Annex 6

Waste Generation Data

6 Waste Generation Data

6.1 Waste Amount and Composition Determination

In order to formulate a practical SWM master plan for DSM city, current data on the quantity and nature of the waste produced by different generation sources within the Study's scope is required. This annex presents the methodology and results of the Waste Amount and Composition Survey (WACS) together with other relevant data which is then used to calculate waste generation amounts for each category of waste.

6.1.1 Waste Generation Amount Methodology

WACS was carried out from the 19-26 June 1996 at the start of the dry season. In this survey, waste was collected daily for 8 days continuously from sampling points in the following categories:

- Household waste (low, middle and high income)
- Commercial waste (restaurant and other)
- Institutional waste
- Market waste
- Street sweeping waste

79 sampling points were selected as shown in Table 6-1 in order to obtain representative data for each category of waste.

Table 6-1: WACS Sample Selection

Waste Category	Type of Source	Number of Sampling Points in each Area				Total Number of Samples
		UA	SUPA	SUUA	RA	
Household	High Income	5	5	5	5	20
	Middle Income	5	5	5	5	20
	Low Income	-	7	8	5	20
Commercial	Restaurants	5	-	-	-	5
	Other	5	-	-	-	5
Institutional	Institutions	5	-	-	-	5
Market	Markets		1	1	-	2
Street Sweeping	Streets	2	-	-	-	2
	TOTAL	27	18	19	15	79

Note: The low income group in the urban area was not surveyed as the number of low income households in this area is very few.

Plastic bags of different colours were used in order to distinguish between different generation sources for all categories except market waste. These were distributed to all sampling points at which time the survey's purpose and procedure was explained to participants. These bags were collected daily over a 8 day period with the waste samples being weighed immediately after collection using a spring balance. The plastic bags were then sealed in order to maintain the original condition of the waste samples and taken to a common collection point at Vingunguti disposal site at which stage all of the waste samples in each category were mixed for the analysis of waste composition. For market

waste, the samples were transported by tip truck to a weighbridge at the National Milling Corporation for weighing before going to Vingunguti disposal site for composition analysis.

Detailed WACS results are set out in Annex 5. Average daily waste generation amounts were calculated using this data for days 2-8 of the survey period as the first day was a trial run. The waste generation amount results were then used to determine a waste amount generation rate (WAGR) for each category as set out in Section 6.1.3. In the case of market and institutional waste, some adjustment of the WAGRs was made.

Some important waste generation sources; namely hotels, trunk road maintenance and the informal sector were not included in WACS for practical reasons. Instead, WAGR data for these categories was obtained through interviews with relevant authorities and workers in conjunction with statistical data as set out in Section 6.1.3.

Statistical data was collected from various sources in order to quantify the total number of generators for each source. This data was then combined with WAGR data to determine the total waste generation amount for each generation source as set out in Section 6.1.3.

The data for the number of commercial enterprises (restaurants, other, guesthouses/hotels), institutions and informal sector operators applies to the 52 wards in DSM and not just to the study area of 39 wards as it was not possible to obtain data on a ward by ward basis for these categories. However, approximately 2 million of the estimated total population in 1996 of 2.3 million live within the study area. Hence, the number of commercial enterprises, institutions and informal sector operators in wards outside of the study area can be considered to be relatively small and the error introduced by using the data for all 52 wards will be relatively insignificant.

6.1.2 Waste Composition Analysis

a. Introduction

Physical and chemical waste composition analyses were carried out using waste samples collected during WACS from each generation source, according to the frequency shown in Table 6-2. Physical composition analysis in wet base was carried out for samples from all generation sources while chemical composition analysis, in the form of carbon and nitrogen content analyses, was only carried out for market waste in order to assess it's suitability for compost.

Table 6-2: Frequency of Waste Composition Analysis

Type of waste	Physical composition analysis	Chemical composition analysis
Household (High Income)	1 sample/day x 7 days for each type of waste	nil
Household (Middle Income)		nil
Household (Low Income)		nil
Commercial (Restaurant)		nil
Commercial (Other)		nil
Institutional		nil
Market		1 sample/day x 3 days
Street Sweeping		nil

b. Methodology

b.1 Waste Reduction

For each category of waste, all of the waste samples were mixed together. The volume of waste in this mixture was then reduced to 30-50 litres using the method described below.

1) Mixing: Large items in the waste (e.g. boxes, tins, etc.) were first cut into smaller pieces. The waste was then well mixed.

2) Dividing: After mixing, the waste was divided into four segments of approximately equal volume.

3) Reducing: Two segments of waste diagonally opposite each other were removed and the remaining two segments were combined.

4) Steps 1-3 were repeated until the waste volume was reduced to the designated amount of 30-50 litres. The waste was then put in a volumetrically calibrated plastic bucket.

5) The plastic bucket was dropped in a controlled manner three times from a height of 30 cm to the ground to consolidate the waste. The volume and weight (wet basis) were measured using the scale on the bucket and a platform balance respectively. The Apparent Specific Gravity (ASG) was calculated using the following formula.

ASG = (Weight of waste (wet basis))/Volume of waste

b.2 Physical Composition

The physical composition was measured in wet base as follows. Without any drying, samples from each generation source were divided into the following 10 groups and each group was then weighed. The results were expressed as percentages of the total sample weight.

i) kitchen waste	ii) paper
iii) textile	iv) plastic
v) grass and wood	vi) leather and rubber
vi) metal	viii) glass
ix) ceramic and stone	x) other (sand, ash, soil, etc.)

b.3 Moisture Content

The samples were then dried for two days in a dryer at 105°C and the weight of each item was then measured again. The moisture content was calculated using the following formula.

Moisture Content (%) = (original weight - dry weight)/original weight x 100

b.4 Chemical Analysis

Chemical analysis was carried out after drying for market waste samples only. Non-combustible samples were first removed, leaving six combustible samples as follows:

i) kitchen waste
ii) paper
iii) textile
iv) plastic
v) grass and wood
vi) leather and rubber

Each combustible sample was cut into 2-5 mm pieces. The six samples were then reduced in weight to about 500 g in accordance with the composition results. Each combustible sample was then fractionated by a cutting mill into pieces less than 2 mm in size, followed by remixing of the samples and chemical analysis. Ultimate analysis was carried out for carbon and nitrogen only.

The waste composition results for all WACS generation sources are presented in Section 6.1.4.

6.1.3 Waste Generation Amount Results

a. Household Waste

a.1 Definition

Waste arising as a result of domestic activities including food preparation, sweeping, cleaning, fuel burning, gardening and recreation. It includes garbage such as old clothing, old furnishings, obsolete appliances, packing and reading matter. It also includes waste generated from micro-business (informal sector) activities operated by a family within its house.

a.2 Sampling Rationale

For household waste in DSM, households were classified according to *location* and *household income level* as it was expected that waste characteristics such as the WAGR and the waste composition would be related to these two parameters.

Household location was characterised according to the categories proposed and defined in P/R (1): urban area (UA), semi-urban planned (SUPA), semi-urban unplanned (SUUA) and rural (RA) areas.

Household income levels were expressed in terms of the following 3 income level categories:

- High income: more than 95,000 Tsh/household/month
- Middle income: 50,000 - 95,000 Tsh/household/month
- Low income: below 50,000 Tsh/household/month

These income ranges were chosen using data from Question No. 1-6 of the POS conducted during this Study. This question was concerned with household expenditure rather than income, as it was expected a more honest answer would be obtained to a question concerning expenditure rather than income. Stated expenditures were assumed to be indicative of income and the income ranges were selected so that the percentages in each income level category are of the same order of magnitude.

The POS percentage results for each income and area category are shown in Table 6-3. This data was converted to actual population figures using the total estimated population (1996) in each area category, shown in the last column of Table 6-3.

