Study on International Cooperation in the field of Waste Management

September 2009

Corp. Japan Waste Management Consultant Association

Table of Contents

1 Japanese International Cooperation in Solid Waste Management Sector

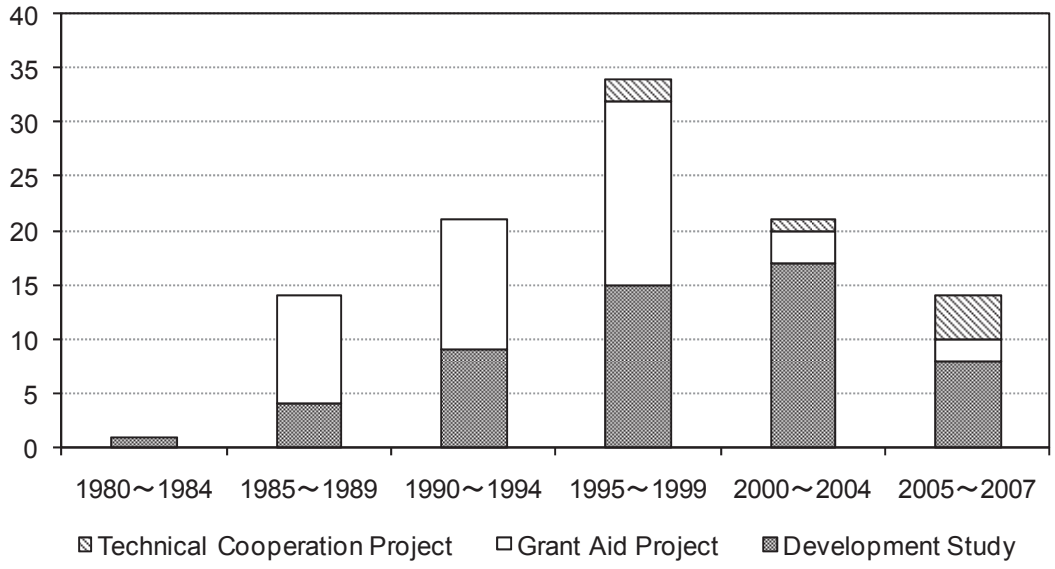
1.1 JICA Projects in SWM sector

There are many types of international cooperation scheme in the solid waste management sector not only by the Japanese government but also by the private sector or NGO/NPO.

In this section, experiences of JICA (Japan International Cooperation Agency) before JICA and JBIC (Japan Bank of International Cooperation) was unified in October 2008, are introduced because quite many JICA projects have been conducted in the wide variety of SWM field and its cost were very huge.

a. Number of JICA Project by Scheme

JICA had conducted SWM projects since 1982 to 2007 by the following three major schemes, the grant aid project (44 projects), the development study (54 projects), and the technical cooperation project (7 projects). As shown in Figure 1, there is a peak in 1995-1999 when 34 projects were carried out in total. The number of project in every 5 years has been decreasing after this peak, especially the number of the development study has been dropped significantly.

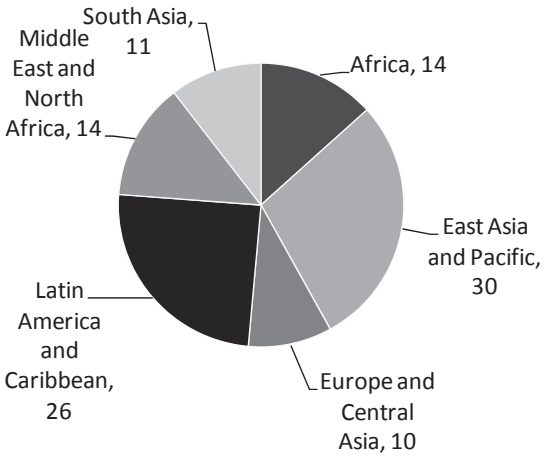


Note: Implementation year is applied for grant projects, closing year is applied for development studies
(Source: JICA Annual Report, Japan's ODA white paper 2001 by MOFA)

Figure 1: JICA Projects by Scheme (1982 to 2007)

b. Number of JICA Project by Region

Figure 2 illustrates number of JICA projects by region since 1982, showing that projects in East Asia/Pacific region and Latin America region were comparatively more than other regions. Grouping of regions are followed to that of the World Bank, and East Asia includes countries in Southeast Asia.



Note: Projects include three major schemes i.e. grant project, development study and technical cooperation project
(Source: JICA Annual Report, Japan's ODA white paper 2001 by MOFA)

Figure 2: JICA Projects by Region (1982 to 2007)

c. The Number of Projects in each Country

The number of projects in each country after 1982 is shown in Table 1. The largest number of the projects in one country is 6 projects in Philippines, then 5 projects in Malaysia and Pakistan, and 4 projects in Thailand, Syria and Vietnam.

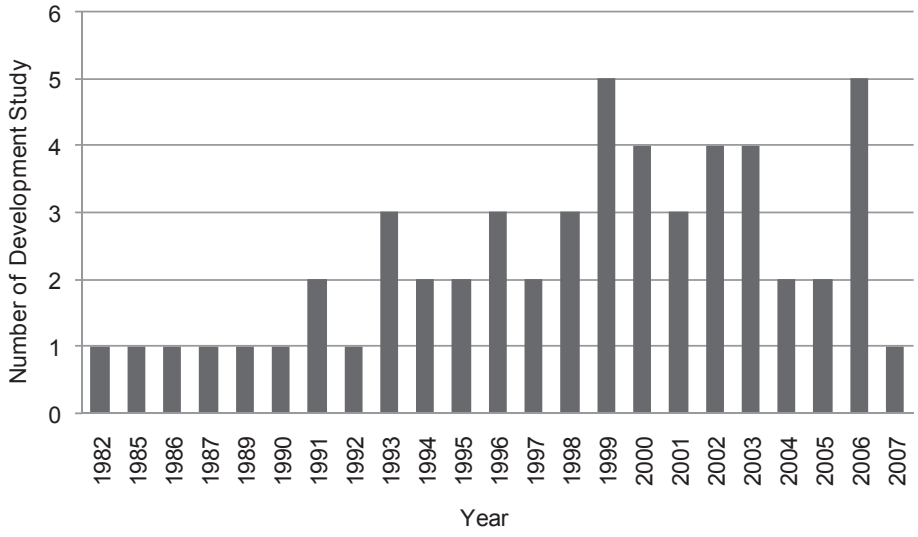
Table 1: The Number of Project(s) by Country (1982 - 2007)

Number of Project(s)	Country
6	Philippines
5	Malaysia, Pakistan
4	Thailand, Syria, Vietnam
3	El Salvador, Nicaragua, Sri Lanka, Jordan, Brazil, Indonesia
2	Bolivia, Dominican Republic, Laos, Honduras, Tanzania, Mongolia, Peru, Romania, Guatemala, Mexico, Egypt, Paraguay, Yemen, China
1	Poland, Morocco, Mali, Korea, Turkey, Azerbaijan, Cuba, Djibouti, Tunisia, Panama, Togo, Vanuatu, Zaire, Kazakhstan, Solomon, Palestinian national Authority, Madagascar, Hungary, Ethiopia, Bangladesh, Maldives, Zimbabwe, Chile, Sudan, Kenya, Bulgaria, Rwanda, Cambodia, Cenegal, Nigir, Nepal

(Source: JICA annual report, ODA white paper, etc.)

d. Development Study

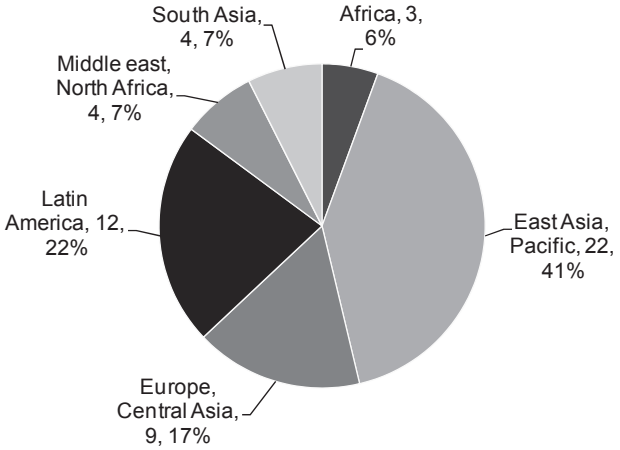
54 projects had been conducted under the scheme of JICA development study until 2007 since the first case of Bangkok City, the kingdom of Thailand, which was carried out during 1880 to 1982. While only one case was being conducted in 80's, the number of case in each year had increased from 90's to the beginning of 2000's, which resulted in 2 to 5 cases/year. However, the number of JICA technical cooperation projects has been increased since 2007 as replacing from the development study.



(Source: JICA Annual Report, Japan's ODA white paper 2001 by MOFA)

Figure 3: Number of JICA Development Study in each year (year of final report)

Figure 4 gives distribution of the development study by region. East Asia and Pacific region holds the largest portion, 41% of all studies. Following region is Latin America, indicating 22% of all.

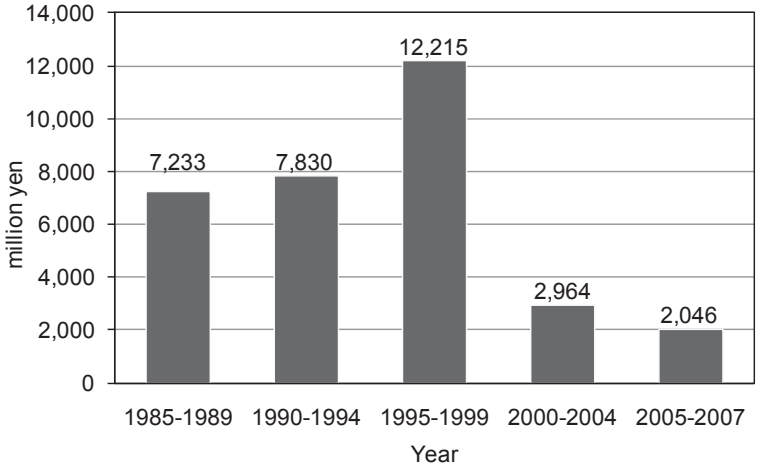


(Source: JICA Annual Report, Japan's ODA white paper 2001 by MOFA)

Figure4: Development Studies by Region (1982-2007)

e. Grant Aid Project

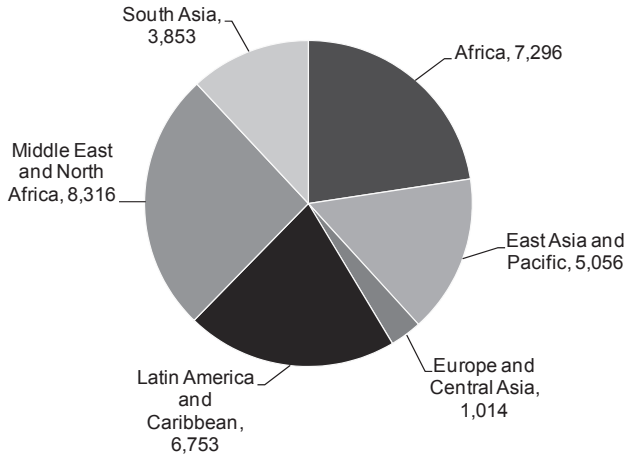
More than thirty two (32) billion yen was invested to the grant aid project in SWM sector from 1982 to 2007. Figure 5 shows the amount of grant aid projects from 1985. There is the peak of 12,215 million yen in 1995 to 1999 then significantly decreased. Actually the grant aid project had been stopped for a while during the late 90's to early 2000's but have been restored since 2002 conducting the procurement of SWM equipment project in Hanoi, Vietnam.



(Source: JICA annual report, ODA white paper)

Figure 5: Amount of Grant Aid Project in Each 5 Year (1982-2007)

As shown in Figure 6, the amount of grant aid project in the Middle East and North Africa region is the largest, then 'Africa', 'Latin America and Caribbean', 'East Asia and Pacific', 'South Asia' and 'Europe and Central Asia' follow in the order of the project amount in each region.



Unit: million yen

(Source: JICA annual report, ODA white report)

Figure 6: Amount of Grant Aid Project in Each Region (1982 - 2007)

1.2 SWM Projects funded by International Organizations

In terms of SWM projects conducted by international organizations, the World Bank discloses its project information on its web site to understand the contents easily. Therefore, the data of the World Bank is summarized first and then those of other international organization are introduced in the latter part.

1.2.1 World Bank

Projects related to solid waste management is often implemented as not only main sector but also one of sectors of urban environment improvement projects. There is a maximum of five sectors in each project targeted herein. A project that SWM sector ranked as the first sector is more focusing solid waste management than ranked as the second to the fifth sector. Regardless of such rank, however, number of SWM project is counted as the same level below.

a. Number of SWM Projects by Regions and Countries

Number of SWM projects in each region and country approved from 1988 to 2008 is shown in Table 2. Total number of the projects is 187, and largest number of the projects is in East Asia and Pacific region, Africa, and Europe and Central Asia, in that order. Looking into by countries, 23 projects were carried out in China which is the largest number, then 8 projects in Brazil and Indonesia respectively follows.

Table 2: Number of SWM Projects by World Bank in each Region and Country (1988 - 2008)

Region	Country	Number of Projects
Africa	Africa Region (over several countries)	3
	Angola	1
	Benin	2
	Burkina Faso	3
	Central African Republic	1
	Cote d'Ivoire	3
	Eritrea	1
	Ethiopia	2
	Gambia, The	1
	Guinea	2
	Lesotho	1
	Liberia	2
	Madagascar	1
	Mozambique	1
	Nigeria	5
	Republic of Mauritius	1
	Sierra Leone	3
	South Africa	1

Region	Country	Number of Projects
	Tanzania	1
	Uganda	4
	Zambia	1
	Sub-total	40
East Asia and Oceania	China	23
	Indonesia	8
	Korea, Republic of	1
	Malaysia	1
	Philippines	2
	Timor-Leste	1
	Vanuatu	1
	Vietnam	4
	Sub-total	41
Europe and Middle Asia	Albania	1
	Azerbaijan	2
	Belarus	3
	Bosnia and Herzegovina	6
	Croatia	1
	Georgia	1
	Kazakhstan	2
	Kosovo	1
	Kyrgyz Republic	1
	Latvia	3
	Macedonia, former Yugoslav Republic of	1
	Moldova	1
	Montenegro	1
	Romania	3
	Russian Federation	2
	Serbia	2
	Tajikistan	1
	Turkey	3
	Ukraine	2
	Uzbekistan	2
	Sub-total	39
Middle and South America	Argentina	5
	Brazil	8
	Chile	1
	Colombia	3
	Dominican Republic	1
	Ecuador	3
	Jamaica	1

Region	Country	Number of Projects
	Latin America	1
	Mexico	4
	OECS Countries	2
	Peru	2
	Uruguay	1
	Venezuela, Republica Bolivariana de	2
	Sub-total	34
Middle East and North Africa	Algeria	1
	Djibouti	1
	Egypt, Arab Republic of	4
	Iran, Islamic Republic of	1
	Iraq	2
	Jordan	2
	Lebanon	1
	Middle East and North Africa	1
	Tunisia	3
	West Bank and Gaza	2
	Yemen, Republic of	1
	Sub-total	19
South Asia	Afghanistan	3
	Bangladesh	1
	India	4
	Maldives	1
	Nepal	1
	Pakistan	2
	Sri Lanka	2
	Sub-total	14
Total		187

(Source: World Bank)

b. Changes of SWM Project in Each Year by World Bank

As Table 3 shows the number of the approved SWM projects, 7 projects approved in one year was the largest till 2004. However, since 2005, the approved number has been drastically increased.

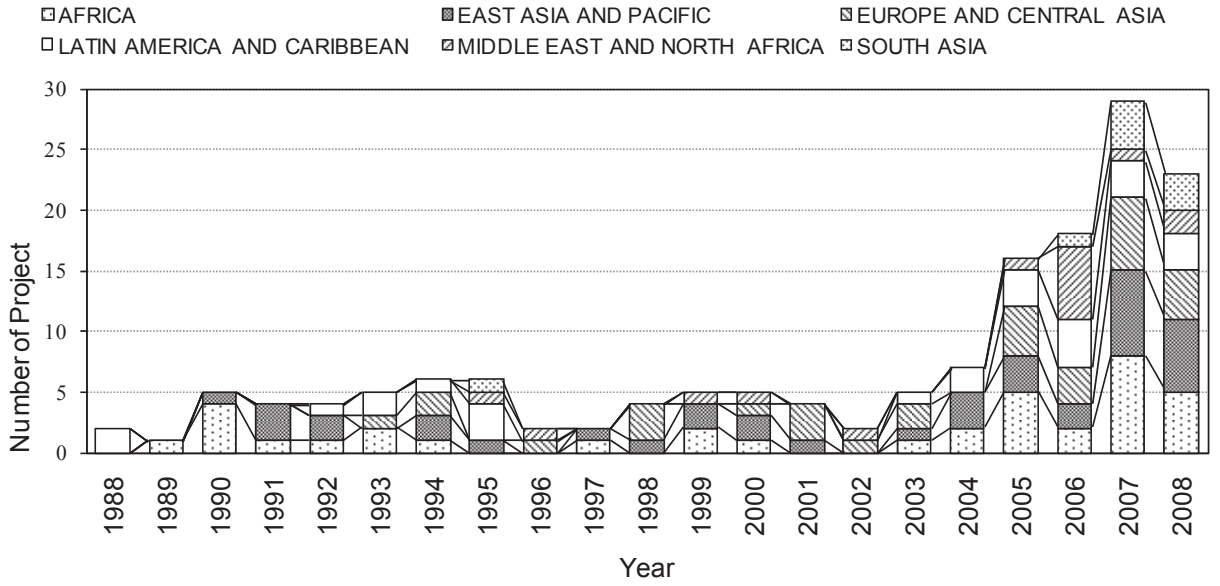
In recent years, projects in Africa, Europe and Central Asia, and East Asia and Pacific region are relatively more than other regions.

