activities (e.g.

scavengers) because it may relieve them of their jobs.

iii. The prices of recyclable materials are not stable.

iv. The amount of recyclable materials in MSW is not so much.

v. The volume reduction by the introduction of a sorting facility is little.

H.3.5 Final Disposal

a. Location and Number of Final Disposal Sites

As for the location and number of final disposal sites for the Master Plan alternatives study, it was confirmed as follows;

i. A-2 and A-5 sites in the Chaco area were selected as the candidate inter-municipal disposal sites for the study of alternatives of the Master Plan.

ii. As for the inter-municipal disposal sites for the municipalities of the eastern and southern parts of the Study area, the examination without identification of the specific sites was done and recommendations for the inter-municipal disposal operation was made.

b. Final Disposal Methods

There are several final disposal methods as listed below:

- open dumping;
- controlled tipping; and
- sanitary landfill.

Although the controlled tipping method is employed in the Cateura and Trumandy landfills, the open dumping is dominant in the Study area. These methods should not be tolerated in the future in view of their adverse effects on the landscape, public health and environment.

A sanitary landfill should be used for final disposal. A sanitary landfill is proven to be the most economical and acceptable method for the disposal of solid wastes. The term sanitary landfill means a operation in which the wastes to be disposed of are compacted and covered with a layer of soil at the end of each day's operation.

When the disposal site has reached its ultimate capacity – that is, after all disposal operations have been completed – a final layer of 60 cm or more of cover materials is applied.

The advantages of sanitary landfills are shown below:

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

- The initial investment is low compared with other disposal methods, such as composting and incineration.

- A sanitary landfill is a complete or final disposal method compared to incineration and composting which 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 of separate collections.

- A sanitary landfill is flexible; increased quantities of solid wastes can be disposed of with little additional personnel and equipment.

- Submerged land may be reclaimed for use as parking lots, playgrounds, golf courses, botanical gardens, etc..

c. **Landfill Structure**

There are five types of landfill structure, as follows:

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

The contribution to the mitigation of environmental pollution is improved in accordance with the above list. Figure H.3.5a shows the structure of each landfill type.