Table 6-3: The Population of DSM in 1996 according to Income and Area

Income Category		High	Middle	Low	Total
Expenditure Range (Tsh/household/month)		>95,000	50,000-95,000	<50,000	
UA	Population %	47%	50%	3%	100%
	Population	26,734	28,440	1,706	56,880
SUPA	Population %	30%	47%	23%	100%
	Population	232,907	364,887	178,562	776,356
SUUA	Population %	9%	56%	35%	100%
	Population	86,671	539,289	337,056	963,016
RA	Population %	22%	56%	22%	100%
	Population	51,475	131,028	51,475	233,978
Total	Population %	20%	52%	28%	100%
	Population	397,787	1,063,644	568,799	2,030,230

Based on the POS results and the proposed income range categories, household waste sampling areas were selected as shown in Table 6-4.

Table 6-4: Selection of Sample Areas for Household Waste

Area Category	Sample Area		
	High Income	Middle Income	Low Income
UA	Upanga West	Kariakoo	---
SUPA	Mwananyamala	Mwananyamala	Mwananyamala
SUUA	Keko	Keko	Keko
RA	Ubungo	Ubungo	Ubungo

Sampling points were selected with the assistance of the Ward Secretary in these wards. Each household was interviewed and data was obtained concerning the number of people per household and total household income. The former data was needed in order to calculate the WAGR while the latter was used to confirm the assumed income levels.

a.3 Waste Amount Generation Rates

Table 6-5 shows the results for WAGRs according to income and area categories. The weighted average WAGR is 698 g/cap/d and WAGRs are consistent for households in different locations, ranging from 683 - 755 g/cap/d.

Usually, WAGRs increase with household income level but in this case Table 6-5 shows that the middle income WAGR is slightly higher than that for high income households. This may be due to the much higher proportion of grass/wood waste for middle income (30.9%) households compared with high income (19.8%) households as shown in Table 6-13.

These results are consistent with WAGRs for "detached houses" determined in other JICA studies in developing countries throughout the world. Detached houses in this sense refers to houses which are separate from each other (i.e. not apartments) in which case, the quantity of waste generated and hence the WAGR is increased due to the presence of a large proportion of garden and "sweeping" waste. Table 6-13 shows that

household waste consists of 44.7% grass/wood and soil/ash/sand waste so that approximately half of the WAGR can be attributed to "garden/sweeping" waste.

Table 6-5: Household Waste Generation Rates by Income and Area

Income Category		High	Middle	Low	Total	Weighted Average WAGR by Area (g/cap/d)
Expenditure Range (Tsh/household/month)		>95,000	50,000-95,000	<50,000		
UA	Population	26,734	28,440	1,706	56,880	
	WA (kg/d)	19,890	22,183	872	42,945	755
SUPA	Population	232,907	364,887	178,562	776,356	
	WA (kg/d)	173,283	284,612	91,245	549,140	707
SUUA	Population	86,671	539,289	337,056	963,016	
	WA (kg/d)	64,483	420,645	172,236	657,364	683
RA	Population	51,475	131,028	51,475	233,978	
	WA (kg/d)	38,297	102,202	26,304	166,803	713
Total	**Population**	397,787	1,063,644	568,799	2,030,230	
	WAGR (g/cap/d)	744	780	511		698

Note: 1) WA = waste generation amount in each area category (A) according to income (I).
2) WA (A,I) = population in A x WAGR (I).
3) Weighted Average WAGR for area A = (Sum(WA) for A)/total population in A.

Table 6-6 compares the WAGRs measured in this survey with that of Haskoning's 1988 DSM Study and those of recent studies carried out by ERL[1] for four towns in Uganda. The methodologies used in these other studies is basically the same as that used in this Study.

Table 6-6: Comparison of the Waste Generation Rates with Other Data

unit: g/cap/d

Income group	JICA DSM study (1996)	Haskoning DSM study (1988)	Tororo, Uganda	Masaka, Uganda	Mbarara, Uganda	Mbale, Uganda
High income	744		500	800	700	400
Middle income	780		600	1,100	1,200	700
Low income	511		1,040	600	800	600
Weighted Average	698	377	-	-	-	-

The household WAGR for DSM in 1996 is reasonably consistent with those measured in the four Ugandan towns but is almost double the value obtained by Haskoning in 1988. The WAGR and composition can change very quickly in accordance with changing economic and social conditions and peoples' living conditions, etc. The large increase in the WAGR may partially be attributed to such changes which have been occurring, especially as economic liberalisation has been rapid since 1990.

[1] "GTZ/World Bank Seven Towns Project" Reports, Environmental Resources Limited (ERL), 1990

a.4 Household Waste Generation Amount

Household Waste - Summary
Parameter: population in each category according to area and income
Source of Data: 1988 Census; SDP; P/R (1) population projection, POS results
Estimated Total Population: 2,030,230 (1996)
WAGR: variable according to income level - see Table 6-7
Total Household Waste Generation Amount = 1,416.3 t/d

The amount of household waste generated can be calculated in terms of income or area. Both calculations are similar and involve using the WAGRs for high, middle and low income households and multiplying these by the appropriate population figure from the POS as described below:

Waste Generation Amount according to area = Sum (population in each income category in a particular area x WAGR for that income category).

Waste Generation Amount according to income = total population in each income category x WAGR for that income category.

The data used and results of these calculations are summarised in Table 6-7.

Table 6-7: Calculation of Household Waste Generation Amount

A: Summary of Waste Amount Generation Rates (WAGR) and Population Data according to Area and Income

Income Category		High	Middle	Low	Total
WAGR (g/cap/d)		744	780	511	698
Population	UA	26,734	28,440	1,706	56,880
	SUPA	232,907	364,887	178,562	776,356
	SUUA	86,671	539,289	337,056	963,016
	RA	51,475	131,028	51,475	233,978
	Total	397,787	1,063,644	568,799	2,030,230

B: Calculation of Waste Amounts (WA) using Data from A

Income Category		High	Middle	Low	Total
Waste Amount (kg/d)	UA	19,890	22,183	872	42,945
	SUPA	173,283	284,611	91,245	549,139
	SUUA	64,483	420,645	172,236	657,364
	RA	38,297	102,202	26,304	166,803
	Total	295,953	829,641	290,657	1,416,251

b. Commercial Waste

b.1 Definition

Wastes arising from retail and wholesale outlets, commercial offices (e.g. travel agents, Bureau de Change), restaurants, hotels, guesthouses, etc. These wastes generally consist of packaging and container materials, used office supplies and food wastes.

Guesthouse and hotel wastes also contain guest room and garden wastes and in the case of beachfront hotels, "beach sweeping" waste may also be included.

b.2 Sampling Rationale

Commercial waste was classified into three categories: restaurant, other enterprises and guesthouse/hotel waste as the waste produced by each category is normally quite different in terms of quantity and composition.

Only restaurant and other enterprises sampling points were selected for WACS. These were all in the urban area and are listed below:

Restaurant:
1. M.G. Pandya Hotel, Makunganya St.
2. Chick King, Jamhuri St.
3. Amrapali Hotel, Zanaki St.
4. Burco, Mkwepo St.
5. Kilimanjaro Business Link Ltd, Zanaki-Libya St.

Other:		
	1. R.T.C	Building materials/hardware/sewing machines (wholesale)
	2. Hassan Printers	Stationery (retail)
	3. Dubai Shopping	Electrical appliances (retail)
	4. Kara Traders	Hardware (retail)
	5. Kitenge Quality Shop	Clothing (retail)

The restaurants used as sampling points for WACS were chosen to represent a cross-section of restaurants in DSM in terms of size, type of food and the number of customers. Size was assessed in terms of the number of chairs in the restaurant and ranged from 30-92 chairs. Two of the restaurants sold traditional Tanzanian meals; two sold a mixture of Tanzanian/Asian meals and snacks and the fifth sold fast food. Two restaurants had a high number of daily customers; one medium and two low.