Table 3: Project Numbers approved in each year (1988～2008)

REGION	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
AFRICA	0	1	4	1	1	2	1	0	0	1	0
EAST ASIA AND PACIFIC	0	0	1	3	2	0	2	1	0	1	1
EUROPE AND CENTRAL ASIA	0	0	0	0	0	1	2	0	1	0	3
LATIN AMERICA AND CARIBBEAN	2	0	0	0	1	2	1	3	0	0	0
MIDDLE EAST AND NORTH AFRICA	0	0	0	0	0	0	0	1	1	0	0
SOUTH ASIA	0	0	0	0	0	0	0	1	0	0	0
Subtotal	2	1	5	4	4	5	6	6	2	2	4

REGION	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total
AFRICA	2	1	0	0	1	2	5	2	8	5	37
EAST ASIA AND PACIFIC	2	2	1	0	1	3	3	2	7	6	38
EUROPE AND CENTRAL ASIA	0	1	3	1	2	0	4	3	6	4	31
LATIN AMERICA AND CARIBBEAN	0	0	0	0	1	2	3	4	3	3	25
MIDDLE EAST AND NORTH AFRICA	1	1	0	1	0	0	1	6	1	2	15
SOUTH ASIA	0	0	0	0	0	0	0	1	4	3	9
Subtotal	5	5	4	2	5	7	16	18	29	23	155

Note: 32 projects which an approved year is unknown are not included above.
(Source: World Bank)



(Source: World Bank)

Figure 7: Number of Project by World Bank in each year (year of approved)

c. Financial Amount of the Projects by World Bank

Table 4 shows the financial amount by each project by region. Since there are various components in each project, the financial amount is also different. Projects that the amount is under five million US dollars counts 75 and it holds about 40% of all. On the other hand, there are six project with over 100 million US dollars.

Table 4: Amount of Project by World Bank (1988～2008)

REGION	Commitment Amont (Unit: million US$)							Total
	～5	10～20	20～30	30～40	40～70	70～100	100～	
AFRICA	18	8	3	1	0	0	1	40
EAST ASIA AND PACIFIC	15	6	3	3	5	1	0	41
EUROPE AND CENTRAL ASIA	12	8	4	2	3	3	2	39
LATIN AMERICA AND CARIBBEAN	11	6	2	0	4	2	2	34
MIDDLE EAST AND NORTH AFRICA	12	1	0	1	2	1	1	19
SOUTH ASIA	7	1	1	2	2	0	0	14
Total	75	30	13	9	16	7	6	187

(Source: World Bank)

1.2.2 Other International Organization

The recent SWM projects by Asian Development Bank (ADB), Inter-American Development Bank (IDB), European Bank for Reconstruction and Development (EBRD) are described below. The following information is obtained from the home page of each organization, but limited because some projects do not includes keywords such as solid waste or recycling which easily show the contents of the project. Some projects titled as like the urban environment improvement projects may sometimes include SWM part as well as the World Bank Project. The following data does not include such project, means it could be said more SWM projects are conducted in total.

Table 5: SWM Projects by Asian Development Bank (ADB)

Country	Number of Project(s)
Thailand	3
Regional*	3
China	3
Indonesia	2
Philippines	2
Lao PDR	2
Tuvalu	1
India	1
Cook Islands	1
VietNam	1
Marshall Islands	1
Total	20

*Regional: Projects over plural countries

(Source: ADB)

Table 6: SWM Projects by Inter-American Development Bank (IDB)

COUNTRY	Number of Project(s)
Argentina	6
Bahamas	5
Jamaica	5
Guyana	4
Ecuador	4
Belize	4
Barbados	3
El Salvador	3
Nicaragua	2
Uruguay	2
Bolivia	2
Regional	2
Guatemala	1
Peru	1
Panama	1
Brazil	1
Dominican Republic	1
Chile	1
Venezuela	1
Honduras	1
Colombia	1
Total	51

(Source: IDB)

Table 7: SWM Projects by European Bank for Reconstruction and Development (EBRD)

Country	Number of Project(s)
Croatia	2
Romania	2
Russia	1
Serbia	1
Tajikistan	1
Uzbekistan	1
Total	8

(Source: EBRD)

1.3 Project Results Conducted by Members of Japan Waste Management Consultant Association

Japan Waste Management Consultant Association (JWMCA) conducts the questionnaire survey for the members who carried out the overseas projects every year. From 2004 to 2008, member firms conducted 36 to 49 SWM projects each year with amount of approximately 0.8 to 2.8 billion Japanese yen.

It could be observed that the number of overseas SWM projects tends to increase slightly these years. In addition, as shown in 2007 and 2008, one of the characteristic points of the overseas SWM project is that project amount of the foreign government including Yen Loan project is relatively very large.

Table 8: Order Achievement of the Overseas Works by the Member of Japan Waste Management Consultant Association

Source of funds	FY 2008			FY 2007			FY 2006			FY 2005			FY 2004		
	no.	million Yen		no.	million Yen		no.	million Yen		no.	million Yen		no.	million Yen	
JICA (projects*)	22	899	31.9%	16	894	68.9%	31	824	86.8%	21	690	79.5%	21	1106	84.8%
JICA (services**)	7	65	2.3%	4	35	2.7%	1	1	0.1%	4	81	9.3%	6	97	7.4%
JBIC***	3	9	0.3%	7	83	6.4%	4	7	0.7%	4	21	2.4%	3	10	0.8%
International Donor	1	1533	54.5%	1	6	0.5%	1	44	4.6%	0	0	0.0%	1	4	0.3%
Local Government	2	188	6.7%	2	190	14.6%	0	0	0.0%	0	0	0.0%	2	29	2.2%
Other public organization	4	37	1.3%	5	66	5.1%	5	11	1.2%	2	50	5.8%	4	33	2.5%
Private sector and others	10	82	2.9%	2	23	1.8%	4	62	6.5%	5	26	3.0%	9	25	1.9%
Total	49	2815	100.0%	37	1298	100.0%	46	949	100.0%	36	868	100.0%	46	1304	100.0%

* Development Study, Grant Aid Project, Technical Cooperation Project
** Individual Expert Services
*** Before unified with JICA in 2008

(Source: JWMCA)

Notice：The number of projects are total of answers from member firms, being different from actual number.

2 Characteristics and Considerations about Waste Management in Developing Countries based on the Data from Implemented Investigations

2.1 Developing Countries

2.1.1 Criteria of Developing Countries

Development Assistance Committee (DAC) in Organization for Economic Co-operation and Development (OECD) and Ministry of Foreign Affairs of Japan (MoFA) define the developing countries/countries for assistance as 180 countries/regions as Table 1.

Table 1: Category of Developing Countries

Category	Developing Countries/Regions					Transition Countries/Regions	
	Least among Less Developed Countries	Low Income Countries	Low Middle Income Countries	Middle Income Countries	Upper Middle Income Countries	CEEC/ NIS	More developed Countries/ Regions
Number of countries	49	22	45	28	2	12	22
GNP per Capita (principal)	Less than US$699[*3-1]	Less than US$766		More than US$3,036 Less than US$9,386	More than US$9,386	—	—

(Reference: Japan's ODA white paper 2001 by MOFA)

2.1.2 Classification for geographic regions of developing countries

The following table shows the classification for the geographic regions of developing countries.

[*3-1] Additionally, there are other conditions, such as population, human resource development, fragility of the economy and so on.

Table 2: Classification for Geographic Regions of Developing Countries

Region		Country
1	East Asia	Indonesia, China, Philippine, Viet Nam, Cambodia, Laos, Malaysia, Mongolia, Myanmar, Timor-Leste, Thailand and others
2	South-west Asia	India, Pakistan, Sri Lanka, Bangladesh, Nepal, Bhutan, Maldives and others
3	Central Asia	Kazakhstan, Azerbaijan, Uzbekistan, Kyrgyz Republic, Georgia, Armenia, Turkmenistan, Tajikistan and others
4	Africa	Tanzania, Ethiopia, Mozambique, Angola, Malawi, Ghana, Senegal, Zambia, Mauritania, Guinea, South Africa, Mali, Niger, Cape Verde, Eritrea, Cameroon Burkina Faso, Madagascar, Uganda, Gambia, Djibouti, Nigeria, Benin, Swaziland, Zimbabwe, Lesotho, Sierra Leone, Mauritius, Cote d'Ivoire, Gabon Central African Republic, Sao Tome and Principe, Botswana, Namibia, Seychelles, Rwanda, Congo, Rep., Togo, Chad, Congo, Dem. Rep., Burundi, Guinea-Bissau, Equatorial Guinea, Comoros, Liberia, Kenya and others
5	Middle East	Afghanistan, Tunisia, Morocco, Jordan, Yemen, Egypt, Lebanon, Iran, (Palestinian National Authority), Saudi Arabia, Iraq, Oman, Sudan, Turkey, Bahrain, Algeria, Syrian Arab Republic and others
6	Middle and South America	Peru, Brazil, Honduras, Dominican Republic, Bolivia, El Salvador, Nicaragua, Guatemala, Ecuador, Paraguay, Argentina, Dominica, Haiti, Antigua and Barbuda, St. Lucia, St. Kitts and Nevis, Panama, Colombia, Uruguay, Venezuela, RB, Cuba, Trinidad and Tobago, Grenada, Belize, Guyana, Barbados, Suriname, St. Vincent and the Grenadines, (Montserrat), Costa Rica Jamaica, Mexico, Chile and others
7	Oceania	Fiji, Samoa, Palau, Micronesia, Fed. Sts., Tonga, Kiribati, Marshall Islands, Vanuatu, Tuvalu, Nauru, (Cook Islands), (Niue), Papua New Guinea, Solomon Islands and others
8	Europe (including NIS)	Bulgaria, Romania, Bosnia and Herzegovina, Hungary, Moldova, Albania, Macedonia, FYR, Slovak Republic, Czech Republic, Croatia, Serbia and Montenegro, Slovenia, Malta, Poland and others

2.1.3 Economic Level of Developing Countries

Figure 9 shows the average GNI (Gross National Income) in each region calculated with the data on the homepage of World Bank which collects data about GDP per capita in developing countries.

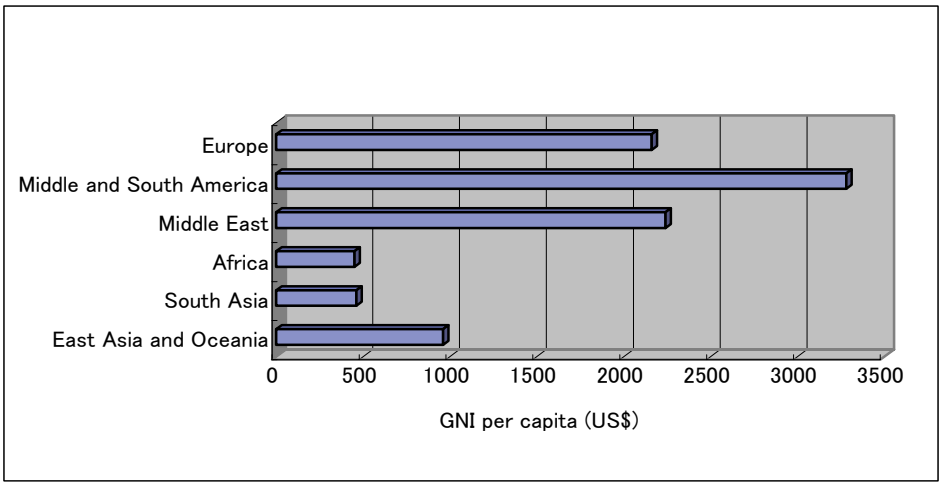


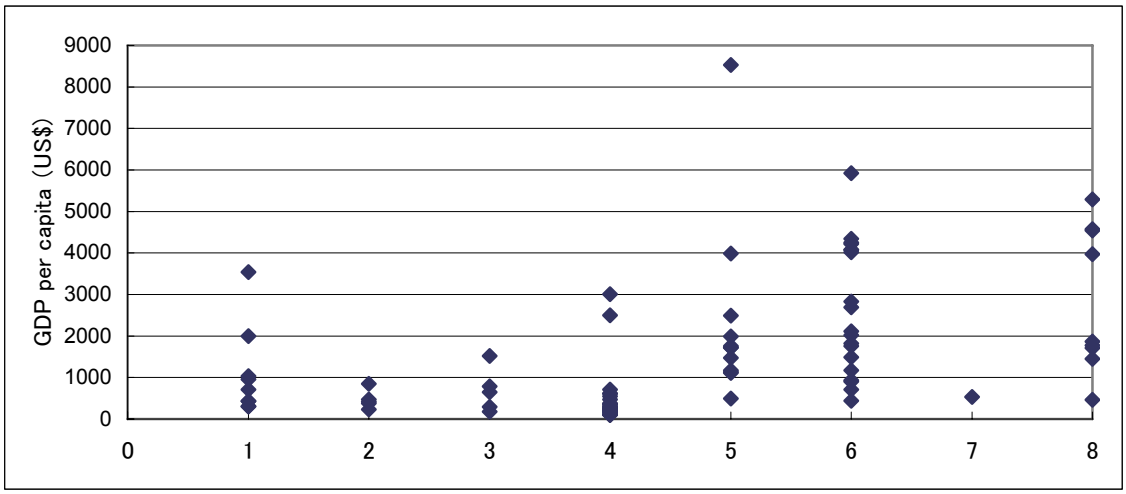
Figure 9: GNI in Each Region in 2002 (Reference: homepage of World Bank)

The averages of GNI per capita in Africa, South Asia and East Asia are low as US$450, US$460 and US$960 respectively. The average of GNI per capita in Middle and South America is the highest as US$3,280. Figure 10 shows the plot of each country's GDP per capita in each region. Countries categorized as LLDC[1] (Least among Less Developed Countries) are mostly in Asia and Africa area, whereas GDP per capita is more than US$1,000 in some countries in East Asia, such as Philippine, Thailand and Malaysia. It can be said that the economic gap is getting larger. In South Asia, GDP per capita is generally low as the range is around US$230 to US$850. In Central Asia, all GDP per capita are less than US$1,000 except for Kazakhstan. Among all, GDP per capita in Africa, except for South Africa and Botswana, is the lowest. In Middle East, Middle and South America and Europe, the economic levels are higher than Asia and Africa, however, a lot of countries are categorized as LLDC, LIC[2] (Low Income Countries) and LMIC[3] (Low Middle Income Countries).

[1] Least among Less Developed Countries, which are the countries especially less developed in developing countries, are designated by Committee for Development Policy (CDP) in UN. The present basis is under US$699 and so on (49 countries from 2001).

[2] Low Income Countries: countries/regions which GNP per capita is less than US$766 in 1995 in principal (22 countries/regions except for LLDC in 2000)

Therefore it can be found that the economic gaps are large in these areas.



1: East Asia, 2: South Asia, 3: Central Asia, 4: Africa,

5: Middle East, 6: Middle and South America, 7: Oceania, 8: Europe

Figure10: Regional Distribution for GDP per capita

2.2 Data about wastes from implemented investigations

This report collects data about Municipal Solid Waste (MSW) management in 47 cities from Development Studies and Basic Design Studies for Grant Aid implemented by JICA in the past. And the characteristics are summarized from several points of view, such as the economic level and geographic regions.

[3] Low Middle Income Countries: countries/regions which GNP per capita is more than US$766 and less than US$3,036 in 1995 in principal (45 countries/regions in 2000)

Table 3: Number of Data about Wastes

Region	No. of Cities
East Asia	10
South West Asia	8
Central Asia	1
Africa	3
Middle East	8(7)
Middle and South America	14
Europe	4
Total	48(47)*

*: There are two data about Alexandria City from both Development Study and Study for Grant Aid.

2.3 Waste Generation

The amount of waste generation is the sum total calculated by multiplying the unit amount of waste and the number of the generation source. Although usually there are not any data about the unit amount of waste, most of Development Studies implemented the survey about waste amount and calculated the unit amount for household wastes and business wastes respectively. On the other hand, the number of the generation source is quoted from the statistics. This report uses only consistency data of the latest numbers of population and enterprises because the agencies dealing this kind of data are plural.

2.3.1 Amount of Waste Generation

a. Waste generation and Population

Figure 11 shows the relationship of the amount of waste generation (the sum total of household wastes and business wastes) calculated in this report and population in each city. As a result, the waste generation increases linearly according to the increase of population, except for Mexico City. This relationship is not simple because the amount of waste generation is the sum total calculated by multiplying the unit amount of waste and the number of the generation source as mentioned above. However the following figure makes it possible to estimate the amount of waste generation

according to the scale of population in the city.