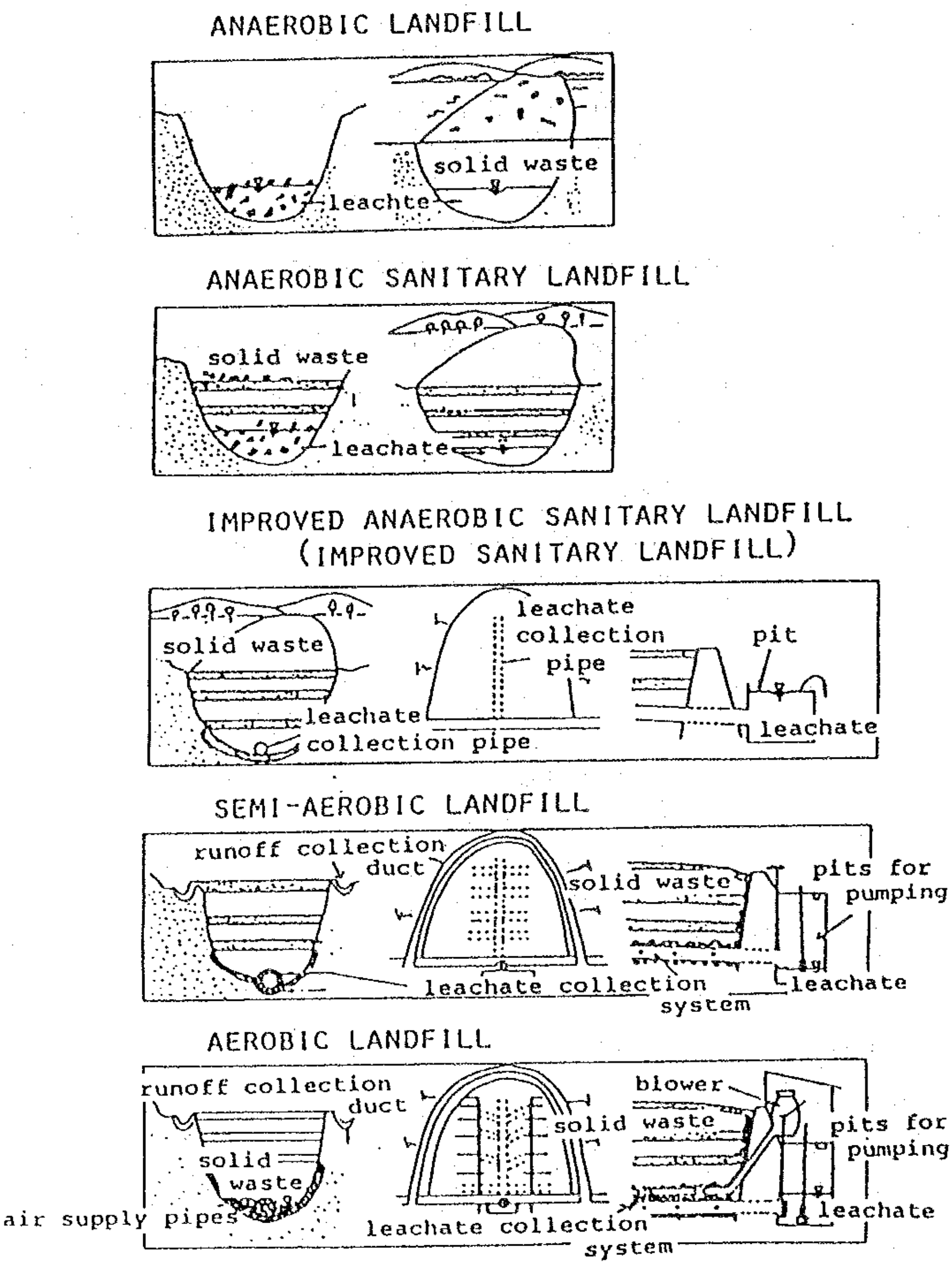


Figure H.3.5a Landfill Structures

da. Anaerobic Landfill

As the leachate generated in the landfill layers is hardly drained, the landfill layers constantly maintain anaerobic condition. The quality of the leachate is very poor, causing bad odor and the propagation of vector and vermin.

db. Anaerobic Sanitary Landfill

Covering soil is applied on each layer of waste. This covering soil restrains the bad odor, incidental fires and the propagation of harmful insects to a certain extent. However the problems of leachate and gas generation remain. As in the case of anaerobic landfill, the disposed solid waste maintains anaerobic conditions.

dc. Improved Anaerobic Sanitary Landfill

In addition to covering soil, a drainage facility for the leachate is introduced a the bottom of the disposal site. The quality of the leachate is accordingly improved, although the anaerobic conditions are still maintained.

dd. Semi-Aerobic Sanitary Landfill

As the leachate is constantly drained by drainage pipes, the quality of the leachate is fairly improved. These drainage pipes stimulate natural ventilation, achieving aerobic conditions in the landfill layers. As a result, the decomposition of the solid waste is accelerated.

de. Aerobic Sanitary Landfill

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

The landfill sites in the Study area currently employ the anaerobic and/or anaerobic sanitary landfill structure.

In view of the above advantages and disadvantages of the landfill structure types, it is planned that final disposal sites in the Master Plan will employ the semi-aerobic sanitary landfill structure with leachate drain pipes for level 3 of (refer to **f.** of this section) sanitary landfill.

d. **Recovery of Methane Gas**

The recovery of methane gas was not considered in the alternative study due to the following reasons;

i. The proposed disposal sites are flat and it is rather difficult to recover the methane gas at flat and shallow disposal sites.

ii. It will take many years for the recovery of methane gas and also require a mounting-up disposal operation.

e. **Level of Sanitary Landfill Development and Operation**

The level of sanitary landfill development and operation can be classified into the following four levels.

Level 1: Controlled tipping
Level 2: Sanitary landfill with a bund and daily soil covering
Level 3: Sanitary landfill with leachate circulation
Level 4: Sanitary landfill with leachate treatment

The details of above mentioned level of sanitary landfill development and operation are described below. The prospective levels of sanitary landfill development and operation are illustrated in Figure H.3.5b.

In order to prevent the deterioration of the surrounding environment and to avoid cost increase due to leachate treatment, the level of sanitary landfill is determined as level 3 for the landfills of Highly Urbanized and Urbanized Municipalities and as level 2 for the landfills of Less Urbanized Municipalities.