By choosing the sampling points in this manner, the average WAGR for all five restaurants is thought to be representative of all restaurants in DSM and hence the parameter used to convert this WAGR to the total generation amount of restaurant waste is simply the number of restaurants. A more exact parameter would involve calculating the WAGR in terms of the daily number of customers or even the number of chairs but such data is not easily obtainable.

The other commercial enterprises used as sampling points for WACS were chosen to represent a cross-section of commercial, non-restaurant enterprises in DSM and included four retail shops selling different goods and one wholesale shop. The parameter used to convert the WAGR to total amount of waste is simply the number of shops.

Hotels and guesthouses were considered separately as each group has different characteristics as hotels are typically large commercial enterprises, often catering for tourists and with gardens and restaurants and possibly other facilities open to the general public. Guesthouses are smaller enterprises catering more for local people and often with no restaurant or other eating places. No sampling points for hotels and guesthouses were chosen during WACS. Instead, waste generation amounts were estimated using statistical data and appropriate WAGRs based on amended household WAGRs.

b.3 Commercial Waste Generation Amount

The amount of waste generated by each commercial category is summarised below. Detailed data is shown in Section 6.2 where relevant.

b.3.1 Restaurant Waste

Parameter: total number of restaurants
Source of Data: 1995/96 business licensing information, Regional Trade Office (RTO); Central Register of Establishments (CRE) June 1996 Data, CRE Unit, Bureau of Statistics
Total number of restaurants: 365
WAGR: 37.446 kg/enterprise/day
Total Restaurant Waste Generation Amount: 13,669 kg/d = 13.7 t/d

Note: 1. Four of the restaurant WACS sampling points were open 7 days per week and one 6 days per week. The WAGR is calculated on a 7 day basis in order to get the average WAGR per day over a 1 week period. For example, for the restaurant which is open 6 days per week, the waste generation amount is divided by 7 to get the average WAGR for that restaurant.
2. The data obtained from the RTO covers restaurants and bars and stated a total of 365. The CRE data covers restaurants, cafes and other eating and drinking places and gave a total of 364.

b.3.2 Other Commercial Enterprises Waste:

Parameter: total number of commercial (other) enterprises
Source of Data: 1995/96 business licence information, Ministry of Trade (MOT) and RTO
Total number of enterprises: 13,241
WAGR: 0.906 kg/enterprise/d
Total Commercial (Other) Waste Generation Amount: 11,996 kg/d = 12.0 t/d

Note: All of the commercial (other) enterprises selected as WACS sampling points are open 5-6 days per week. The WAGR is calculated on a 7 day basis as explained above for restaurants.

b.3.3 Guesthouse and Hotel Waste

Parameter: total number of hotels and guesthouses in DSM
Sources of Data: "Hotels and National Parks Statistics 1994", Bureau of Statistics; 1995/96 business licence information, Ilala District Trade Office; MOT
Total Number of Hotels: 51
Total Number of Guesthouses: 322
WAGR: Hotels: 0.744 kg/bed/d; Guesthouses: 0.405 kg/bed/d
Total Guesthouse and Hotel Waste Generation Amount: 1,562.7 kg/d = 1.6 t/d

Guesthouse and Hotel waste generation amounts were estimated separately. In both cases, the WAGR was expressed in terms of kg/bed/d where bed refers to a utilised bed night which is considered to be equivalent to the number of overnight guests (i.e. one overnight guest takes up one bed night).

For hotels, the most recent statistics available were for 1994 and stated that there were 252,646 utilised bednights during that year[2]. The following assumptions were made in order to calculate the hotel waste generation amount:

1. The present number of hotels is the same as in 1994. This is reasonable as some hotels have closed since then (permanently or for renovation) while some new hotels have been built.
2. The waste produced by restaurants in these hotels which are open to the general public is included in the restaurant waste generation amount already calculated.
3. Each bed is occupied by one person, who takes at least one meal a day at the hotel.
4. The WAGR for hotels expressed in terms of kg/bed/d is equal to the WAGR for high income households (0.744 kg/cap/d). Practically, this can be interpreted as meaning that the waste generated by one overnight guest, directly and through the services provided by hotel staff, is equivalent to the waste produced by one person in an average high income household.

252,646 bednights utilised in 1994 is equivalent to an average of 692 bednights being utilised per day or 692 bed/d. Multiplying this figure by the WAGR of 0.744 kg/bed/d gives a total waste generation amount of 515.0 kg/d.

For guesthouses in 1995/96 there were a total of 322 licensed guesthouses[3]. No data was available on the number of rooms, beds and bed occupancy rates in these guesthouses. The following assumptions were made in order to calculate the guesthouse waste generation amount:

1. There are no restaurants or other eating facilities in these guesthouses. This is reasonable as DTO stated that there are only a small number of guesthouses which cater for both accommodation and food/drink.
2. Each guesthouse has 12 rooms. This is considered to be an average size for a guesthouse in DSM. Hence, total number of rooms in all guesthouses = 12 x 322 = 3,864.
3. The ratio of beds:rooms is the same as for hotels (3430:2059). Hence, total number of beds in all guesthouses = 3,864 x (3,430/2,059) = 6437.
4. The bed occupancy rate is the same as for hotels (40.2%). Hence, total number of utilised bednights/d = 6,437 x 0.402 = 2,588 or 2,588 bed/d.
5. Each bed is occupied by one person.
6. The WAGR for guesthouses expressed in terms of kg/bed/d is assumed to be equal to 0.58 of the weighted average household WAGR (0.698 kg/cap/d). Practically, this can be interpreted as meaning that the waste generated by one overnight guest,

[2] The Hotels and National Park Statistics 1994 book has statistics for all hotels charging a minimum of 700/- per bednight. In DSM in 1994 there were 51 hotels of this type with a total of 2,059 rooms and 3,430 beds. For all of 1994 the bednights available were 628,218 and the bednights utilised were 252,646, representing a bed occupancy rate of 40.2%. Tourist hotels, which currently number 21 (MOT) are included in this list.

[3] In 1995/96 there were 143, 84 and 95 licensed guesthouses in Temeke, Kinondoni and Ilala districts respectively.

directly and through the service provided by guesthouse staff, is equivalent to the waste produced by one person in an average household excluding kitchen waste which accounts for 42% of household waste (Table 6-13). Thus, the household WAGR must be multiplied by 0.58 to exclude kitchen waste, giving a WAGR of 0.405 kg/bed/d.

Multiplying this WAGR by the total number of utilised beds gives a waste generation amount of 0.405 x 2,588 = 1,047.7 kg/d.

Hence, total hotel and guesthouse waste generation amount = 1,562.7 kg/d = 1.6 t/d

b.3.4 Total Commercial Waste Generation Amount

The total commercial waste generation amount can now be calculated combining the restaurant, other and guesthouse/hotel values of 13.7 t/d, 12.0 t/d and 1.6 t/d respectively to give 27.3 t/d.

Haskoning estimated the waste generation amount for hotels and restaurants through collection data of the City Cleansing Department, monitoring of selected hotels and restaurants during one week and interviews with hotel and restaurant keepers. The waste generated by other commercial enterprises was estimated by multiplying the number of people living in commercial areas (city centre and Kariakoo) by a factor of 0.2 kg/cap/d, this being an average figure derived from other research conducted in major cities. This methodology gave generation amounts of 25 t/d and 20 t/d for restaurant/hotel and shop waste respectively. These values are higher than corresponding values found in this Study (15.3 and 12.0 t/d) by 63-67%.

c. Institutional Waste

c.1 Definition

Wastes from public (e.g. government offices/ministries; parastatals; banks, tourist hotels, insurance companies, hospitals, schools, universities; etc.) and private sector institutions (e.g. religious and charitable organisations, embassies, private banks, schools, hospitals, etc.). In this study, institutional waste is restricted to office or administrative waste which consists mainly of paper with a smaller proportion of food waste from institution canteens. Hence other types of waste produced in institutions such as TAZARA and THA from industrial and manufacturing activities are excluded with only their administrative waste being included. Similarly, for hospitals and government owned hotels, DSM airport and some other institutions, only waste arising from administrative activities is included here. Waste from army barracks is excluded completely.

c.2 Sampling Rationale

The five institutional waste sampling points were selected in the urban area as follows.