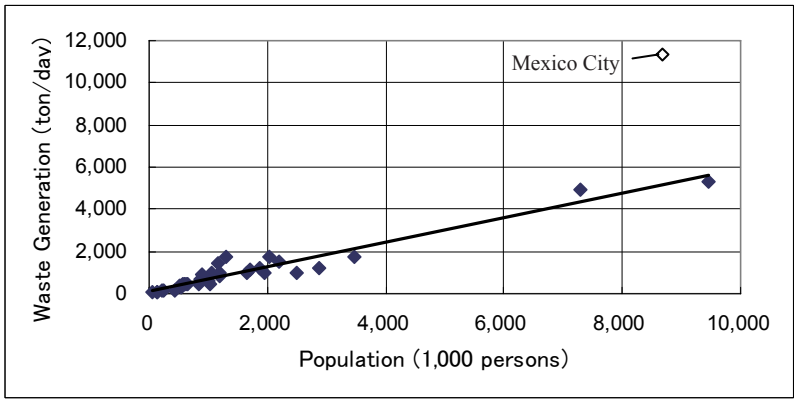


Figure 11: Waste Generation and Population

b. Waste Generation per Person per Day in Each Region

Figure 12 shows the waste generation per person per day in each region. The values in South Asia and Middle and South America are relatively large and the value in Middle East tends to be small. The waste generation per person per day in South Asia and Middle and South America exceeds the value of Japan which is 1.111 kg/person/day in 2002

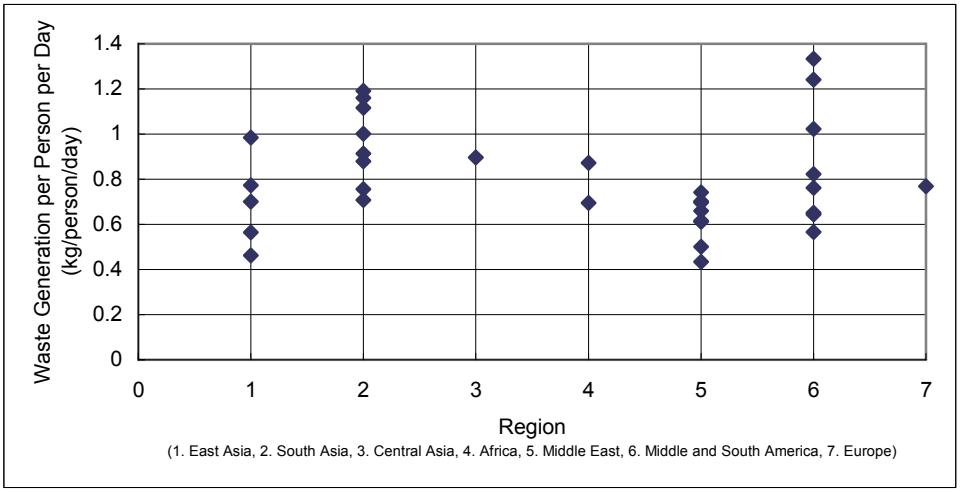


Figure 12: Waste Generation per Person per Day in Each Region

As mentioned above, the waste generation calculated here consists of household wastes and business wastes. Figure 13 shows the comparison between the ratios of these two kinds in each region. It is

found that the ratio of household wastes in Central Asia is the lowest as 55% and that ratio in Europe is the highest as 85%.

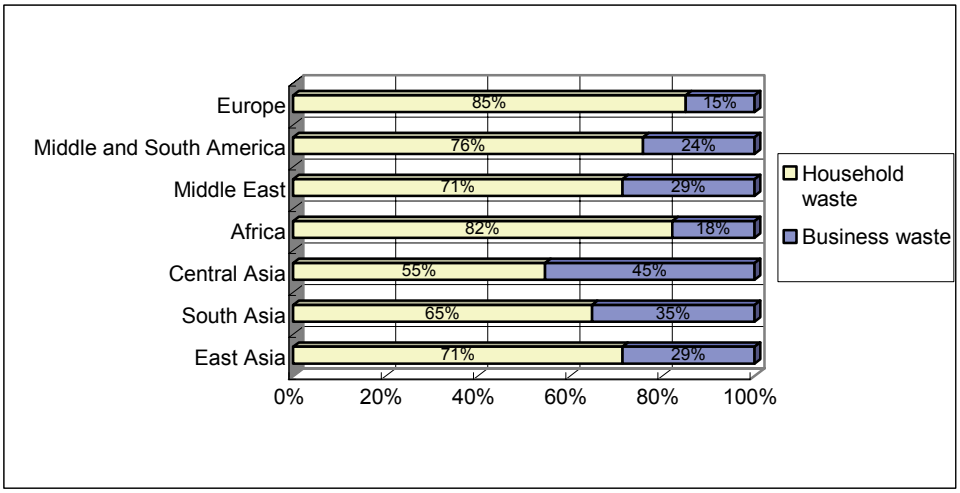


Figure 13: Ratio Comparison between Household wastes and Business Wastes in Each Region

c. Waste Generation per Person per Day in Each City Population Scale

Figure 14 shows the ratio of household wastes and business wastes in each city population scale in developing countries. The case of Japan is shown in Figure 15.

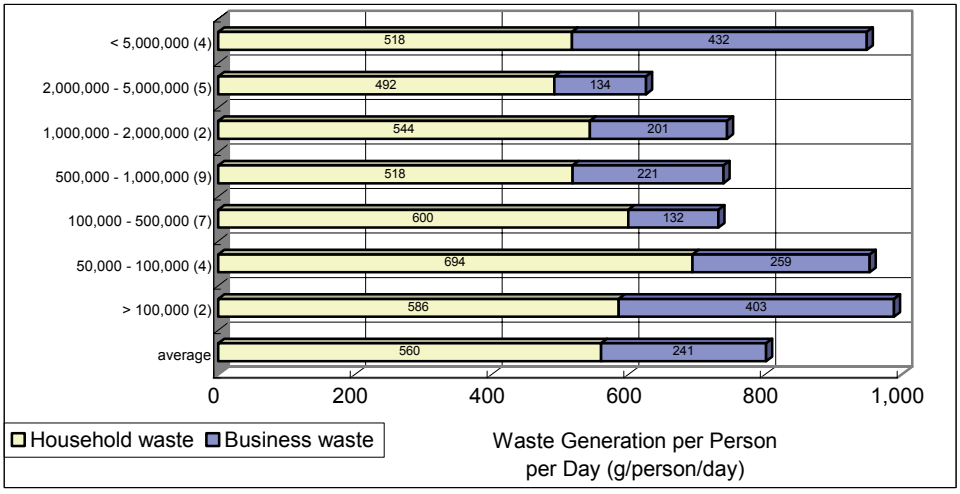


Figure 14: Waste Generation per Person per Day in Each City Population Scale in

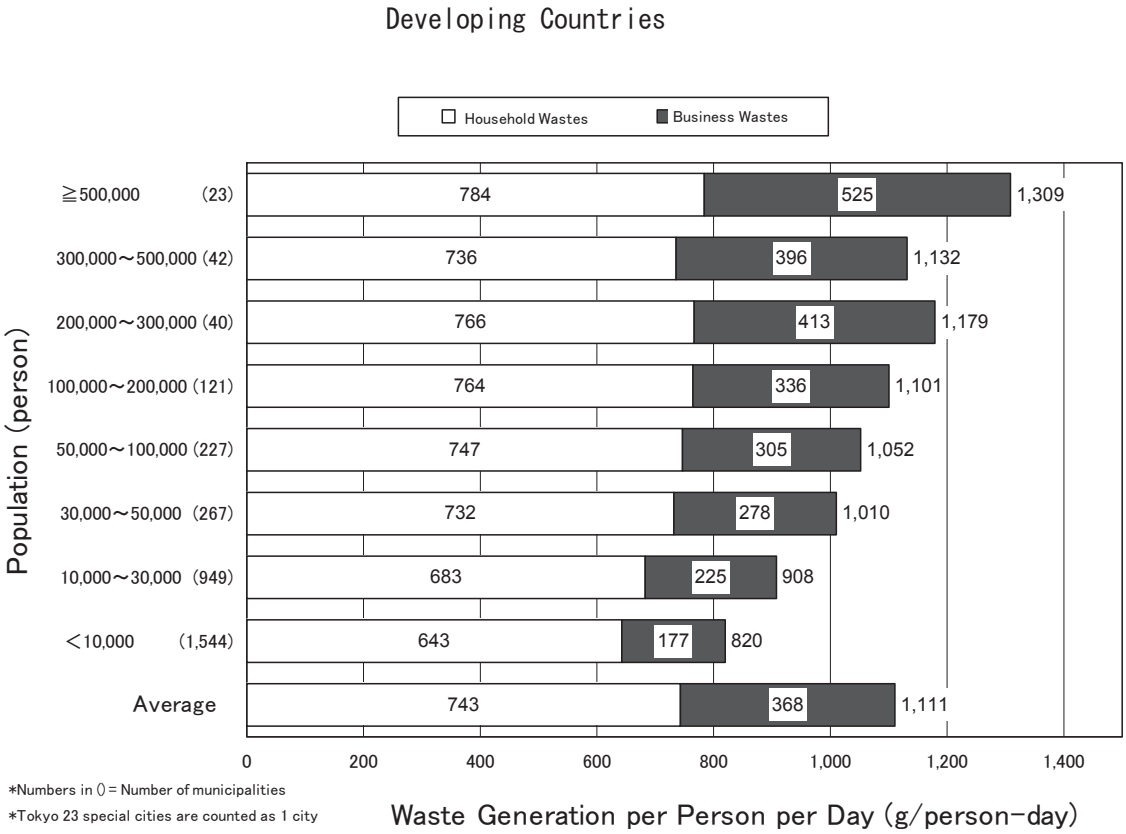


Figure 15: Waste Generation per Person per Day in Each City Population Scale in Japan (FY 2002)

Reference: Waste Management in Japan (FY2002), Waste Management and Recycling Dept. of the Ministry of the Environment

In the case of Japan, the ratio of business wastes increases according to the increase of the population scale. Consequently the waste generation itself tends to increase. Regarding household wastes, the amount is less than 800g/person/day regardless with the population scale.

Contrary to the case of Japan, the waste generation in developing countries is more than 950g/person/day in cities which population is less than 100,000 and in cities which population is more than 5 million. The waste generation is 626 to 745g/person/day in cities which population is more than 100,000 and less than 5 million. And there are any relationship between the ratio of business wastes and the population scale. Regarding household wastes, the amount is mostly 500 to 600g/person/day regardless with the population scale.

d. Waste Generation per Person per Day and Economic Level

Figure 16 shows the relationship between waste generation (the sum total of household wastes and business wastes) per person per day and the economic level (GDP per capita).

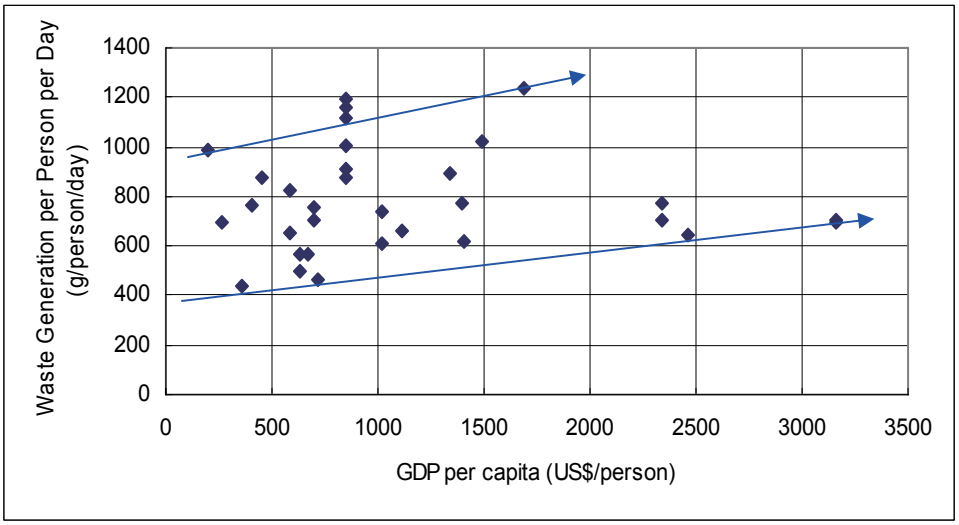


Figure 16: Waste Generation per Person per Day and Economic Level

This figure presents a tendency that waste generation per person increases as the economic level becomes high although there is a range as about 500g.

2.3.2 Unit Amount of Waste Generation

a. Unit of Measurement for Unit Amount of Waste Generation

The unit amounts of waste generation are calculated with actual measurements for each waste from households, commercial places (restaurants and others), markets, schools, hotels, offices, road cleaning and so on. The units of measurements for each are various, therefore this report adopts the units of measurements for generation sources in statistics as Table 4.

Table 4: Unit of Measurement for Unit Amount of Waste Generation (Examples)

Type of Waste		Unit of Measurement	Unit of Measurement for Generation Source (example)
Household wastes		kg/person/day	Population
Commercial wastes	Restaurants	kg/table/day, kg/shop/day	No, of tables, No, of shops
	Others	kg/shop/day	No. of shops
Market wastes		kg/shop/day, kg/m^2/day	No. of shops, sales floor area
School wastes		kg/student/day	No. of students
Hotel wastes		kg/room/day	No, of rooms, No. of beds
Office wastes		kg/m^2/day	Site area
Road cleaning wastes		kg/km/day	Km
Hospital wastes		kg/bed/day	No. of beds, No. of patients
Factory wastes (general solid wastes)		kg/employee/day, kg/m^2/day	No. of employees, site area, production

b. Unit of Household Wastes Generation

As mentioned above, it is not easy to compare simply among all types of units of waste generation because each type of waste has each unit of measurement. This report carries out a comparative analysis about the unit of household wastes generation.

b.1 Unit of Household Waste Generation in Each Region

Figure 17 shows the unit of household waste generation in each region. The following characteristics would be just references because there are not plenty of data for analysis in some regions.

The unit of household waste generation is generally 0.4 to 0.8kg/person/day. At the point of regions, the unit of household waste generations in Middle East is small as 0.284 to 0.540kg/person/day and its range is narrow. Whereas that unit in Europe is large as 0.654 to 0.843kg and its range is narrow as in Middle East. However, the ranges of those units in East Asia, South Asia and Middle and South America are wide. The reason would be that these regions have the various cultures and lifestyles compared to Middle East and Europe.

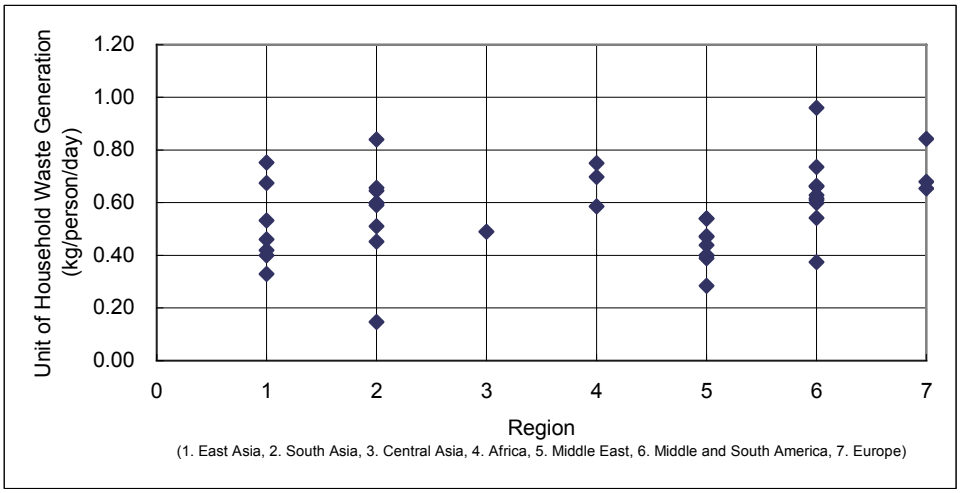


Figure 17: Unit of Household Waste Generation in Each Region

b.2 Unit of Household Waste Generation and Economic Level

The units of household waste generation are classified as the economic level (Figure 18). There is not a clear relationship of the unit of household waste generation with the economic level. In the case of the sum total waste generation, the ratio of business wastes has a close relationship with the economic level. However, in the case of household waste, it would be greatly affected by the lifestyle and habitats more than the economic level.

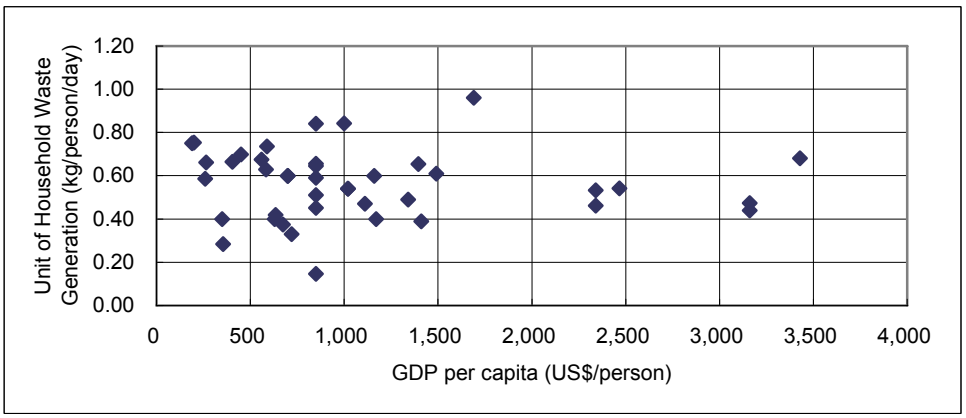


Figure 18: Unit of Household Waste Generation and Economic Level

Accordingly, this report analyzes the relationship between the unit of household waste generation and the economic level among the regions which have similar lifestyles and habitats (Figure 19, Figure 20 and Figure 21). Concerning Africa and Europe, these regions are exceptions for this analysis because they have only three data respectively.

Figure 19 shows the case of Asian region. The plots are scattered and a clear tendency is not found among East Asia, South Asia and Central Asia.

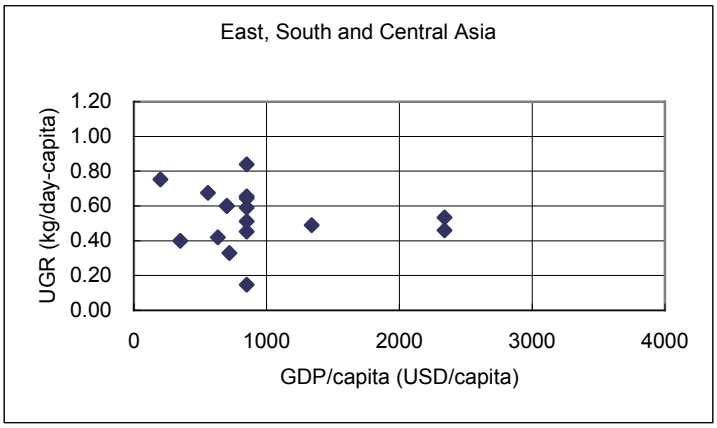


Figure 19: Unit of Household Waste Generation and Economic Level in Asian Region

In Middle East, the unit of household waste generation tends to increase gently as the economic level becomes high as shown in Figure 20.

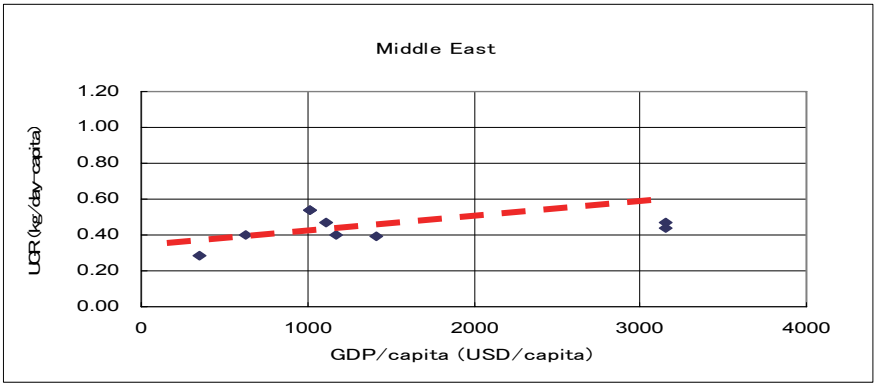


Figure 20: Unit of Household Waste Generation and Economic Level in Middle East

In Middle and South America, it is not a clear tendency, however, it seems that a tendency is the same as Middle East with a wide range (Figure 21).

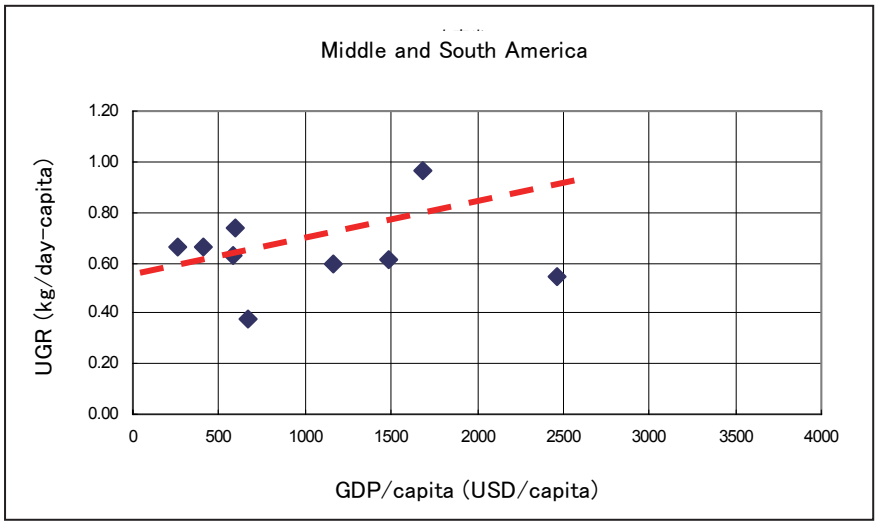


Figure 21: Unit of Household Waste Generation and Economic Level in Middle and South America

The tendencies in Middle East and Middle and South America are recognized as the unit of household waste generation increases according to the economic level although there are not any tendencies in Asian region. This is because the lifestyle is not diverse in Middle East and Middle and South America. Therefore these regions have a relationship between the unit of household waste generation and the economic level.

In order to establish the plan for waste management, estimation of waste generation is essential. It is necessary to establish a method for estimating the unit amount of waste generation. Therefore, the survey for waste generation in these cities mentioned above needs to be implemented continuously and the results also need to be examined with the estimation. It is required that the practical estimation method will be established with such examinations.

c. Unit of Conversion Amount of Business Waste Generation per Person per Day and Economic Level

The unit amount of business waste generation is calculated as dividing the rest of the sum total except for household wastes by population. Contrary to the unit of household waste generation, the unit of business waste generation increases according to GDP as Figure 22.

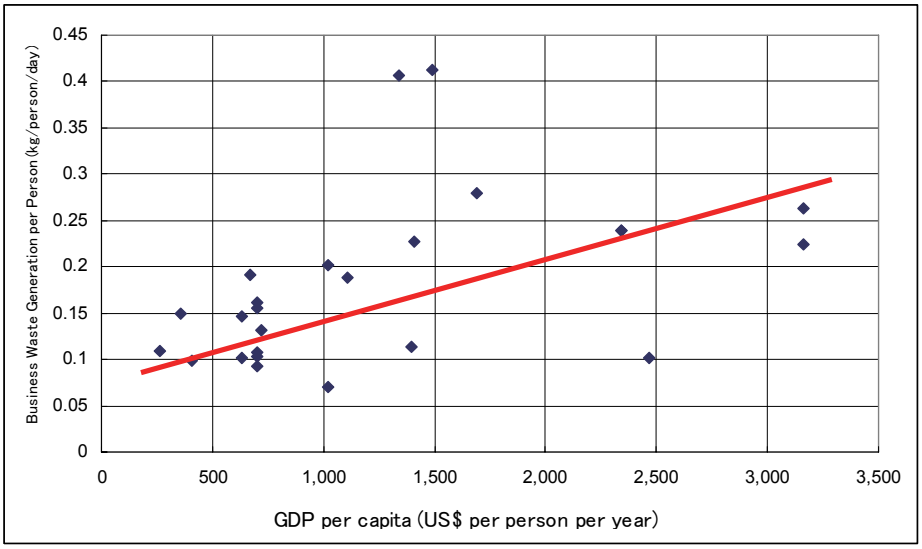


Figure 22: Unit of Business Waste Generation per Person and Economic Level

From this point of view, the unit of business waste generation has a strong correlation with the economic level. This correlation should be considered for estimating the future waste amount.

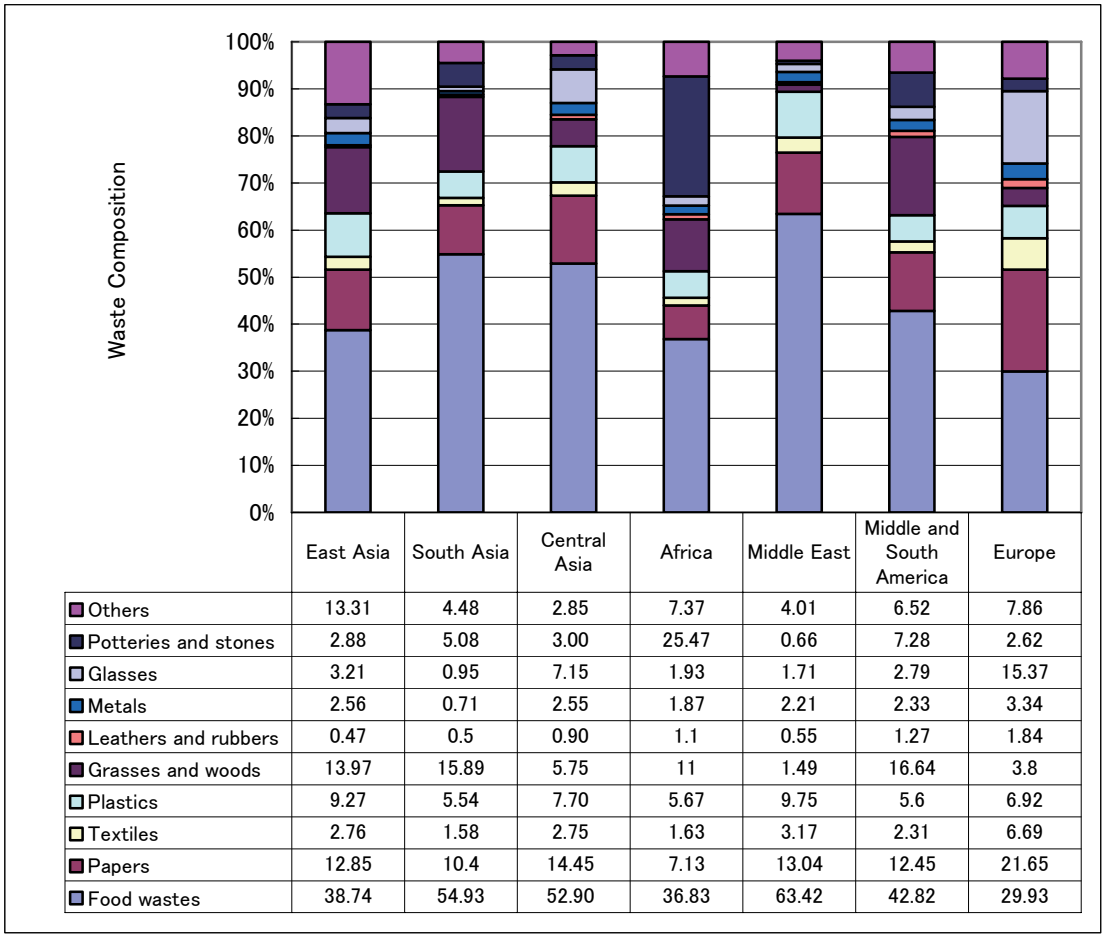
2.4 Composition (Quality) of Waste

a. Quality of Wastes in Each Regions

Quality of wastes resulted in each survey are summarized in each region presented as Figure 23, Figure 24 and Figure 25.

Figure 23 shows the comparison of the average composition of waste by regions. The ratio of food

wastes in Middle East is the highest as 63.4%. And the ratios in South Asia, Central Asia and Middle and South America follow the ratio in Middle East. The ratios of grasses and woods in East Asia, South Asia and Middle and South America are relatively high as about 15%, whereas the ratios in Europe, Middle East and Central Asia are relatively low.



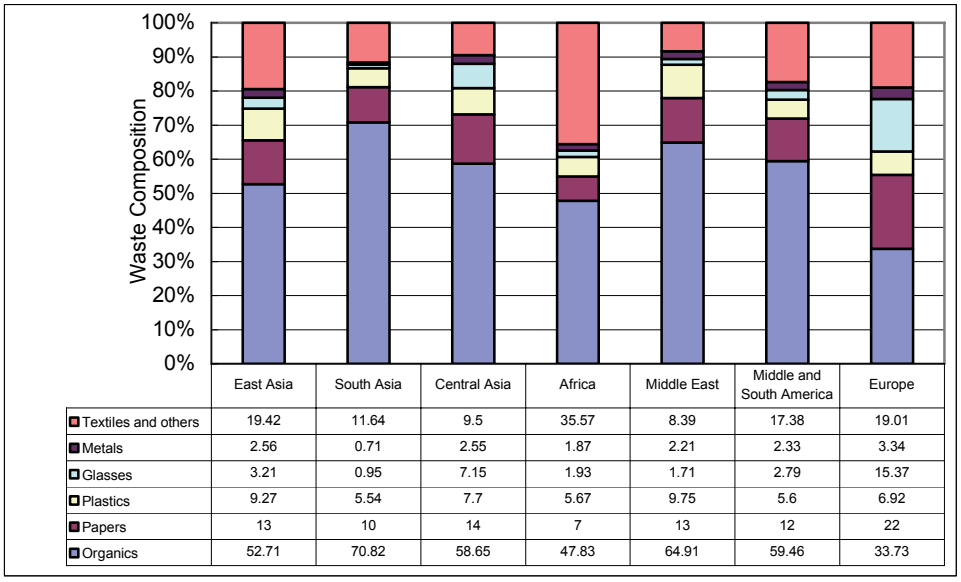
	East Asia	South Asia	Central Asia	Africa	Middle East	Middle and South America	Europe
Others	13.31	4.48	2.85	7.37	4.01	6.52	7.86
Potteries and stones	2.88	5.08	3.00	25.47	0.66	7.28	2.62
Glasses	3.21	0.95	7.15	1.93	1.71	2.79	15.37
Metals	2.56	0.71	2.55	1.87	2.21	2.33	3.34
Leathers and rubbers	0.47	0.5	0.90	1.1	0.55	1.27	1.84
Grasses and woods	13.97	15.89	5.75	11	1.49	16.64	3.8
Plastics	9.27	5.54	7.70	5.67	9.75	5.6	6.92
Textiles	2.76	1.58	2.75	1.63	3.17	2.31	6.69
Papers	12.85	10.4	14.45	7.13	13.04	12.45	21.65
Food wastes	38.74	54.93	52.90	36.83	63.42	42.82	29.93

Figure 23: Quality of Wastes in Each Region

The quality of wastes in developing countries is shown Figure 24 and that quality in developed countries is shown in Figure 25. To compare these qualities, this report arranges the items as “organics” consists of food wastes and grasses and woods, “textiles and others” consists of textiles, leathers, rubbers, potteries, stones and others (OECD Environmental Data Compedium 2002 appears at the end of this report).

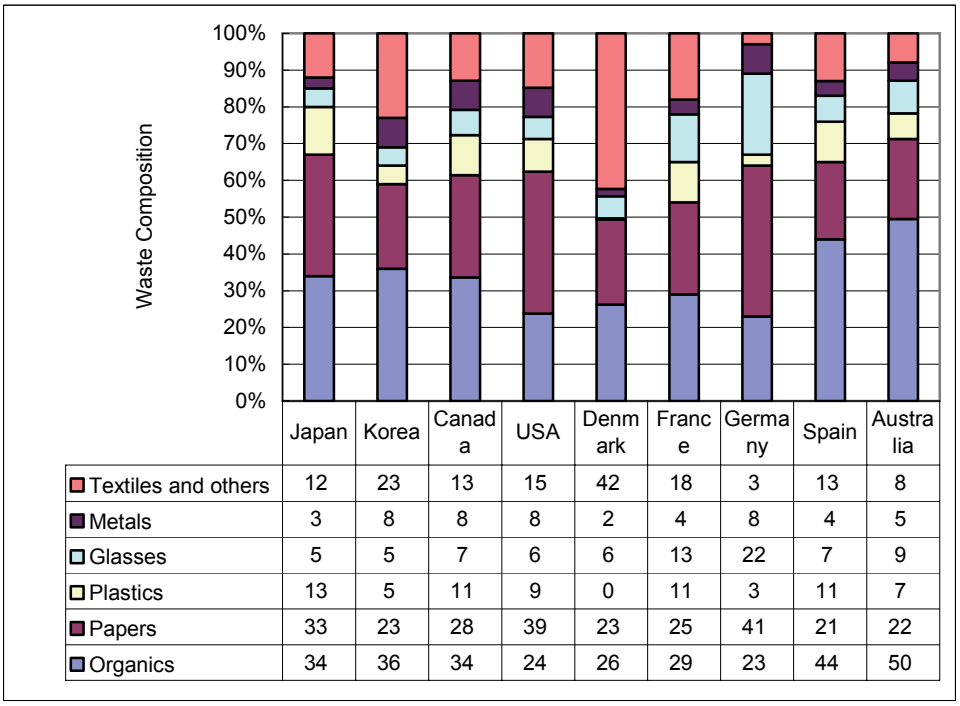
The ratio of organics in developing countries except for Europe is 50 to 70% and it is higher than that in developed countries as about 30% (only 44% in Spain and 50% in Australia). However, the ratio of papers in developing countries is about 10% and it is lower than that ratio in developed countries as about 30%. The ratio of plastics in developing countries is 5 to 10% and it is mostly same as that ratio in developed countries as 0 to 13% (the ratio in Japan is the highest of all).

In this report, Europe is categorized as a developing country, however the composition of wastes in Europe is similar to the composition in developed countries. It can be said that the lifestyle in the assisted countries in Europe is mostly equal to that of developed countries although their economic levels are low.



	East Asia	South Asia	Central Asia	Africa	Middle East	Middle and South America	Europe
Textiles and others	19.42	11.64	9.5	35.57	8.39	17.38	19.01
Metals	2.56	0.71	2.55	1.87	2.21	2.33	3.34
Glasses	3.21	0.95	7.15	1.93	1.71	2.79	15.37
Plastics	9.27	5.54	7.7	5.67	9.75	5.6	6.92
Papers	13	10	14	7	13	12	22
Organics	52.71	70.82	58.65	47.83	64.91	59.46	33.73

Figure 24: Quality of Wastes in Developing Countries



	Japan	Korea	Canada	USA	Denmark	France	Germany	Spain	Australia
Textiles and others	12	23	13	15	42	18	3	13	8
Metals	3	8	8	8	2	4	8	4	5
Glasses	5	5	7	6	6	13	22	7	9
Plastics	13	5	11	9	0	11	3	11	7
Papers	33	23	28	39	23	25	41	21	22
Organics	34	36	34	24	26	29	23	44	50

Figure 25: Quality of Wastes in Developed Countries

Reference: OECD Environmental Data Compedium 2002 (Japanese data is in 2000 and others are in 1995)

b. Quality of Wastes and Economic Level

In order to confirm the relationship between the quality of wastes and the economic level, this report focuses on the relationship between GDP per capita and the ratio of food wastes, paper wastes and plastic wastes respectively.

b.1 Food Wastes

The ratio of food wastes are plotted in the range as 10 to 70% as Figure 26 and it does not have any relationships with the economic level.