1. NAFCO, Morogoro St.
2. SDP, Samora St.
3. NUWA, Gerezani St.
4. NEMC, Sokoine Drive
5. NLUPC, Sokoine Drive

The institutions used as sampling points in WACS were chosen for practical reasons according to the following criteria. Section 6.2 contains more details on the data used.

- the institution agrees to participate in WACS. This excludes institutions such as banks, army and many government offices from being sampled, normally for reasons of confidentiality.
- the institution employs up to 100 workers. This excludes many large government offices, banks, insurance companies, parastatal organisations and many educational institutions and hospitals.
- the institution is located within the 5 wards in the central city area to facilitate collection of the waste samples.
- the institution does not carry out any major manufacturing or industrial activities nor is it a hospital, government owned hotel nor DSM airport.

Four of the institutions selected for sampling are parastatal institutions whilst the fifth is a NGO non-profit making institution. All are office based institutions, located in the central city area with the number of employees ranging from 18-50. The WAGR is expressed in terms of the number of workers in this case and not the number of institutions. Institutions in DSM range in size from around 20 to over 2,000 workers with the average number of workers being 145 according to the CRE data. As all the institutions sampled had 50 workers or less (average = 37), basing the WAGR on the number of institutions would result in an unrealistically low value for the total amount of waste produced.

c.3 Institutional Waste Generation Amount

Parameter: total number of workers in institutions Source of Data: CRE June 1996 data, CRE Unit, Bureau of Statistics; 1995/96 business licence data, MOT Total number of Institutions: 429 Total number of workers: 62,246 WAGR: 0.172 kg/worker/day Total Institutional Waste Generation Amount: 10,706 kg/day = 10.7 t/d

Note: All of the institutions selected as WACS sampling points are open 5 days per week. The WAGR is calculated on a 7 day basis as explained above for restaurants.

The waste produced per worker per day in each of the institutions varied significantly from 19-54 g/worker/d with an average value of 36 g/worker/d. As the sample size is 5, only 1% of the total number of institutions, the calculated amount of 2.2 t/d is not considered to be very accurate and by considering the range in the WAGRs of 19-54 g/worker/d, the average WAGR of 36g/worker/d is estimated to have an associated error of +/-50%. The sample size would need to be increased to at least 5% (21 institutions) of the total number of institutions to obtain a more accurate value. However, this is not very practical in terms of the extra time and organisation required to sample 21 institutions instead of 5. Furthermore, it is not justified as the amount of institutional waste is very small, compared with that from other waste generators.

The other source of error is the accuracy of the data for the number of institutions and institutional workers. The institutional data was obtained from June 1996 CRE data but is not considered to be current as the CRE data takes a long time to be updated. The

number of workers is underestimated as the relevant data has not been obtained from all institutions. Hence, the error in the institutional workers' data is estimated to be +/- 30% giving an overall error of +/- 80%.

Haskoning estimated the institutional waste generation amount to be 10 t/d for centre city institutions (Ministries, offices and banks, etc.) through collection data of the City Cleansing Department and monitoring of selected institutions. By knowing the number of workers in these institutions and the total number of workers in all institutions within the city centre, the total waste generation amount was obtained by extrapolation as done in this Study. A rough estimation of the waste generation amount for other institutions (laboratories, university, army, airport and institutions outside the city centre), of 50 t/d was made, of which most was generated by the army. Haskoning stated that the waste generation amount per worker per day varied substantially between different institutions as found in this Study.

Haskoning's total institutional waste generation amount of 60 t/d is substantially greater than that calculated in this Study. A major reason for this is that Haskoning's definition of institutional waste is much broader than that used here. In particular, army wastes were excluded in this Study as were manufacturing and industrial wastes produced by some institutions as well as hospital and government owned hotel wastes apart from wastes associated with administrative activities in such institutions.

A check on the accuracy of the estimated institutional waste generation amount can be made using DCC Vingunguti Disposal site records for institutional 'bill" customers (NBA and TTCL). Disposal site data for the first 6 months of 1996 for these two institutions is tabulated below in Table 6-8.

Table 6-8: Vingunguti Disposal Site Data for NBC and TTCL for Jan.-Jun. 1996

Institution	Jan.	Feb.	Mar.	Apr.	May	Jun.	Total	Avg. (t/d)	No. of Workers	WAGR (kg/worker/d)
NBC (t/m)	91	28	21	0	0	35	175	0.93	2674	0.349
TTCL (t/m)	35	14	28	28	28	14	147	0.81	no data	-----
Total (t/m)	126	42	49	28	28	49	332			
Avg. (t/d)	4.1	1.4	1.6	0.9	0.9	1.6		1.74		

Note: 1. t/m = tonnes per month.
2. Average tonnage per day for NBC is based on the three months (Feb., Mar. and Jun.) for which the recorded data was consistent.
3. The DCC Disposal site staff record the number of trips per vehicle and convert to tonnage assuming that the NBC and TTCL vehicles each carry 7 t of waste per trip.

Assuming the DCC truck:tonnage conversion factors are correct, this data shows that the waste generated by institutions must be greater than predicted by calculation using the WAGR as the average waste generation amount for the two institutions (NBC and TTCL) alone is equal to 1.7 t/d, 77% of the predicted waste generation amount of 2.2 t/d for all institutions in the study area.

Hence, the WAGR has been amended using:

1. the WAGR from WACS of 0.036 kg/worker/d.
2. the calculated WAGR for NBC of 0.349 kg/worker/d (see Table 6-8). A WAGR for TTCL could not be calculated as no worker data was available.

3. WAGRs of 0.173, 0.209 and 0.095 kg/worker/d for the University of DSM, Ardhi Institute and Water Resources Institute cited by Kaseva and Gupta[4].

The WAGR to be used in this Study is taken as the average of these five values: 0.172 kg/worker/d. This gives a waste generation amount of 10.7 t/d which although still considerably less than Haskoning's value of 60 t/d is considered a reasonable figure, in terms of the definition of institutional waste used in this Study. The range in the waste generation amount, calculated using the lowest and highest WAGRs is 2.2-21.7 t/d.

Subsequent weighbridge data obtained for 11-28 Feb. 1997 showed that the conversion factors for NBC and TTCL vehicles were incorrect (see P/R (3)). This data showed that NBC made on average 0.4 trips/day and disposed of 0.5 t/day waste, equivalent to 1.25 t/trip. However, the average WAGR used is a realistic value as the following analysis shows: multiplying the WAGR of 0.172 kg/worker/d by the number of NBC workers from Table 6-8 of 2,674 gives a waste generation amount of 0.46 t/d for NBC which agrees well with the measured weighbridge value of 0.5 t/d and confirms the validity of the calculated WAGR.

d. Market Waste

d.1 Definition

Waste from markets (both wholesale and retail). Market waste mainly consists of food/produce waste, grasses and other organic packaging materials and food waste from canteens operating within the markets.

d.2 Sampling Rationale

Two markets, Mwananyamala Map and Buguruni, were selected for sampling because these were observed to be representative of typical markets in DSM. During the survey period, market operators were instructed to store their wastes separately from the market waste collection point and to carry them directly to the tip truck on its arrival for sample collection. This was to avoid household wastes, commonly disposed of at the market waste collection point by residents from nearby areas and petty traders, being mixed with the market waste.

d.3 Market Waste Generation Amount

Parameter: total number of retail and wholesale market operators workers
Source of Data: DCC Market data, Market Census
Total number of markets: 69
Total number of retail operators: 7,766
Total number of wholesale operators: 1,803
WAGR: retail: 3.12 kg/op/d; wholesale: 5.36 kg/op/d
Total Market Waste Generation Amount: 33,894 kg/d = 33.9 t/d

Note: Markets operate on a 7 day basis.