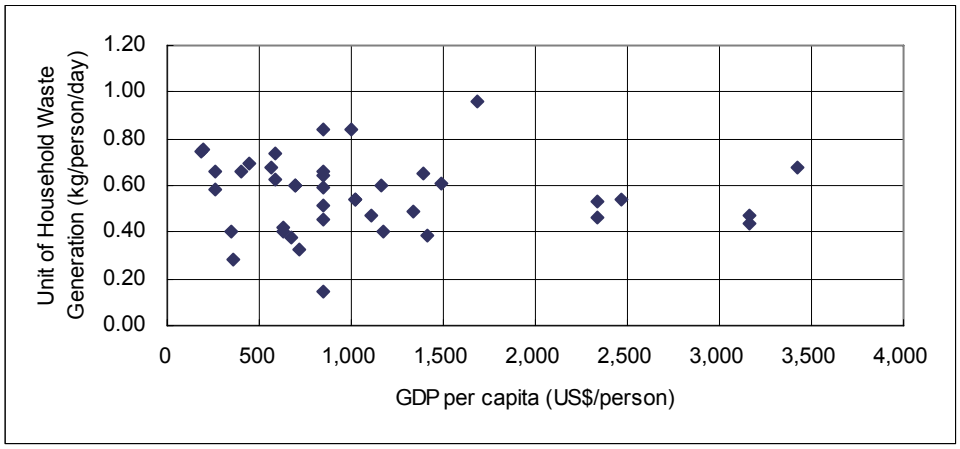


Figure 26: Ratio of Food Wastes and GDP per Capita

b.2 Paper Wastes

The ratio of paper wastes is under 25% and it seems to be plotted regardless with the economic level. However, in cities which GDP per capita is less than US$1,000, the ratio of paper wastes in some cities is under 5%. And in cities which GDP per capita is more than US$1,000, the ratio of paper wastes in all cities is over 5%.

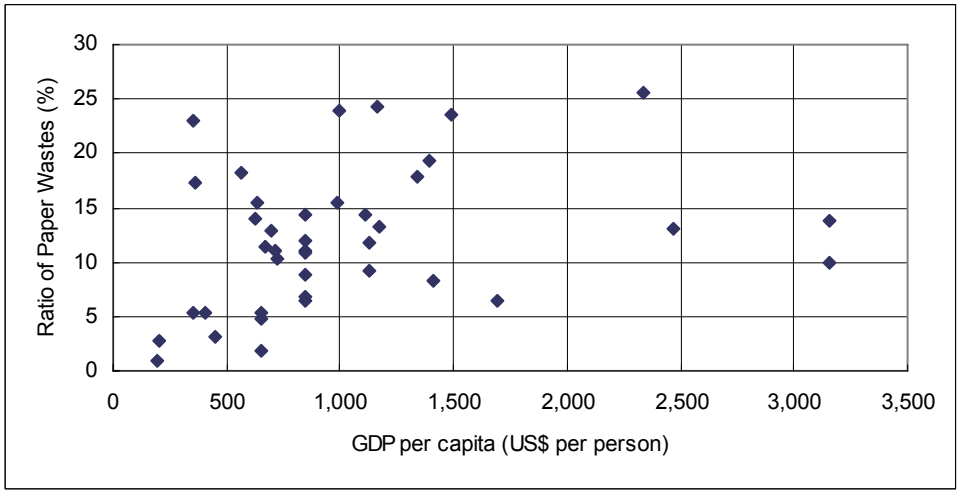


Figure 27: Ratio of Paper Wastes and GDP per Capita

b.3 Plastic Wastes

The ratio of plastic wastes is generally under 15% regardless with the economic level except for the ratio of Aleppo in Syrian as 36%. That ratio in most cities is under 10%.

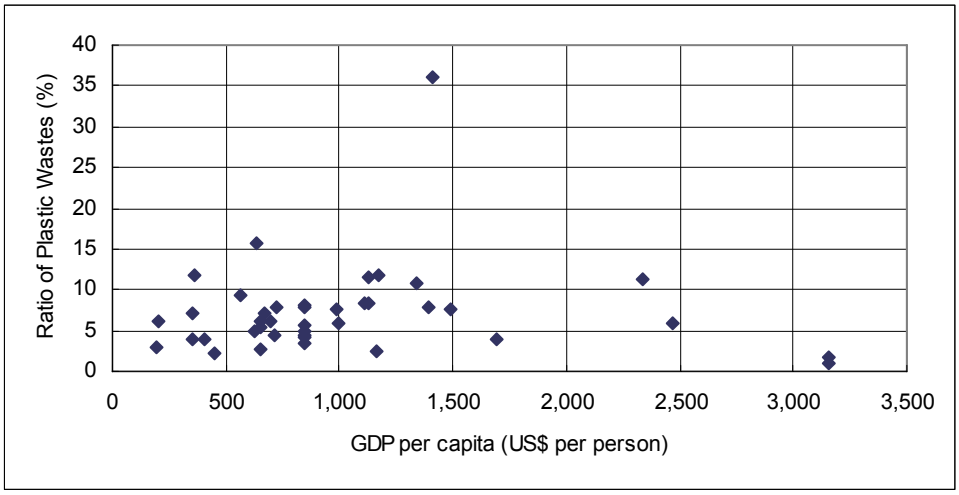


Figure 28: Ratio of Plastic Wastes and GDP per Capita

c. Ratio of Valuables

In general, it is said that the ratio of valuables (the sum of metals, glasses, papers and plastics) in developing countries is less than that ratio in developed countries. The ratio of valuables in developing countries is shown in Table 5: Ratio of Valuables in Wastes in Developing Countries and that ratio in developed countries is shown in Table 6: . The ratio of valuables in developing countries is in the range as 17 to 32% whereas that ratio in developed countries is in the range as 31 to 74%. That ratio in developing countries is obviously low and this fact proves the generality.

Table 5: Ratio of Valuables in Wastes in Developing Countries

Region	East Asia	South Asia	Central Asia	Africa	Middle East	Middle and South America	Europe
Valuables (%)	27.89	17.6	31.85	16.6	26.71	23.17	47.28

Reference: the sum total of papers, plastics, glasses and metals in Figure 24.

Table 6: Ratio of Valuables in Wastes in Developed Countries

Country	Japan	Korea	Canada	USA	Denmark	France	German	Spain	Australia
Valuables (%)	54	41	54	62	31	53	74	43	43

Reference: the sum total of papers, plastics, glasses and metals in Figure 25.

This report plots the ratio of valuables in developing countries on each economic level (GDP per capita) as Figure 29. As a result, it can be said as a whole that the ratio of valuables increases according to the economic level although the result has dispersion.

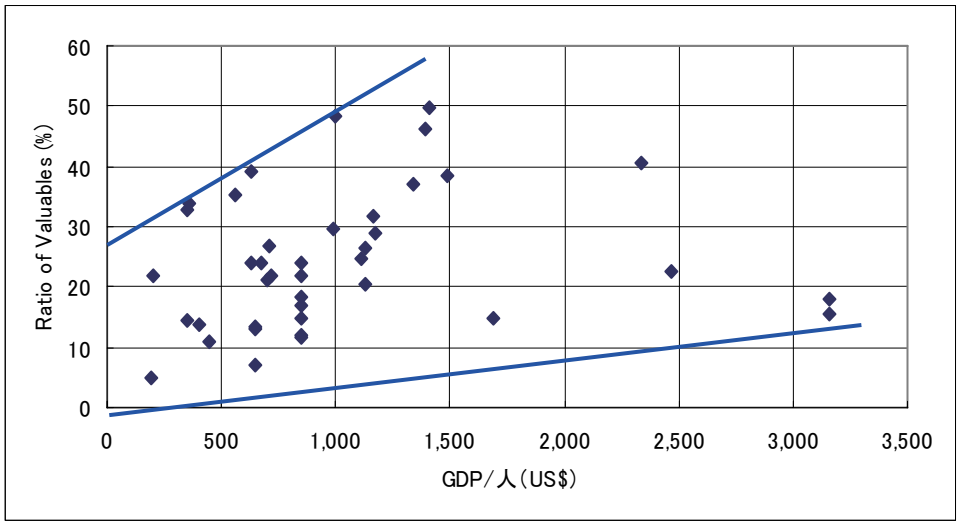


Figure 29: Ratio of Valuables and Economic Level

d. Apparent Specific Gravities

As Figure 21, the apparent specific gravities in target cities are plotted in the range from 0.16 to 0.58 kg/L and most of them are in the range from 0.2 to 0.4 kg/L. The average is 0.30kg/L. The reason why the apparent specific gravity in Africa is larger than other regions would be that the ratio of pottery and stones is high in Africa (see Figure 30).

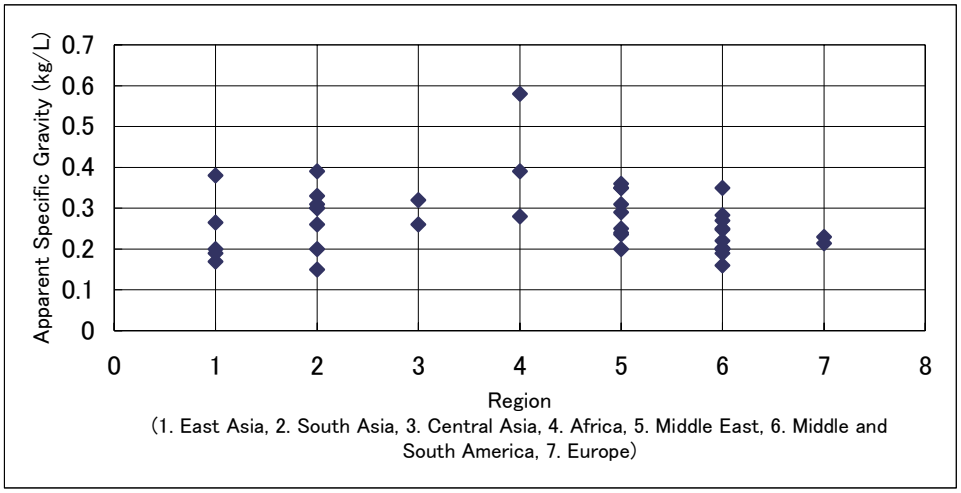


Figure 30: Apparent Specific Gravity in Each Area

e. Net Calorific Value

It is not common that incineration is a component as intermediate treatment in SWM plan in developing countries because of the high initial and running cost, technical difficulty, and so on. Therefore the data of net calorific value are collected from only one forth of all target cities. Among the data this report collected, the highest value was 1,864 kcal/kg in Poznan (Poland) and the lowest was 753 kcal/kg in Metro Guatemala (Guatemala).

2.5 Collection and Transportation

The collection rate in each city is plotted according to its economic level in Figure 31. As a whole, the collection rate is getting higher and higher according to the economic level although the collection rates in several cities which GDP per capita is lower than US$1,500 spread out as from 20 to 100%. However, there are many cities which succeed in the high collection rate even though their economic level is not so high.

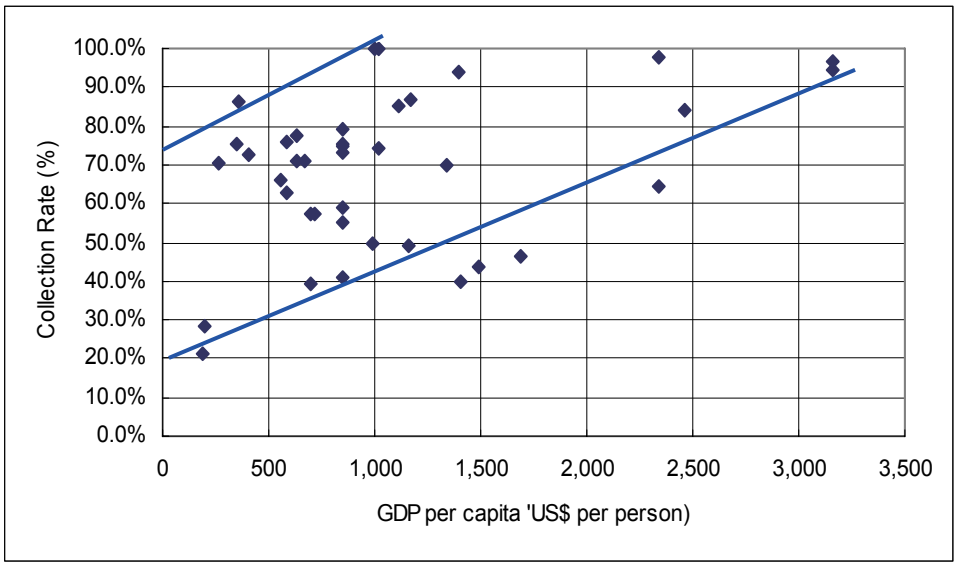


Figure 31: Collection Rate and GDP per Capita

2.6 Recycling

Regarding the situation of recycling in developing countries, the informal sector mainly collects valuables at the generation source, collection process and landfills. Table 7 presents three ratios; the ratio of valuables (refer as A), which is the ratio of papers, plastics, metal and glasses in total waste generation, the recycling rate (refer as B), which is the ratio of the recycling amount at generation source, collection process and landfills in total waste generation and the ratio "A/B". Here there are several cases in which the ratio "A/B" is more than 100% because recycling in these cases includes food waste recycling and compositing.

Table 7: Situation of Recycling in Developing Countries

Country	City	Ratio of Valuables (A)	Recycling Rate (B)	A/B	Note
Laos	Vientiane	21.9%	16.9%	77.2%	Including food waste recycling
Indonesia	Ujung Pandang	21.8%	3.2%	14.6%	
Philippine	Metro Manila	39.2%	6.1%	15.6%	

Sri Lanka	Budulla	16.8%	19.5%	116.1%	Including food waste recycling
Sri Lanka	Chilaw	12.0%	4.5%	37.9%	
Sri Lanka	Gampaha	24.1%	20.4%	84.5%	
Sri Lanka	Kandy	21.9%	9.2%	41.8%	
Sri Lanka	Matale	11.5%	9.4%	81.5%	
Sri Lanka	Negombo	15.0%	13.2%	88.2%	
Sri Lanka	Nuwara Eliya	18.4%	13.8%	75.0%	
Tanzania	Dar es Salaam	10.8%	6.8%	62.7%	
Egypt	Alexandria	33.0%	0.7%	2.0%	
Egypt	Alexandria	24.0%	2.8%	11.5%	
Syria	Lattakia + surrounding three cities	20.3%	5.2%	25.5%	
Syria	Homs	26.4%	4.9%	18.6%	
Syria	Aleppo	24.6%	9.4%	38.2%	
Turkey	Metro Adana	15.4%	5.9%	38.3%	
Turkey	Metro Mersin	18.1%	10.6%	58.6%	
Nicaragua	Managua	13.9%	4.4%	31.8%	
Nicaragua	Leon	13.2%	17.3%	131.6%	Including food waste recycling
Nicaragua	Chinandega	7.1%	11.2%	156.7%	Including food waste recycling
Nicaragua	Granada	13.6%	8.8%	64.6%	
Honduras	Tegucigalpa	24.0%	4.0%	16.8%	
Paraguay	Metro Asunción	14.7%	7.8%	53.2%	
El Salvador	Metro San Salvador	22.5%	1.5%	6.9%	
Mexico	Mexico City	46.2%	16.9%	36.5%	

On the other hand, the situation of recycling in Japan is shown in Table 8 and Figure 32 referred form “Waste Management in Japan (FY2002)” by Waste Management and Recycling Dept. of the Ministry of the Environment. The recycling rate in this statistic is the recycling amount divided by the sum of the total treatment amount and the community recycling amount. Compared to this recycling rate in Japan, the recycling rate in Table 16 is calculated as lower because the recycling amount is divided by the waste generation. However, there are five cities in twenty six cities of

developing countries (18% of developing countries) which recycle rates exceed the Japanese recycle rate as 15.9% in 2002. The recycle rates in nine cities of all developing countries (35% of all) exceed 10%. As has been noted, it can be said that the recycling activity in developing countries is mostly in the same level as that in developed countries. However, the recycling activity can be affected by the development of the recycling industry. Therefore it is required before making a recycling plan in developing countries to investigate the situation of the industry supporting the recycling activity because the foundation of the recycling industry is not stable.

Table 8: Recycling Rate and Total Amount of Valuables in Japan

FY		FY1993	FY1994	FY1995	FY1996	FY1997	FY1998	FY1999	FY2000	FY2001	FY2002
Recyclable amount by municipal authorities	(1,000t/year)	2,195	2,566	2,782	2,995	3,345	3,970	4,438	5,095	5,410	5,831
Recyclable amount after intermediate treatment	(1,000t/year)	2,195	2,566	2,782	2,995	3,345	2,360	2,595	2,871	3,116	3,503
Direct recycling amount	(1,000t/year)	-	-	-		-	1,610	1,833	2,224	2,294	2,328
Community recycling amount	(1,000t/year)	1,920	2,135	2,318	2,470	2,515	2,521	2,604	2,765	2,837	2,807
Total recyclable amount	**(1,000t/year)**	**4,115**	**4,701**	**5,100**	**5,465**	**5,860**	**6,491**	**7,032**	**7,860**	**8,246**	**8,638**
Total treatment amount	(1,000t/year)	49,338	49,664	49,899	50,443	50,573	51,107	51,191	52,090	51,961	51,445
Total waste generation	(1,000t/year)	50,304	50,536	50,694	51,155	51,200	51,595	51,446	52,362	52,097	51,610
Recycling Rate	**(%)**	**8.0**	**9.1**	**9.8**	**10.3**	**11.0**	**12.1**	**13.1**	**14.3**	**15.0**	**15.9**

Note)

- "Recyclable amount after intermediate treatment" means the recycled amount of collected metals, such as steel and aluminum, after the treatment of recyclable wastes, bulky wastes and so on.
- "Community recycling amount" is not included as total waste generation and indicates the collected amount by residents groups, which are in a register of municipal authorities, with the equipments and the subsidies of municipal authorities.
- It is supposed that "Direct recycling amount" was included in "Recyclable amount after intermediate treatment" by FY1997.
- Recycle Rate (%) = [Direct recycling amount + Recyclable amount after intermediate treatment + Community recycling amount] / [Total treatment amount + Community recycling amount]

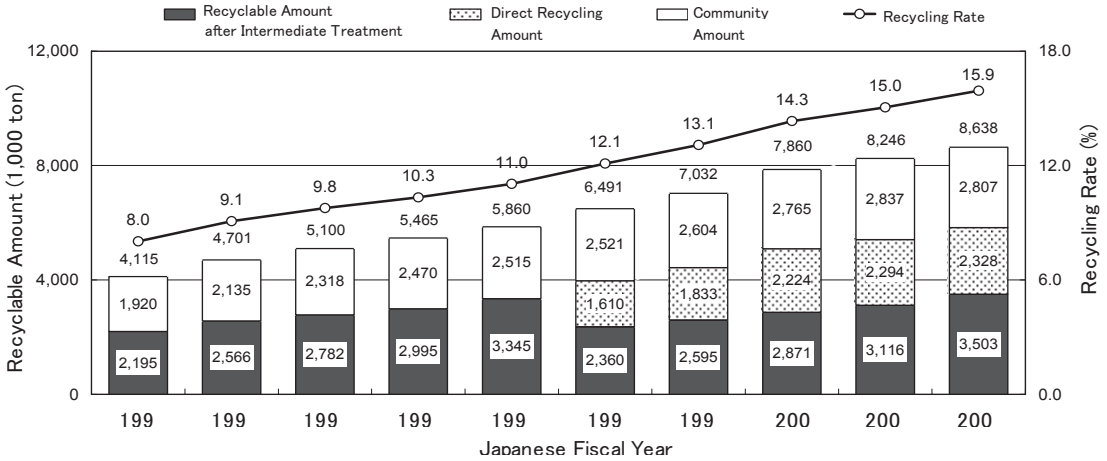


Figure 32: Annual Change of Total Recycling Amount and Recycle Rate

2.7 Budget for Waste Management

In Japan, the budget for waste management in FY2002 was 239.56 billion yen based on the annual expenses of municipal authorities and regional affairs associations. It occupies 4.6% of all annual expense of municipal authorities, and it can be calculated as 19,000 yen (about US$172) per person[4].

The municipal budget per person in developing countries increases according to the economic level as shown in Figure 33. However, the budget of waste management per person in each city is mostly less than US$15 regardless of the economic level, except for that of Malaysia as US$33.6 and US$18.5 (Figure 34).

[4] Referred from the statistics by Ministry of Internal Affairs and Communications

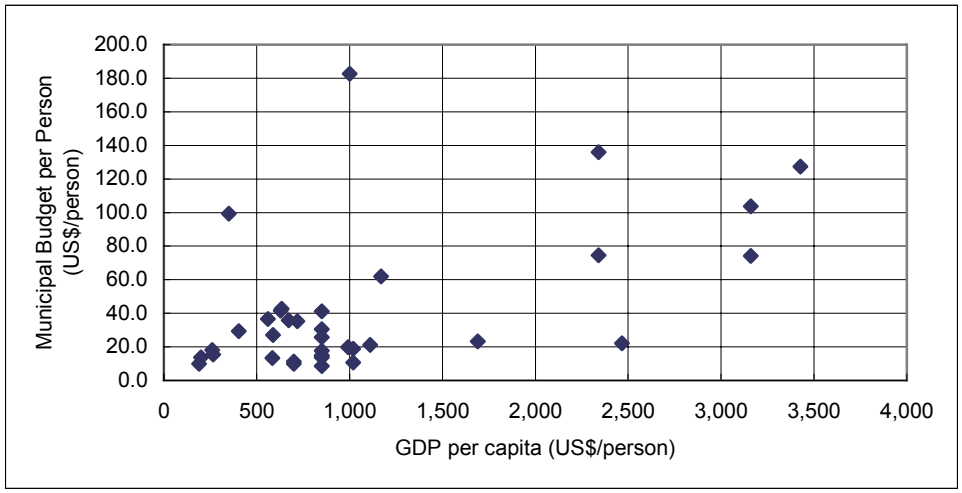


Figure 33: Municipal Budget and GDP per Person

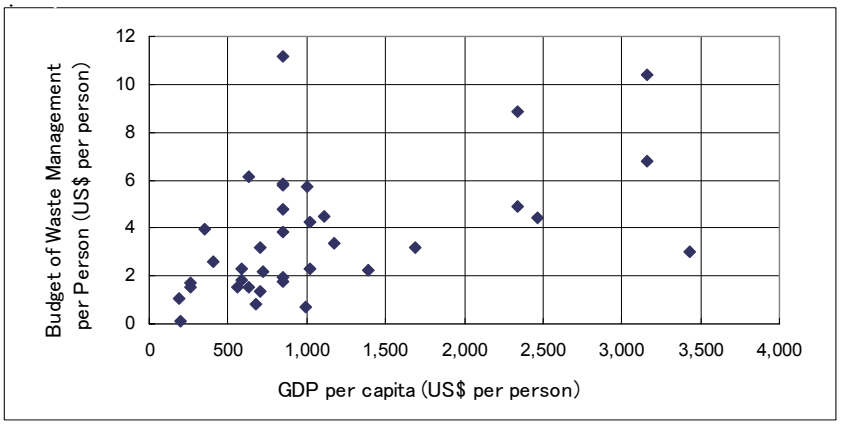


Figure 34: Budget of Waste Management and GDP per Person

Cities, which GDP per capita is in the range from US$500 to US$1,000, have the highest ratio of the budget of waste management to the whole municipal budget in. The maximum ratio is 35%.

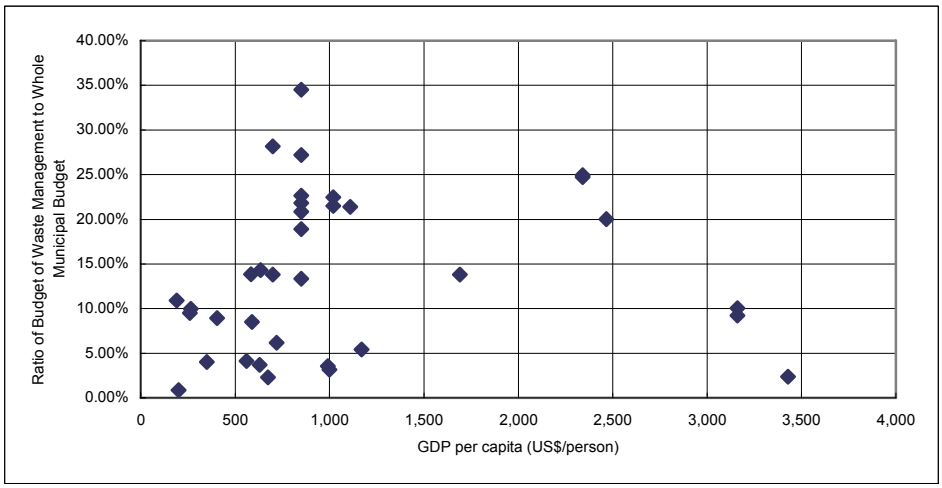


Figure 35: Ratio of Budget of Waste Management to Whole Municipal Budget

Figure 36 shows the ratio of the budget of waste management to GDP in each economic level. According this result, all plots are under 0.2% of GDP except for that of Mexico City as 0.511%. For reference, GDP per capita in Japan is US$30,733[5] and the budget of waste management per person is US$150.1 in FY2002. Therefore the ratio of the budget of waste management to GDP is 0.277%.

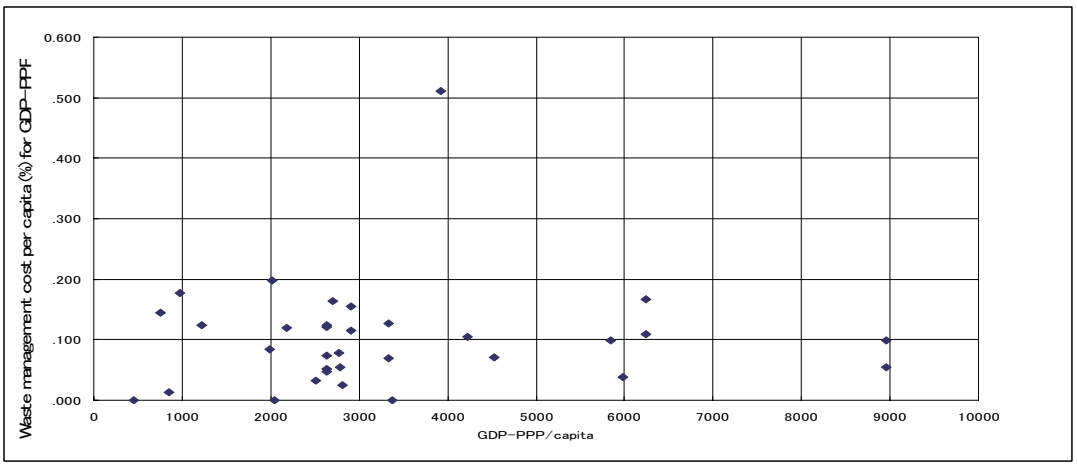


Figure 36: Ratio of Budget of Waste Management to GDP

[5] Reference: World Statistics edited by Statistical Research and Training Institute, Ministry of Internal Affairs and Communications, and issued by Statistics Bureau, Ministry of Internal Affairs and Communications

Generally, the budget of waste management increases according that the economic level becomes higher. However, that budget in the cities, which GDP per capita is under US$4,000, is limited at the minimum just for waste transportation from the center of each city.

Figure 37 shows the budget of waste management per ton according to the economic level. All plots are under US$40 regardless of the economic level except for the two plots of Malaysia. And most of all plots are under US$30.

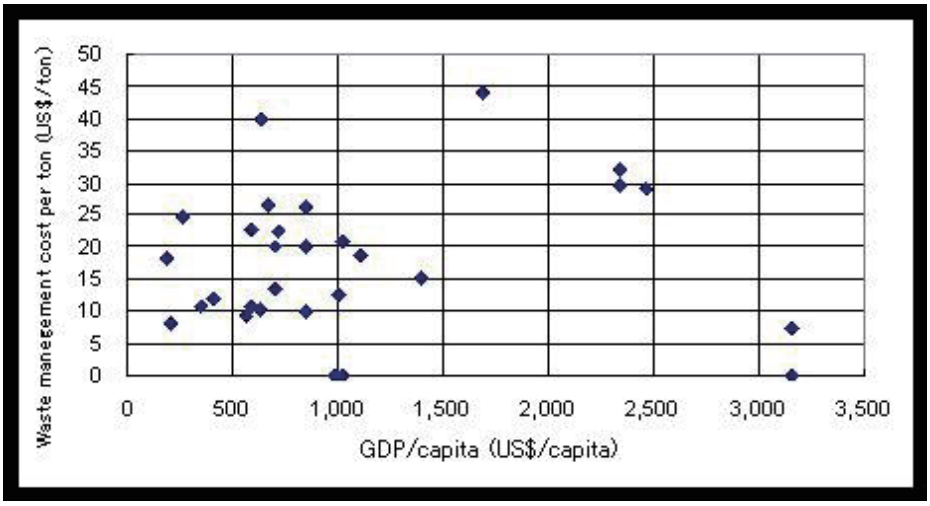


Figure 37: Budget of Waste Management per Ton and Economic Level

2.8 Contract to Private Sector

Twenty three cities in investigated forth seven cities make contract to the private sector about a part of collection and transportation. Among them, some cases are just to rent (and to maintain sometimes) equipments and just to collect by hand.

It is impossible to show precisely that the contract to private sector contributes to the low cost and the high collection rate because there are seldom to report the comparison before and after the contract to private sector. Among the collected data, the average collection rate in cities without the

contract to the private sector is 53%, whereas the average in cities with the contract is 80%. It is clear difference, however it is not confirmed that the private sector provides the collection service fully in all target areas, such as in the slum area which can be seen in most of all developing countries and low-income people live in. It is because one of the conditions to implement the service is to be profitable for private sector.

Consequently it needs to be careful to propose the introduction of the contract to private sector in preparing the Master Plan and in other cases. If entry of the private sector is allowed, it is desirable that municipal authorities are capable to manage and control the service by the private sector. However, generally the capacity of municipal authorities in developing countries does not reach the level as mentioned above. This is one of the reasons why the capacity development for waste management is important. Although the human resources and budget in municipal authorities are limited, it will be effective as one of the methods for support to establishment the management system with public involvement of beneficiaries, such as residents and communities.

Zabbaleen in Egypt

In Egypt, there is a traditional job, which is called as "zabbaleen", to collect wastes and to sell valuables. People in pursuance of this job contract with citizens directly, and make a living by collecting wastes with collection fee from citizens and selling valuables picked up in collected wastes. Also they use food wastes for raising livestock and sell the livestock.

Zabbaleen do not receive any payment for consignment from the waste management implementation agency, that is, the municipal authority. It means that zabbaleen is not a form of contract to the private sector. However, zabbaleen needs to receive permission from the waste management implementation agency to specify the target area, households and other items for their activity. Moreover the waste management implementation agency makes the area/households permitted for zabbaleen's activity as exceptions for the target of public collection. Accordingly their activity can be classified as one form of contracts to the private sector because their activity is carried out with some limitation by the public sector.

In Alexandria City, the activity of zabbaleen tends to decrease, and it is regarded that they treat only several percentage in all waste generation. [*3–6]

[*3–6] In Cairo, which is the capital city in Egypt and not a target city of this report, "zabbaleen" is still active and their activity cannot be ignored because they deal with more than 20% of all waste generation. Also in India, there is a job (called as a sweeper caste) which is mostly same as "zabbaleen".

3 Recommendations on Effective and Efficient Implementation of Solid Waste Management Study in Developing Countries

3.1 Visualization of the Current SWM Status with Waste Flow Chart

Identification of the current SWM is an essential part of solid waste management planning and of great importance in terms of clarifying the current issues of SWM. Most of the JICA studies on SWM spent about the initial 3 to 4 months for identification of the current SWM conditions through a series of on-site surveys on waste amount and composition, time and motion on solid waste collection, public opinion on SWM, and so forth.

Based on the results of the surveys above, the current SWM system can drawn in the form of a waste flow chart, as shown in Figure 38, to visualize the flow of solid waste from generation at sources to its final destination. The waste flow chart helps identifying the current issues of SWM and possible measures for their improvement. This section discusses the methodology for formulating the waste flow chart.

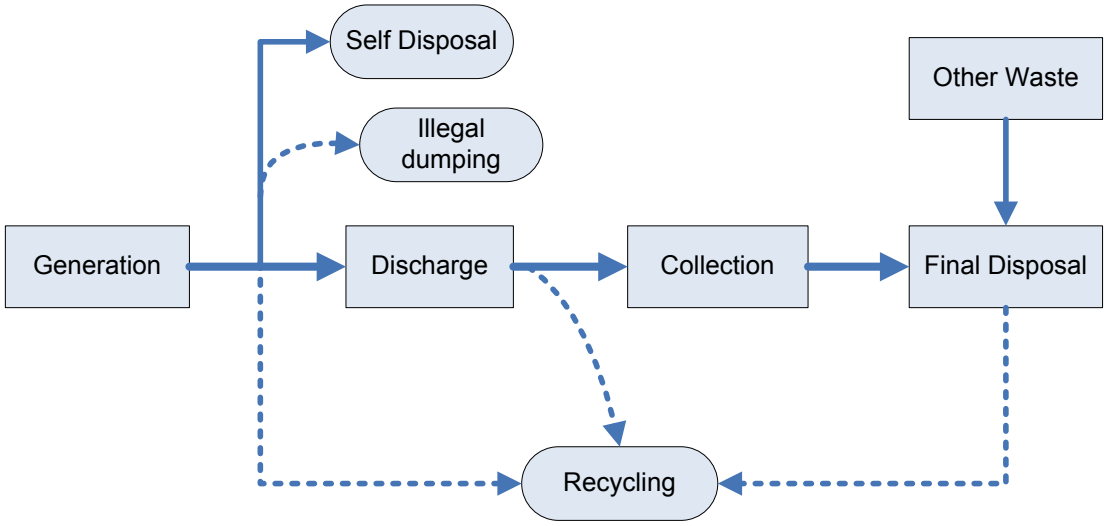


Figure 38: Waste Flow Chart

3.1.1 Methodology for Formulation of Waste Flow Chart

a. Estimation of Waste Generation and Final Disposal

The first step of waste flow chart formulation is to estimate the total generation and final disposal of waste. There is always the difference in amount between waste generation and final disposal since a considerable amount of waste generated is reduced through recycling or intermediate treatment of waste before being brought to final disposal landfills. Such waste stream between the generation at sources and final disposal is to be identified through the surveys on recycling, intermediate treatment and other relevant activities.

a.1 Estimation of Waste Generation

Waste generation is estimated as the summation of the product of per unit waste generation and number of units. If the waste amount and composition survey (WACS) is conducted, per unit waste generation can be determined by types of generation units (see Table 13 as an example) while the number of unit will be determined on the basis of available statistical information and data on the unit.

Household waste generation can be estimated as the product of per capita waste generation, which will be determined based on the result of WACS, and population. Although the current and future population data is available from census or other statistics in most of the country, it is necessary to obtain consensus among the relevant stakeholders on the population data to be used for estimation of the total household waste generation.

Waste generation from non-household sources (mainly businesses) involves some difficulties in its estimation due to the lack of statistical data on number of business establishments and variety of waste generation characteristics among types of businesses. Therefore, a simplified method of estimating waste generation from non-household sources is introduced below.

First of all, per unit collection is estimated as the result of dividing the total amount of waste collection by the population serviced with that waste collection. The product of this per unit collection and the total population in the municipality (including serviced and non-services areas) can be estimated as the total waste generation in the municipality. Therefore, the difference between this total waste generation and the household waste generation estimated above can be regarded as the waste generation from non-household sources.

In the case of estimating the waste generation in low-income area such as slums, it is not necessary to separately estimate waste generation from non-household sources since the majority of such area is composed of households.

a.2 Estimation of Final Disposal Amount

The total amount of final disposal is estimated based on the weighbridge (track scale) record at final disposal landfills or the record of the number of carry-in track trips. In the case of JICA SWM studies, a weighbridge is sometimes installed at the final disposal landfill. In such a case, the final disposal amount can be accurately estimated based on registration of all carry-in tracks into computerized database and weighing every carry-in track.