Haskoning differentiated between wholesale and retail operators in his estimation of market waste generation rates. The same distinction has been made here as wholesale operators produce significantly more waste than retail operators, due to the large

[4] "Recycling - an Environmentally Friendly and Income Generating Activity Towards Sustainable Solid Waste Management. Case Study - DSM city, Tanzania"; M.E. Kaseva and S.K. Gupta, Unpublished Paper; Ardhi Institute; DSM; 1996

amounts of organic packaging material (mainly grasses) used in transporting wholesale market goods (see annex 2).

d.3.1 Retail Waste Generation Rate

The two markets surveyed during WACS were Myananyamala Map and Buguruni, both of which have very few wholesale operators (7 and 9 out of totals of 347 and 359 operators respectively). Hence the WACS data for these markets has been used to calculate the WAGR for retail operators. Discussions with market representatives at the two markets revealed that the operator participation rate in WACS was 90% and 65% respectively and hence the calculated retail WAGR was adjusted to take this into account as shown in Table 6-9.

Table 6-9: Calculation of WAGR for retail operators

Market	Avg. Waste Qty. Collected (kg/d)	% Operator Participation Rate	Amended Qty. of Waste (kg/d)	No. of Operators	WAGR (kg/op/d)
Mwananyamala	817.1	90	907.8	347	2.62
Buguruni	782.9	65	1204.4	359	3.35

Note: op = operator

The WAGR of 2.62 kg/op/d calculated for Mwananyamala market is considered to be too low as in this market 25% of the operators run shops, well above the average of 10% for the 19 markets surveyed. Shops are known to produce less waste than other trading operations in markets. Hence, the waste generation rate is increased by 10% to compensate for this, giving a value of 2.88 kg/op/d. The average waste generation rate is calculated using the latter figure for Mwananyamala Map and that of Buguruni market to give a value of 3.12 kg/op/d.

d.3.2 Wholesale Waste Generation Rate

Kariakoo Market has the highest number of official wholesale operators compared with any other market in DSM and records the daily collection and disposal of waste from the market as it hires private contractors to do this. Hence, the wholesale waste generation rate was obtained from Kariakoo market waste collection data assuming that the waste collected is from market operators only and not from petty traders operating in the vicinity of the market.

For June 1996, when WACS was conducted, an average of 1500 wholesale operators were present and an average of 4 trips per day for market waste removal were made by private contractors from KMC[5]. The quantity of market waste carried by contractors' trucks is 2-2.5 tonnes/trip from weighbridge measurements. Hence the amount of waste generated from Kariakoo market during June 1996 was 8-10 tonnes per day. Taking the average figure of 9 tonnes/day = 9,000 kg/day and letting G = waste generation rate from wholesale operators, then:

Wholesale waste generation + retail waste generation = total waste generation

No of wholesale operators x G + no of retail operators x 3.12 = 9,000

1,500xG + 306x3.12 = 9,000 kg/d

G = 5.36 kg/op/d

[5] Source: KMC Market Dept Superintendent

Vingunguti weighbridge data was subsequently obtained for Kariakoo market for the period 11-28 February 1997. The daily average number of trips and tonnages of waste were 3.9 trips/d and 9.7 tonnes/d respectively, corresponding to 2.45 tonnes/trip (see P/R (3)). These values are consistent with those quoted above for June 1996 and support the validity of the above data and the calculated WAGRs.

d.3.3 Waste Generation Amount

The number of retail and wholesale market operators in official markets was estimated to be 7,766 and 1,803 respectively as explained in Section 6.2. Combining this data with the corresponding WAGRs above gives a total market waste generation amount of 33.9 t/d[6], equivalent to 0.017 kg/cap/d using the estimate population figure for 1996 of 2,030,230.

d.3.4 Comparison with other Studies

Haskoning determined market waste generation rates through collection data of City Cleansing, KMC data, interviews with market representatives and field visits. He estimated the number of retail and wholesale market operators to be 4,500 and 2,000 respectively and waste generation rates to be 20 kg/op/d and 30 kg/op/d for retail and wholesale operators respectively and calculated the total market waste generation to be 150 t/d, which represented 25% of the domestic solid waste generation in 1988 and was stated to be a normal figure for cities in Africa and Asia. The waste generation amount of 33.9 t/d calculated here corresponds to 2.4% of the present domestic solid waste generation, an order of magnitude less than the figure of Haskoning.

ERL[7] estimated the market waste generation rates in the towns of Jinja and Tororo in Uganda to be 0.11-0.14 kg/cap/day while the value calculated here of 0.017 kg/cap/day is an order of magnitude less than the former figure. Their methodology was not stated.

Both these comparisons suggest that the calculated value significantly understates the true market waste generation amount. However, the Vingunguti weighbridge data for Kariakoo market obtained for the period 11-28 February 1997 supports the market waste generation amount obtained in this Study. An average figure of 9.7 t/d of market waste were disposed of at Vingunguti disposal site from Kariakoo market during this period, which is consistent with the stated figure of 9 t/d for June 1996 obtained from Kariakoo market records, as explained in Section d.3.2 above. This means that the market retail and wholesale WAGRs are of the correct order of magnitude and validates the calculated market waste generation amount. Furthermore, it suggests others reasons are responsible for the lack of agreement between the data obtained in this Study and that cited above from the other two studies.

One possible reason for the difference is that this Study's calculations are based only on official markets in DSM. Data from the Informal Sector survey carried out for DSM in 1995 states there are 88,841 operators selling fruit, vegetables, fish and meat and a further 63,022 selling cooked food in the city. Markets are based on the former activities and also contain a smaller proportion of operators selling cooked food. Market operators are counted as part of the informal sector so the total of 9,569 operators in official markets represents 11% of the 88,841 total of "market" operators working in the

[6] 5.36x1,803 + 3.12 x 7,766

[7] "GTZ/World Bank Seven Towns Project" Reports, Environmental Resources Limited

city. If some allowance is made for cooked food sale then this percentage will be even smaller. Hence, the actual market waste generation amount (official and unofficial market) will be ten times greater than the calculated value (official markets only) which explains the order of magnitude difference between the results of this Study and those of the two other studies.

Another possibility is that the data of Haskoning is too high. Market waste collection points (WCPs) are often used by nearby residents and petty traders as dumping places for their own waste. During WACS, efforts were made to ensure that the market waste collected originated only from market operators. Operators were instructed to store their waste in baskets/boxes and then to bring this waste to the collection vehicle when it arrived where loading was supervised. If the waste from these other sources is also included as market waste, then the market WAGR will be artificially high as illustrated by the following two examples:

- KMC have found a big difference in the amount of waste collected for disposal from the market following the eviction of petty traders from the surrounding area in March this year. In February 1996 an average of 5.8 trips of waste were being made per day while in June the average was 4. The June figure represents market waste only (no petty traders) and corresponds to the end of the rainy season when the production of waste in the market is high. On this basis it is anticipated that the dry season waste production average will be 3 trips/day. Records to date for July (dry season) vindicate this. Hence the figure for February, which is in the middle of the dry season should be 3 trips/day rather than the 5.8 trips/day recorded. The difference of 2.8 trips/day may be attributed to the waste contributed by petty traders and possibly some residents and means that the amount of market waste and hence the WAGR has been artificially increased by 93%.
- The amount of waste dumped by residents at market WCPs was estimated using POS (Q3-1) results, as shown in Table 6-10, to calculate the number of people who dump waste at market WCPs and multiplying this number by the average weighted household waste generation rate of 0.698 kg/cap/d to get 47.1 t/d of waste. If this is added to the 33.9 t/d market waste generation amount calculated above, this would artificially increase market waste and the WAGR by a factor of 2.39 to 81 t/d.