If the weighbridge is not available, the final disposal amount needs to be estimated based on the counting of carry-in track trips. In this case, the loading capacity (pay load) of carry-in tracks has to be identified by each type with the weighbridges that are usually available at oil refineries or port facilities. Based on the data of loading capacity by types of waste collection tracks, the total final disposal amount of waste can be estimated as the result of multiplying the number of carry-in track trips by their loading capacities.

b. Waste Stream between the generation at sources and final disposal

Possible destinations of waste before its final disposal include on-site treatment/disposal, recycling (at sources, in collection process, and waste picking at final disposal sites), intermediate treatment, illegal dumping, and so forth. There are also the wastes directly brought to the landfills from factories, which are not defined as municipal solid waste. To identify such waste stream, supplementary surveys are required such as public opinion survey (POS) on waste, interview and questionnaire surveys on waste collection workers, recyclers, waste pickers, hospitals/clinics, and industries. As to the amount of illegal dumping, it is usually only possible to estimate as the unknown waste that cannot be identified through all the surveys conducted.

3.1.2 Methods of Waste Flow Analysis for Identifying Waste Management Issues

Based on the three examples shown below, this section discusses how to identify the waste management issues with waste flow analysis. The 3 examples discussed here are:

- Vientiane, Lao People's Democratic Republic,
- Asuncion, Republic of Paraguay, and
- Adana, Republic of Turkey

a. Waste flow in the city with insufficient collection service (Vientiane, Laos)

While the city is estimated to generate 138.4 tons of waste daily, only 15.0 tons are collected with the collection rate of 10.8%. The remaining 123.4 tons of waste are estimated to be treated/disposed on site, recycled, or illegally disposed somewhere. The total disposal amount is estimated to be 17.1 tons per day as the sum of daily collection amount and direct disposal at the landfill (probably from factories) of 2.4 tons daily and subtracting the amount of recyclables picked up at the landfill of 0.3 ton per day.

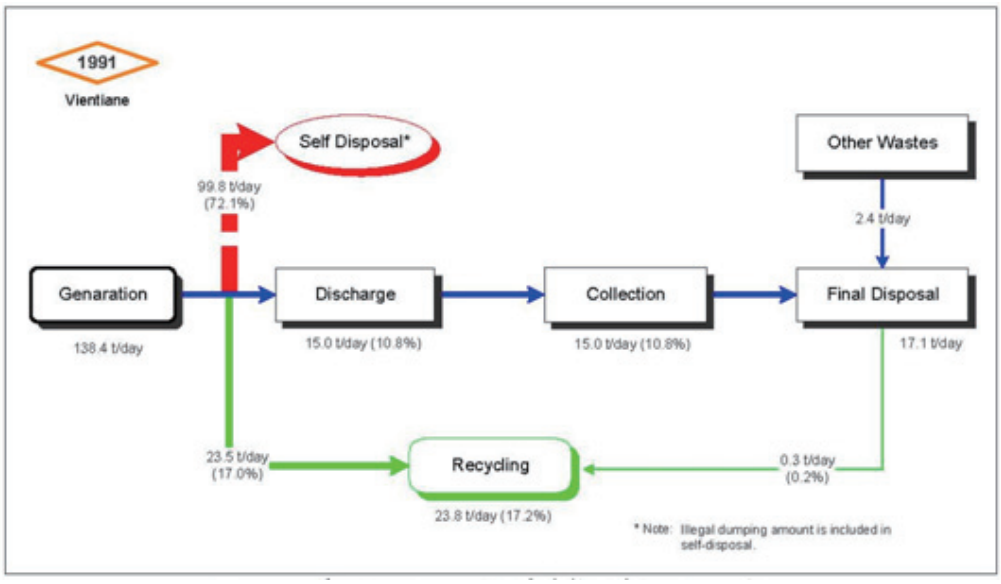


Figure 39: Waste Flow in Vientiane, Laos (1991)

This waste flow clearly shows the weakness of the current public solid waste management service by the city. It is important for proper SWM planning to further investigate and identify the specific causes and factors of such weakness, e.g. lack of collection vehicles, weak financial capacity for SWM service operation, low public awareness on waste and clean environment, etc. In this case, the following issues are identified as critical to proper SWM.

- Establishment of the enhanced waste collection system
- Establishment of the Citizen's cooperation in road sweeping, drainage clean-up and public place cleaning
- Establishment of Maintenance system for vehicles, machinery and equipment
- Sanitary landfill operation at the existing final disposal site

b. Waste flow in the city with expansion of its collection service to outer city areas (Asuncion, Paraguay)

The study area is composed of 15 municipalities with the total waste generation of 870 tons daily. The daily waste collection is 426 tons with the collection rate of 63.6%. Due to limited space for on-site treatment and disposal, the collection rate reaches almost 100% at urbanized city center. On the other hand, the outer city area has enough space for open burning and on-site disposal; therefore a considerable number of illegal dumping of waste can be found in urban/suburban borders. With the expansion of urban areas, the existing final disposal landfill located in the city center is still in operation with unsanitary manner (open dumping), of which the environmental impact becomes more and more serious with the increasing amount of waste disposal.

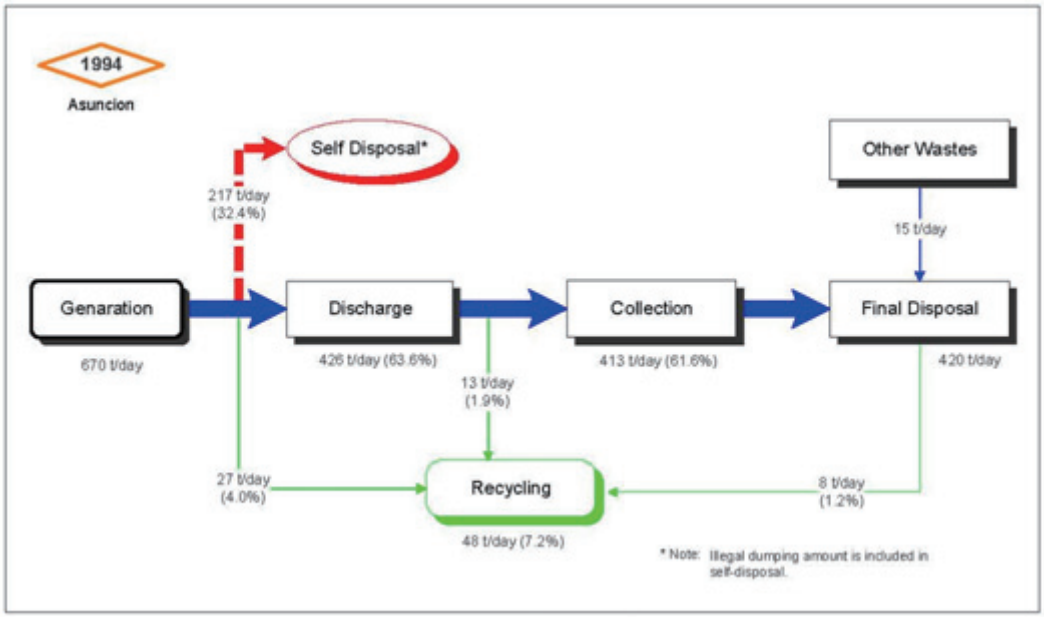


Figure 40: Waste Flow in Asuncion, Paraguay (1994)

The waste flow above implies the emerging issues of insufficient waste collection service particularly at outer city areas and proper final disposal of increased waste (420 tons per day) The SWM issues identified in this study area are:

- Improvement of waste collection at each municipality
- Efficiency improvement of waste collection and haulage
- Development of a new area-wide final disposal landfill

c. Waste flow in the city with efficient collection service (Adana, Turkey)

The city produces 834 tons of waste daily while 780 tons are collected. Including the daily recycling amount of 15 tons, the collection rate in the city reaches more than 95% with only estimated 1% of illegal dumping. There is no significant problem on waste collection. However, the average daily disposal amount of 796 tons in the city is estimated to increase potential environmental impact upon its surrounding area. In this respect, waste reduction and proper disposal with high quality sanitary landfill are the central issue of SWM in the city to minimize potential environmental impact arising from waste disposal. The key issues on SWM identified in the city include:

- Waste minimization (Segregated collection of waste, Development of recycling facilities)
- Development of new final disposal landfill and high quality sanitary operation of landfill

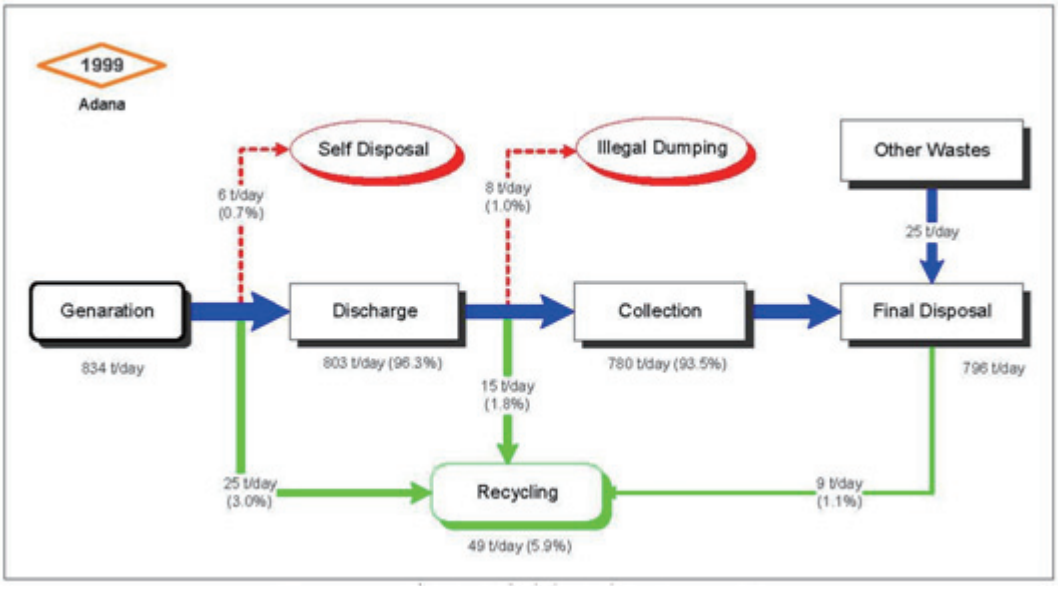


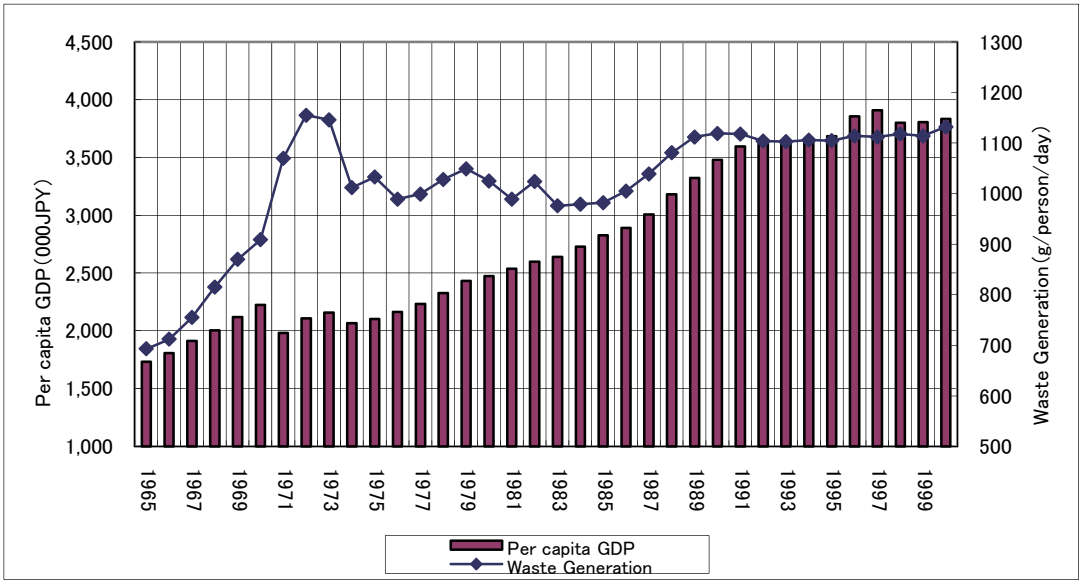
Figure 41: Waste Flow in Adana, Turkey (1999)

3.2 Estimation of the Future Waste Generation Per Unit by Utilizing Economic Indicators (GDP)

3.2.1 Waste Generation and Economic Activity Level

As far as looking into the data collected here, waste generation from non-household sources (especially from business) has highly positive correlation with the level of economic activity (GDP level). On the other hand, household waste generation has a certain level of positive correlation with the level of economic activity in Latin American and Muslim countries while it is not found in the Asian countries where every country has different and diversified socio-cultural background and lifestyles.

Observing the correlation between GDP and per capita daily waste generation in Japan (see Figure 39 below.), a highly positive correlation can be found during 1965-70 and 1986-1991, when per unit waste generation increased in correspondence with the growth of GDP. The period of 1965-70 is called as “Izanagi Economic Boom” while the period 1986-91 is famous for “Bubble Economic Boom”.



1965～1970: Izanagi Economic Boom　　1973: 1st Oil Crisis
1979: 2nd Oil Crisis　　1986～1991: Bubble Economic Boom

Figure 42: Trend of GDP and Per Capita Waste Generation in Japan

In Japan, the 1st Solid Waste Management and Public Cleansing Law, which was enacted in 1954, has been completely revised in 1970 with one of its focuses on promotion of waste minimization. Therefore, the increase of per capita waste generation in the period of "Izanagi Economic Boom" was accelerated with no legal pressure of waste minimization while the increase in the period of "Bubble Economic Boom" was somehow controlled by the revised law that promotes waste minimization. These correlations between waste generation and economic growth is very unique and interesting in estimating the future waste generation.

Table 18: Per capita GDP and Waste Generation in the Period of "Izanagi Economic Boom" and "Bubble Economic Boom"

Izanagi Economic Boom					Bubble Economic Boom				
Year	Per Capita GDP		Per Capita Waste Generation		Year	Per Capita GDP		Per Capita Waste Generation	
	000 JPY	Growth Rate	g	Growth Rate		000 JPY	Growth Rate	g	Growth Rate
1965	1,733		693		1986	2,892		1,005	
1966	1,808	4.3%	712	2.7%	1987	3,008	4.0%	1,039	3.4%
1967	1,912	5.8%	755	6.0%	1988	3,182	5.8%	1,081	4.0%
1968	2,005	4.9%	815	7.9%	1989	3,323	4.4%	1,112	2.9%
1969	2,119	5.7%	870	6.7%	1990	3,481	4.8%	1,119	0.6%
1970	2,224	5.0%	909	4.5%	1991	3,595	3.3%	1,118	-0.1%
Average	-	5.1%	-	5.6%	Average	-	4.5%	-	2.2%

As shown in the table above, the average growth rate of per capita GDP and waste generation is almost similar in the period of "Izanagi Economic Boom" (5.1% for per capita GDP and 5.6% for per capita waste generation). In the period of "Bubble Economic Boom", on the other hand, the average per capita GDP growth rate of 4.5% is almost double of the average growth rate of per capita waste generation (2.2%). Since 1991, per capita waste generation in Japan has been kept at 1.1 kg daily.

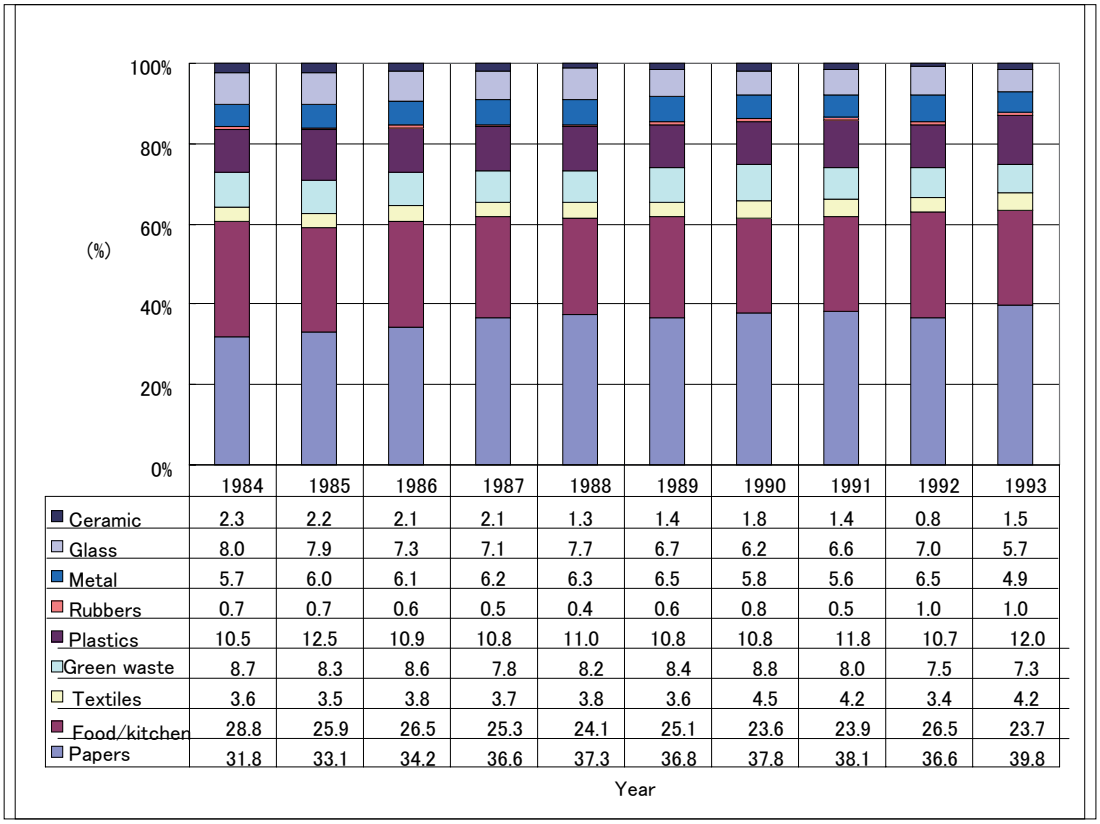
The above data indicates the positive correlation between the growth of per capita GDP and waste generation. However, it should be kept in mind that waste generation is also influenced by socio-cultural background and lifestyle of the relevant countries. It is also important to remind the fact that waste generation will not increase linearly with the growth of economy, but decrease its increase trend gradually at a certain point and become stable, as shown in the case of Japan above. Taking all these into account, the future waste generation has to be carefully estimated in view of the economic development level, socio-cultural background, and lifestyle of the country.