Table 6-10: Waste dumped by households at market waste collection points

Category	Percentage disposing at market place	total population	total number of people dumping at market
UA	27	56,880	15,358
SUPA	3	776,356	23,291
SUUA	3	963,016	28,890
RA	0	233,978	0
Total			67,539

e. Street Sweeping and Trunk Road Maintenance Waste

e.1 Definition

Street sweeping waste includes all waste generated by the street sweeping cleansing service operated by Multinet and is mainly dust and litter. Trunk road maintenance waste is waste arising from grass cutting, tree/flower cutting/pruning and sand sweeping along trunk roads, and silt removal from trunk road drainage channels. These operations are carried out by the Ministry of Works.

e.2 Sampling Rationale

Multinet is responsible for street sweeping within the wards from which it collects waste. It is their policy to carry out street sweeping on all tarmaced roads within the areas they service. At the time of WACS, they were collecting waste from 5 wards in the City centre (urban area) and sweeping streets in 3 of these wards where virtually all the streets were tarmac. The two streets used as WACS sampling points were within these 3 wards and were chosen to be representative of the central city area; one (Jamhuri St.) being in a business area; the other (Indira Gandhi St.) in a commercial area. Observation suggests that these streets may produce more waste than the majority of streets in these wards. The parameter used is the total length of streets in the wards being swept.

As well as street sweeping, there are a number of trunk road maintenance operations carried out, as defined above. For practical reasons, WACS sampling points were not selected for these categories. Instead waste generation amounts were estimated from statistics and interviews with concerned parties.

e.3 Street Sweeping and Trunk Road Maintenance Waste Generation Amounts

Street Sweeping
Parameter: total length of streets swept by Multinet in June 1996
Source of Data: Multinet; by measurement from DSM city map (to scale)
Total length of streets: 32.794 km
WAGR: 40.390 kg/km/day
Total Street Sweeping Waste Generation Amount:1324.6 kg/day = 1.3 t/d

Note: 1) Street sweeping was carried out on a 7 day basis during WACS. Normally, it is conducted 6 day/week.
2) At the time of the WACS survey, street sweeping was only carried out by Multinet in 3 of the 5 wards in which it was collecting waste. Hence, the total length of streets was calculated for these wards only.
3) The same WAGR has been used for all streets in this area, even though some parts of the city centre are relatively free of people, especially Ocean Rd.
4) Some private roads (around State House, Speaker's Office, Karimjee hall, Gymkhana Club, Ocean Rd hospital) have not been included as Multinet does not sweep these.

Trunk Road Maintenance
Parameter: depends upon the type of cleaning operation. See Section 6.2.4
Sources of Data: Ministry of Works staff, DCC Engineering Section
WAGR: see Section 6.2.4
Trunk Road Maintenance Waste Generation Amount: 88.9 t/d.

The different operations grouped together under trunk road maintenance are described fully in Section 6.2.4 together with estimations of the amount of waste generated in each operation. However, as the generation, collection and disposal of wastes from these

operations is controlled by the Ministry of Works and this situation is unlikely to change in the foreseeable future, trunk road maintenance waste was excluded from this Study.

Hence, only street sweeping waste (1.3 t/d) is included in the waste stream.

f. Informal Sector Waste

f.1 Definition

Waste arising from informal sector activities. A large amount of waste of very diverse nature is generated by this sector. In this Study, informal sector waste is restricted to waste from such activities which are conducted outside of a family's home and premises and can be classified as trade/restaurant/hotel or transport/finance/community services enterprises.

f.2 Rationale

The informal sector in DSM is extremely large with an estimated 222,915 operators and 43,755 workers in 1995. The range of enterprises that are included within the informal sector is very wide, including livestock raising, food processing, paper products manufacture, construction activities, taxi services, fruit/vegetable/fish/meat sale, shoe repair, laundry services, hair salons, etc. This sector produces a significant amount of waste of widely varying composition including metal offcuts, scraps of rubber, kitchen waste, sawdust, home brewing waste and hair. For practical reasons, informal sector waste was not included in WACS and Section 6.2.5 explains in detail how the amount of waste generated by the informal sector was estimated using statistical data. The methodology used and the results are summarised below and in Table 6-11.

Informal Sector Enterprises were divided into four groups:

1. Reusable Wastes: for livestock, fishing, other agriculture, sand and stone quarrying. The wastes produced by these enterprises are considered to be recycled and hence a WAGR of 0 was used.

2. Manufacturing and Construction Wastes: A high proportion of the wastes produced by these enterprises is thought to be recycled (e.g. brewing wastes for animal feed; paper waste may be sold to paper manufacturing industries, etc.). However, all these enterprises belong to the industrial and manufacturing sectors which are outside the scope of this Study and hence a WAGR of 0 is used.

3. Trade/Restaurant/Hotel Enterprises: These activities are very similar in nature to those found in a typical market. Hence the market WAGR was used to calculate the total waste generation amount for trading informal sector enterprises.

4. Other Wastes: For the transport, finance/insurance/real estate, community and personal services sectors, these enterprises resemble commercial (other) enterprises but typically produce much less waste than commercial (other) enterprises. Hence the commercial (other) WAGR was multiplied by 0.3 to get a WAGR for these enterprises.

According to the definition of informal sector enterprises, they may be based within or outside of a household. The Household Interview survey found 18 out of 60 households interviewed (30%) carry out one or more informal sector activity within the home with the waste from these activities being included with the household waste. The definition

of household waste used in this Study includes waste generated from micro-business activities operated by a family within its home, meaning that some of the informal sector waste has already been counted as household waste. To compensate for this, the percentage of informal sector workers operating outside of the home (non-home based workers) was determined and used to calculate the amount of waste produced by informal sector non-home based enterprises alone. These results are shown in Table 6-11.

f.3 Informal Sector Waste Generation Amount

Parameter: number of non-home based informal sector operators
Sources of Data: Data Compilation, 1995 DSM Informal Sector Survey, Planning Commission, DSM
Number of operators: Trade: 98,949; Other: 11,050
WAGR: trade: 3.12 kg/op/d; other: 0.34 kg/op/d
Total Non-Home Based Informal Sector Waste Generation Amount: 282.7 t/d

Table 6-11 shows a breakdown of informal sector waste produced by each sector.

Table 6-11: Calculation of Waste generated by Informal Sector Non-Home Based Enterprises

Sector	Non-home based Operators as % of total Operators	Total No. of Operators	WAGR (kg/op/d)	Waste Generation Amount (t/d)
Reusable	65.0	8,683	0	0
Manufacturing & Construction	68.3	45,451	0	0
Trade	64.5	153,409	3.12	278.9
Other	71.9	15,372	0.34	3.8
TOTAL	**65.6**	**222,915**		**282.7**

1) Note: Waste Generation amount = fraction of non-home based operators x total no. of operators x WAGR
2) The number of non-home based trading operators (98,949) is adjusted by subtracting the number of market operators (9,569) from it to give 89,380 operators before calculating the waste generation amount. This is done because all market operators are non-home based and the amount of waste generated by them has already been included in the market waste generation amount.

The informal sector waste generation amount is 282.7 t/d. This is a high generation rate, representing 20% of the total domestic waste generation. However, it is thought to be a reasonable estimate when the number of operators and types of enterprises included in this calculation is considered, as discussed below.

The number of operators in the informal sector is very high, constituting 11% of the total population. If their customers are included as well the actual number of people involved as either an operator, worker or customer is very high, possibly over 50% of the population. Economic statistics verify that the number of people utilising this sector is high. In 1995 the informal sector total gross output and total gross value added were

180 billion and 139 billion Tsh[8]. Based upon the high economic activity and number of people involved in this sector it is expected that it will generate a large amount of waste.