3.3 Historical Trend of Waste Composition Change

To estimate the future change of waste composition, the historical trend of waste composition change needs to be captured based on the past waste composition data. However, such historical data is mostly not available in developing countries. Instead, this section analyzes the trend of waste composition in Tokyo during 1984-1993 as a reference. This period is famous for "Bubble Economic Boom", when Japan's GDP growth ranges from 4 to 5% annually. Although this trend cannot be directly applied to the case of developing countries, it may be useful to know how the waste composition was changed with the growth of economy in Japan.

As shown in Figure 40 below, the change in waste composition in Tokyo is represented by the

decrease in food/kitchen waste and increase in waste paper. Changes in other types of waste is minor such as slight decrease in scrap metal, glass, and ceramics as well as green waste and slight increase in rubber and textile waste.



	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Ceramic	2.3	2.2	2.1	2.1	1.3	1.4	1.8	1.4	0.8	1.5
Glass	8.0	7.9	7.3	7.1	7.7	6.7	6.2	6.6	7.0	5.7
Metal	5.7	6.0	6.1	6.2	6.3	6.5	5.8	5.6	6.5	4.9
Rubbers	0.7	0.7	0.6	0.5	0.4	0.6	0.8	0.5	1.0	1.0
Plastics	10.5	12.5	10.9	10.8	11.0	10.8	10.8	11.8	10.7	12.0
Green waste	8.7	8.3	8.6	7.8	8.2	8.4	8.8	8.0	7.5	7.3
Textiles	3.6	3.5	3.8	3.7	3.8	3.6	4.5	4.2	3.4	4.2
Food/kitchen	28.8	25.9	26.5	25.3	24.1	25.1	23.6	23.9	26.5	23.7
Papers	31.8	33.1	34.2	36.6	37.3	36.8	37.8	38.1	36.6	39.8

Source: TOKYO White Paper on Waste (1995)

Figure 43: Trend of Change in Waste Composition in Tokyo (1984-1993)

3.4 Financial Consideration in Solid Waste Management Planning

Solid waste management in developing countries starts from establishment of the total technical system ranging from collection and haulage of waste to its treatment and final disposal and institutional system composed of legal, organizational and financial mechanism to sustain the technical system. Combination of human resources, machinery and equipment and finance is the essential key to sustainable operation of solid waste management system. Absence in any of the above factors will seriously hinder proper functioning of SWM. This section discusses necessary consideration on finance in SWM planning.

3.4.1 Weak Financial Capacity

Out of the total local government budget of 52,208 billion Japanese Yen in 2002, 2,395.6 billion is allocated for solid waste management and public cleansing in Japan, which is 4.6% of the total local government budget in 2002. Taking the city with 1 million population as an example, the

total local government is estimated as 410 billion JPY while it will spend 19 billion for SWM and public cleansing.

Table 19 below compares the local government budget and SWM budget between Japan and developing countries. Although they cannot be simply compared, taking into account the difference in the year of data and foreign exchange rate, it can still help understand the difference in financial capacity for SWM between Japan and developing countries.

Local government budget allocated per person in the developing countries ranges from 1/680 to 1/7 of Japan while the SWM budget per person is between 1/1500 and 1/7.5 of Japan. In terms of the SWM budget allocated per ton of waste, Japan spends from 7 to 370 times of developing countries, indicating the very limited financial capacity of developing countries.

Table 19: Local Government Budget and SWM Budget in Japan and Developing Countries

	Local Government Budget (US$/person)	SWM Budget (US$/person)	SWM Budget (US$/ton of waste)
Developing Countries*	4.8～496.6	0.1～20.0	1.0～55.9
Japan (2002)**	3,272.2	150.1	370.7(197)

*: JICA Study Reports

**: Estimated based on the data from the statistical bureau of the Ministry of Internal Affairs and Communications (2002)
Figures in parenthesis is the total cost excluding intermediate treatment

Financial Capacity of SWM in developing countries is very weak and limited. Therefore, in many cases, the experience obtained in financially capable country like Japan cannot be directly applied in SWM in developing countries. Taking into account the financial as well as technical capacity of the country, appropriate technical and institutional system should be investigated to establish sustainable SWM in developing countries.

3.4.2 Solid Waste Management Fee

Due to its tight local public financing situation, the amount of budget that can be allocated to SWM is limited and not enough to sustain the quality of public service. In such a situation, SWM fee is, in many cases, collected from the household and businesses who receive SWM service based on beneficiary payment principle.

a. Establishment of Solid Waste Management Fee Structure

Fair allocation of SWM fee among the service recipients are of the most importance in setting the

fee structure. The required level of fee can be determined by estimating the cost of SWM per ton of waste handled, which can be calculated as the result of dividing the total SWM cost by the total amount of waste handled. However, SWM fee is required to be set at the level where the service recipient is willing to and capable to pay. It is also necessary to consider the difference in the quality of SWM service provided and amount of waste generated, depending upon the types of customers (Definitely, both the quality of service and amount of waste generation are different between household and business entities; therefore the waste fee should be different as well.). To make sure and maximize collection of SWM fee from service recipients, the fee structure should be carefully determined through implementation of willingness-to-pay survey, family budget survey, and other necessary questionnaire and interview surveys to set the most appropriate and allowable level of fee depending upon the types of service recipients.

b. Fee Collection

There are several fee collection methods as shown below:

① Direct collection

② Combined collection with public utility service fees (electricity or water supply fees)

③ Collection as tax assessment

In direct collection, door-to-door collection or payment on application is generally applied, but it is difficult to keep high fee collection rate and also to avoid the risk of illegal possession of collected fees by fee collectors. On the other hand, there are also potential advantages of increasing public awareness on waste and creating mutual cooperation at community level if the community-based fee collection is carried out with citizen's involvement.

Combined collection with public utility service fees has the advantage of utilizing the existing utility fee collection system with penalties against non-payment such as temporal termination of utility services. Fee collection can be higher than direct collection. However, the number of utility services recipients is usually less than the number of SWM services recipients due to limited development of public utilities. Therefore, it cannot collect SWM fees from the recipients who do not subscribe public utility services. Combination with direct collection is required to collect the SWM fees from non users of public utility services.

Collection as tax assessment can be applied in the country where resident registration or cadastre, which is the basic unit for levying the SWM fee.

Fee collection system needs to be determined with due consideration of the customs and traditional culture of the country through discussion with local experts.

3.5 Private Sector Utilization in Waste Collection and Haulage Services

Private sector involvement in waste collection and haulage services can be advantageous in terms of achieving the highest service quality with the lowest possible cost if the following conditions are met in the relevant cities.

- Fair and transparent competitive public bidding is made for selecting private contractor for waste collection and haulage;
- Waste collection and haulage service by the private contractors are properly monitored and supervised by the relevant local government to maintain the public service quality.
- Private contractor is forced to be responsible for maintaining the required minimum standard service level of waste collection and haulage by the government control or the sound market mechanism.

However, it must be kept in mind that the waste collection and haulage service business itself must be financially feasible in view of private business if a local government is going to involve private sector in SWM. Otherwise, excessive involvement of private sector in SWM may result in abandonment of the provision of waste collection services to non or low profit areas (mostly in low income household areas) and lowering of SWM service level. Financing SWM service has to be carefully designed to maximize the level of public services on SWM.

3.6 3R（Reduce, Reuse, Recycle） Activities

Sustainable SWM is required to promote (1) **R**eduction of waste at sources (household and businesses), (2) **R**euse and **R**ecycling of the waste generated as much as possible, and (3) proper treatment and disposal of remaining waste. It is of great importance for developing countries in the increasing trend of waste generation to promote this so-called 3R.

In 2005, the Government of Japan announced the New Action Plan to Promote Sound Material-Cycle Society. It calls for supporting establishment of zero waste society in developing countries through transfer of Japanese experience in the efforts of realizing sound material-cycle society (see the column on next page for the details).

3R is a global trend of waste management policy and it is also necessary for the developing countries to include the policies on 3R in SWM plans.

However, the policies on 3R have to be carefully designed in the developing countries, taking into account the current efforts of recycling activities, especially by informal sector. Direct transfer of the Japan's policy and experience on 3R may destroy the current efforts of traditional 3R activities in the developing countries. Current conditions of 3R activities in developing countries must be properly identified and paid due consideration in formulating 3R policies in the SWM in developing countries.

(2) Supporting Zero Waste in Developing Countries

Supporting Zero Waste in Developing Countries through provision of technical assistance and human resource capacity development

- Promote Green Productivity Initiative in cooperation with Asian Productivity Organization (APO) through greening of supply chain in Asia-Pacific Region, etc.
- Promote establishment of regional bases for material-cycle society through human resources capacity development and technical cooperation in the field of 3R
- Promote transport of recycled materials to developing countries through grant aid facilities
- Dispatch of 3R experts and implementation of local expert training programme under Green Aid Plan
- Financial assistance through Japanese Global Environment Fund in environment management activities under private sector initiative
- Collection of Best 3R practices and implementation of pilot 3R projects under Kitakyushu Initiative for Clean Development and other initiatives.

Table 20: Waste Composition in the Cities of the Eastern Asia

Country	Indonesia	Malaysia	Laos	Indonesia	Indonesia	Philippines	Vietnam
City	Jakarta	Penang	Vientiane	Surabaya	Ujunpandang	Metro Manila	Hanoi
Year	1986	1988	1991	1992	1994	1997	2000
Food/kitchen	12.50	32.80	16.90	54.41	66.76	45.82	41.98
Paper	18.20	25.50	2.80	12.46	10.31	15.39	5.27
Textile	5.47	3.40	1.60	1.94	0.81	4.33	1.75
Plastics	9.27	11.20	6.10	7.61	7.94	15.60	7.19
Green	19.37	14.40	38.20	17.44	0.96	7.45	
Rubbers		0.80	1.10	0.54	0.07	0.80	
Combustibles	64.81	88.10	66.70	94.40	86.85	89.39	56.19
Metal	3.27	2.60	3.70	0.90	1.39	5.47	0.59
Glass	4.60	1.40	9.30	0.90	2.14	2.69	1.42
Ceramics	6.46	0.20	Included in glass	3.72	1.64	1.26	6.89
Others	20.86	7.80	20.30	0.10	7.98	1.19	34.94
Non combustibles	35.19	12.00	33.30	5.62	13.15	10.61	43.84
Total	100.00	100.10	100.00	100.02	100.00	100.00	100.03
Relative Density		0.19	0.17		0.27	0.20	0.38

Table 21: Waste Composition in the Cities of the Southern Asia

Country	Sri Lanka							
City	Moratuwa	Badulla	Chilaw	Gampaha	Kandy	Matale	Negombo	NuwaraEliya
Year	1997	2002	2002	2002	2002	2002	2002	2002
Food/kitchen	44.50	64.30	36.60	57.30	58.20	61.30	45.60	71.60
Paper	12.80	10.80	6.80	14.40	12.00	6.40	8.90	11.10
Textile	1.30	1.30	1.30	1.50	1.40	1.10	3.50	1.20
Plastics	6.20	3.40	4.10	7.80	8.00	4.30	4.80	5.70
Green	7.20	14.10	29.70	15.30	12.30	18.10	24.70	5.70
Rubbers	0.30	0.40	0.10	0.40	0.70	1.10	0.90	0.10
Combustibles	72.30	94.30	78.60	96.70	92.60	92.30	88.40	95.40
Metal	1.20	0.80	0.80	0.50	0.80	0.40	0.50	0.70
Glass	0.90	1.80	0.30	1.40	1.10	0.40	0.80	0.90
Ceramics	1.80	2.80	12.10	1.20	5.10	6.60	8.40	2.60
Others	23.80	0.20	8.20	0.60	0.40	0.30	2.00	0.30
Non combustibles	27.70	5.60	21.40	3.70	7.40	7.70	11.70	4.50
Total	100.00	99.90	100.00	100.40	100.00	100.00	100.10	99.90
Relative Density	0.30	0.31	0.20	0.15	0.30	0.33	0.26	0.39

Table 22: Waste Composition in the cities of Central Asia, Africa, and Europe

Region	Central Asia		Africa			Europe	
Country	Kazakhstan	Azarbaijan	Tanzania	Kenya	Niger	Poland	Bulgaria
City	Almaty	Baku	Dar es Salaam	Nairobi	Niamey	Poznan	Sophia
Year	1999	2000	1996	1997	2001	1992	1993
Food/kitchen	54.00	51.80	42.00	51.50	17.00	33.96	25.89
Paper	17.80	11.10	3.10	17.30	1.00	19.34	23.96
Textile	2.20	3.30	1.20	2.70	1.00	7.27	6.11
Plastics	10.90	4.50	2.20	11.80	3.00	7.89	5.95
Green	2.30	9.20	25.30	6.70	1.00	5.90	1.69
Rubbers	0.90	0.90	0.90	2.40	0.00	2.26	1.42
Combustibles	88.10	80.80	74.70	92.40	23.00	76.62	65.02
Metal	2.60	2.50	2.00	2.60	1.00	3.76	2.92
Glass	5.60	8.70	3.50	2.30	0.00	15.16	15.57
Ceramics	0.70	5.30	0.40		76.00	1.53	3.70
Others	3.00	2.70	19.40	2.70	0.00	2.93	12.79
Non combustibles	11.90	19.20	25.30	7.60	77.00	23.38	34.98
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Relative Density	0.32	0.26	0.39	0.28	0.58	0.214	0.23

Table 23: Waste Composition in the Cities of Middle East

Country	Egypt		Syria		Palestine	Turkey		Syria	
City	Alexandria		Damascus	Aleppo	159 cities	Adana	Mersin	Latakia	Homs
Year	1984	1994	1995	1997	1998	1998	1998	2001	2001
Food/kitchen	61.00	74.00	42.10	70.30	44.60	75.53	70.77	72.70	59.80
Paper	23.00	14.00	13.20	14.30	8.30	9.88	13.80	9.20	11.70
Textile	3.00	2.00	6.70	2.00	3.30	1.77	3.43	2.20	4.10
Plastics	4.00	5.00	11.70	8.40	36.00	1.62	1.04	8.40	11.60
Green				0.20	0.20	5.87	6.42	0.30	0.40
Rubbers				2.00	1.20	0.29	0.17	0.40	0.90
Combustibles	91.00	95.00	73.70	97.20	93.60	94.96	95.63	93.20	88.50
Metal	3.00	4.00	2.20	1.50	5.40	0.53	0.72	1.50	1.00
Glass	3.00	1.00	1.80	0.40	0.00	3.33	2.55	1.20	2.10
Ceramics				0.10	0.80	1.14	0.96	1.70	1.20
Others	3.00		22.30	0.80	0.20	0.04	0.14	2.40	7.20
Non combustibles	9.00	5.00	26.30	2.80	6.40	5.04	4.37	6.80	11.50
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Relative Density	0.24	0.36	0.35	0.35	0.24	0.31	0.29	0.20	0.25

Table 24: Waste Composition in the Cities of Caribbean and Latin American Countries

Country	Peru	Guatemala	Paraguay	Nicaragua	Peru	Nicaragua			Mexico	Honduras	El Salvador
City	Lima	Metro Area	Asuncion	Managua	Callao	Granada	Leon	Chinandega	Mexico-city	Tegucigalpa	San Salvador
Year	1984	1992	1994	1995	1995	1997	1997	1997	1998	1999	1999
Food/kitchen	33.50	59.70	36.60	34.86	47.04	49.84	26.13	39.86	38.66	47.20	57.60
Paper	24.30	15.40	6.40	5.37	23.48	5.29	4.75	1.91	25.51	11.50	13.00
Textile	2.90	4.90	1.30	1.87	1.64	1.98	2.03	1.43	3.42	2.80	1.10
Plastics	2.40	7.60	3.90	3.88	7.52	6.11	5.32	2.82	9.13	7.10	5.80
Green		0.10	22.20	27.11	2.39	24.90	35.26	38.21	4.42	11.60	16.80
Rubbers	0.20	0.30	0.70	2.00	1.48	0.29	5.98	0.64	0.11	2.20	0.10
Combustibles	63.30	88.00	71.10	75.09	83.55	88.41	79.47	84.87	81.25	82.40	94.40
Metal	3.40	2.10	1.30	1.69	5.57	1.11	1.76	1.43	4.32	1.90	1.10
Glass	1.70	4.40	3.10	2.91	1.82	1.05	1.34	0.96	7.27	3.50	2.60
Ceramics	31.60	3.10	2.50	8.07	4.25	5.21	3.39	6.77	2.44	12.10	0.70
Others		2.40	22.00	12.24	4.81	4.22	14.04	5.97	4.71	0.10	1.20
Non combustibles	36.70	12.00	28.90	24.91	16.45	11.59	20.53	15.13	18.74	17.60	5.60
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	100.00	100.00
Relative Density	0.16	0.25	0.22	0.20	0.35	0.25	0.27	0.19	0.283	0.20	0.20

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