The two main generators of waste are the fruit/vegetable/fish/meat and cooked food sub-sectors. Non-home based operators in these sectors constitute 67.5% of the total number of non-home based operators.

The fruit, vegetable, fish, meat sub-sector includes all markets (official and unofficial) and many other independent operators around the city. Essentially, these operators (home based and non-home based) are providing fresh food for the city population.

The cooked food sub-sector includes small canteens ("mamantilie" and migihawa" in swahili), fried food and barbecue vendors who produce a lot of waste. It also includes operators selling small food items, like doughnuts, rice cakes, chapattis, etc. which produce little waste. Such enterprises are scattered throughout the city with the heaviest concentrations being in the city centre, Kariakoo and near many large factories. Essentially these operators (home based and non-home based) are providing cooked food for the city population, particularly at lunchtime and in the evenings.

If all operators are considered (home based and non-home based) then the ratio of operators:residents is 1:23 and 1:32 for the fruit/vegetable/fish/meat and cooked food sub-sectors respectively.

The estimated informal sector waste generation amount is based mainly on statistical data and is not considered to be very accurate. It may be possible to carry out a formal survey at a later stage to examine informal sector waste generation but this would need to be designed very carefully due to the size and diversity of the informal sector.

g. Waste Generation Amount Summary

Table 6-12 summarises the waste generation amounts calculated for the different sources investigated.

Table 6-12: Summary of Daily Waste Generation Amount in 1996

Type of waste	Category	Main Source	Daily Generation Amount (t/d)
Household waste	UA	WACS	43.0
	SUPA	WACS	549.1
	SUUA	WACS	657.4
	RA	WACS	166.8
Commercial waste	Restaurant	WACS	13.7
	Hotel	Statistics	1.6
	Other	WACS	12.0
Institutional waste		WACS	10.7
Market waste		WACS	33.9
Street Sweeping waste		WACS	1.3
Informal Sector waste		Statistics	282.7
Total Daily Waste Generation Amount			1,772.2

[8] Data Compilation, 1995 DSM Informal Sector Survey"; J.B. Mwinuka, Planning Commission, DSM, 1996

6.1.4 Waste Composition Results

a. Physical Composition

a.1 Household Waste

Table 6-13 shows the results for composition of household waste according to income category.

Table 6-13: Analysis Results of Waste Composition for Household Wastes

	Category	Household Waste			
		High income	Middle income	Low income	Weighted Average
Physical composition	Kitchen	44.5 %	41.9 %	39.8 %	42.0 %
	Paper	3.1 %	3.0 %	3.3 %	3.1 %
	Textile	3.8 %	0.5 %	0.6 %	1.2 %
	Plastic	3.4 %	1.9 %	1.9 %	2.2 %
	Grass & Wood	19.8 %	30.9 %	15.0 %	25.3 %
	Leather & Rubber	0.3 %	1.0 %	1.2 %	0.9 %
	Metal	1.8 %	2.1 %	1.8 %	2.0 %
	Glass	8.8 %	2.4 %	1 3 %	3.5 %
	Ceramic & Stone	0.5 %	0.3 %	0.4 %	0.4 %
	Other	14.0 %	16.0 %	34.7 %	19.4 %
	Total	100.0 %	100.0 %	100.0 %	100.0 %
ASG		0.31	0.39	0.49	0.39
Moisture Content		31.47 %	31.07 %	30.57 %	31.05 %

Note: "Other" is mainly soil, ash and sand accumulated from gardening activities.

Table 6-13 shows that garden waste, consisting of grass/wood and "other" (mainly soil/ash/sand), is the largest component of household waste (44.7%) followed by kitchen waste (42.0%). There is little variation in the waste composition between different income categories except:

- high income households have a higher percentage of textiles, plastic and glass waste and a lower percentage of leather/rubber than middle and low income households;
- middle income households have a much higher percentage of grass/wood waste than high and low income households.
- low income households have a higher percentage of soil/ash/sand waste than middle and high income households.

While waste moisture content is very similar for each household income category (31%), apparent specific gravity (ASG) decreases significantly with income, being 0.49, 0.39 and 0.31 for low, middle and high income households respectively. The high percentage of soil/ash/sand (34.7%) in low income household waste explains the high ASG value in this case while for middle income households the ASG value of 0.39 may be due to the high percentage of grass/wood.

Table 6-14 compares the household waste composition (weighted average basis) with other studies. The composition of the waste shows a pattern usually found in other developing countries. Comparing Haskoning's results with those of this Study, assuming that the 62.5% figure for vegetable/putrescible waste (classified as kitchen

waste in the table) includes both food and grass/wood waste, then the waste composition for DSM has not significantly changed[9]. The weighted average household density value of 390 kg/m^3 is also the same as that calculated by Haskoning.

Table 6-14: Comparison of Waste Composition Data

unit: %

Constituent	Penang, Malaysia (1987)[1]	Asuncion, Paraquay (1993)[2]	5 towns in Uganda (1990)[3]	DSM, Tanzania (1988)[4]	DSM, Tanzania (1996)[5]	USA (1990)[6]
1. Combustibles	**88.1**	**72.8**	**96.8**	**71.7**	**74.7**	**79.5**
Kitchen waste	32.8	37.4	92.2[7]	62.5[8]	42.0	9.0
Paper	25.5	10.2	1.8	6.2	3.1	40.0
Textile	3.4	1.2	0.6	1.2	1.2	2.0
Plastic	11.2	4.2	1.7[9]	1.8[10]	2.2	7.0
Grass and Wood	14.4	19.2	0.5	--	25.3	20.5
Leather and Rubber	0.8	0.6	--	--	0.9	1.0
2. Non-Combustibles	**12.0**	**20.4**	**3.1**	**29.1**	**25.3**	**20.5**
Metal	2.6	3.1	0.4	1.2	2.0	9.5
Glass	1.4	2.2	0.4	0.3	3.5	8.0
Ceramic and Stone	0.2	0.4	--	--	0.4	--
Other (sand/ash/soil/etc.)	7.8	14.7	2.3	27.6[11]	19.4	3.0
Total (%)	100	100	100	100	100	100
Density (kg/m^3)	190	215	450	390	390	--
Moisture Content (%)	--	--	rel. high[12]	58	31	--

Note: [1] "SWM Study for Pilau Pinang and Seberang Perai Municipalities"; JICA; Aug. 1989
[2] "The Study on the SWM for the Metropolitan Area of Asuncion"; JICA; Aug. 1994
[3] "GTZ/World Bank Seven Towns Project" Reports; ERL; 1990. Average composition data for the five towns: Jinja, Tororo, Masaka, Mbarara and Mbale is stated here using data from the ERL report.
[4] "Masterplan on SWM for Dar-es-Salaam"; Haskoning and M-Konsult Ltd; Mar. 1989
[5] This Study.
[6] "Integrated Solid Waste Management, Engineering Principles and Management Issues"; Tchobanoglous et al.; McGraw Hill, 1993.
[7] In the ERL Study, the very high kitchen waste percentage is mainly due to significant quantities of matoke (plaintain) skins, peelings and leaves.
[8] Kitchen waste refers to vegetable and putrescible waste in Haskoning's Study.
[9] Rubber was only stated for one town and is included with plastic in the ERL Study.
[10] Plastic and rubber were grouped together in Haskoning's Study.
[11] Other refers to sand, ash, bone, stones and pottery in Haskoning's Study..
[12] rel. high = relatively high.

a.2 Other Sources of Waste

The results of the waste composition analysis for commercial (restaurant and other), institutions, market and street sweeping categories are summarised in Table 6-15. No waste composition results for commercial (hotel), trunk road maintenance and informal sector categories were obtained as these categories were not included in the WACS survey.

[9] This can not be verified however as the exact breakdown of the 62.5% figure into food and grass/wood waste is not known.

Table 6-15: Analysis Results of Waste Composition for Other Waste Types

		Commercial		Institution	Market	Street Sweeping
		Restaurant	Other			
Physical composition (%)	Kitchen	93.4	0.8	9.2	59.6	23.0
	Paper	1.9	71.6	71.5	3.2	17.5
	Textile	1.2	2.5	2.6	0.5	1.3
	Plastic	1.7	8.4	6.1	0.9	6.4
	Grass & Wood	0.8	1.5	0.9	27.2	19.0
	Leather & Rubber	0.0	0.5	0.0	0.0	2.4
	Metal	0.5	5.3	4.1	0.1	2.5
	Glass	0.6	0.0	3.3	0.3	1.0
	Ceramic & Stone	0.0	0.5	0.7	0.2	0.9
	Other	0.0	8.9	1.7	8.2	26.1
	Total	100.0	100.0	100.0	100.0	100.0
ASG		0.64	0.03	0.05	0.23	0.22
Moisture Content (%)		55.16	22.11	8.78	53.12	15.51

Note: Other is mainly soil, ash and sand.

Some of the main points from this table are summarised below:

- For commercial waste, the main constituents of restaurant and other waste are kitchen waste (93.4%) and paper (71.6%) respectively.
- For institutional waste, paper (71.5%) is the main constituent.
- Market waste primarily consists of kitchen waste (59.6%), grass/wood (27.2%) and other (soil, ash, sand) waste (8.2%) respectively.
- The main components of street sweeping waste are other waste (26.1%), kitchen waste (23.0%), grass/wood (19.0%) and paper (17.5%).

b. Apparent Specific Gravity (ASG)

ASG of household wastes ranged from 0.31 to 0.42 and its weighted average was 0.39 while ASG of the other wastes ranged from 0.22 to 0.64. As household waste constitutes approximately 96% of the total waste amount from the generation sources surveyed in WACS, the overall waste ASG is taken to be 0.39.

c. Moisture Contents

The moisture contents of household waste were constant at around 31% while the moisture contents of the other wastes varied from 15% to 55%. As above, the overall waste moisture content is taken to be 31 %, the household waste value.

d. Carbon and Nitrogen Contents

The results for carbon and nitrogen content in market waste are shown in Table 6-16.

Table 6-16: Carbon and Nitrogen Results

	Carbon (%)	Nitrogen (%)	C/N-ratio
21 June 1996	19.104	0.743	25.7
25 June 1996	21.336	0.974	21.9
27 June 1996	20.671	1.123	18.4
Average	20.370	0.947	22.0

6.2 Detailed Waste Generators Data

6.2.1 Commercial (Other) Enterprises

The data for the number of other commercial enterprises is broken down into different categories below:

Total number of enterprises:	Wholesale, Retail, Import/Export	12,901	from RTO
	Travel Agents	102	from MOT
	Bureau de Change	88	from MOT
	Others	150	from MOT
	TOTAL	**13,241**	

Note:

1) The commercial enterprises data is compiled by the three District Trade Offices and the Regional Trade Officer (RTO) subsequently receives a summary of this data, listing the total number of enterprises in each district. The above total of 12,901 includes all wholesale, retail, import/export enterprises that were given business licences by the DCC according to Schedule B and C of the business licence application form as described below (except restaurants and ordinary hotels/guesthouses which are specified separately):

Schedule B covers the business of:

a) exporters	b) importers	c) cooperative societies
d) regional trading companies	e) wholesale	f) building contractors
g) specified profession	h) manufacturing & selling	i) selling spare parts
j) hunting	k) printing & publishing newspapers and books	

Schedule C covers the business of:

a) insurance agent	b) restaurants and ordinary hotels	c) auctioneer
d) itinerant trade[10]	e) any other business	

2) The Ministry of Trade (MOT) has records of businesses that have been granted a business licence according to Schedule A of the business licence application form. Schedule A covers the businesses of:

a) commission agent	b) manufacturers' representative	c) estate agent
d) broker	e) travel agent	f) shipping agent
g) shipping	h) commercial traveller	i) clearing and forwarding
j) insurance	k) tourist hotels	l) banking
m) transportation of goods or passengers by air		n) postal services
o) transportation of goods or passengers by railway		p) telecommunication services
q) cargo valuation	r) harbours and harbour handling	s) electricity distribution
t) buying & selling currencies	u) stevedoring or lighterage	v) courier services & mail agents
w) buying and selling motor vehicles (local)		x) broadcasting and television
y) ship chandlers	z) refining crude oil	aa) urban water supply
ab) casinos		

3) In the total number of enterprises list above, "Others" gives an approximate total for other categories listed in Schedule A above excluding travel agents (e) and Bureau de Change (t), which are listed separately, and excluding insurance, tourist hotels, banking, transportation by air and rail, postal services, telecommunication services, electricity

[10] This does not refer to the informal sector but "travelling salesmen" of whom there are very few.

distribution, refining crude oil and urban water supply which should not be included in the commercial (other) category in the context of this Study. In other words it covers a, b, c, d, f, g, h, i, q, r, u, v, w, x, y, and ab.

6.2.2 Institutions

The number of institutions and workers was obtained from the Central Register of Establishments (CRE) by combining data from several different categories. These categories are first defined and the data for each category is then presented:

a) Private Non-Profit Making: This category mainly covers religious (e.g. churches, mosques, etc.) and charitable organisations (e.g. Red Cross, UMATI, etc.). Embassies and NGOs come in this category. Private secondary schools, private kindergartens and private hospitals have also been included here although Bureau of Statistics (BOS) staff said there is some debate within BOS as to whether some of these organisations should be classified as private profit making rather than private non-profit making.

b) Government: This category includes all ministries, regional and district offices as well as the Civil Service Commission. It also includes government secondary schools, police, prisons and army headquarters in DSM (army barracks are excluded).

c) Town Council: This category covers local government authorities running municipalities or urban centres including the Local Government Commission; regional hospitals and some primary schools.

d) District Council: This category covers rural local government authorities in the districts; government district hospitals and other medical facilities and some primary schools.

e) Parastatal Profit Making: This category covers those institutions in which the government owns the majority of shares. It includes parastatals (e.g. NUWA, TANESCO), DSM Airport, government tourist hotels, government banks and government insurance companies.

f) Parastatal Non-profit Making: This covers institutions like the Tanzania Library Service, DSM University and Muhimbili Medical Centre.

Type of Institution	No of institutions	No of Workers
Private non-profit making	98	2523
Government	80	4418
Town Council	3	174
District Council	2	6
Parastatal profit making	217	51766
Parastatal non-profit making	21	3073
TOTAL	**421**	**61960**

Note:

1) Institutional Waste has been defined in Section 6.1.3c to exclude waste produced from manufacturing or industrial activities carried out by some institutions (e.g. TAZARA, THA) as such wastes are classified as industrial/manufacturing wastes which are outside the scope of this Study. There are approximately 10-15 such institutions included in the CRE data and only the administrative waste from such institutions is included here.

2) Hospital are counted as institutions according to the above definitions. However hospital waste is included in a separate category in this Study. In the context of institutional waste, only administrative waste produced by hospitals is considered here as defined in Section 6.1.3c. A similar proviso applies to waste from government owned tourist hotels, DSM airport and some other institutions.

3) One reason this approach is taken for manufacturing and industrial oriented institutions, hospitals, government owned tourist hotels, the airport and some other institutions is that it becomes very complicated to predict waste generation amounts if all types of waste produced by institutions are considered. By restricting the definition to administrative/office waste, the prediction task is simplified. A secondary reason is that individual institutions' data for the number of workers is not readily available, making exclusion of these non-office type institutions from this category very difficult.

4) There are certain other institutions not covered by the above list which should also be included in this category. These are large private profit making institutions such as private banks and private post-secondary educational institutions. Only private banks have been included here:

Private bank	Availability of Data on Workers	No of workers
1) Citi Bank (T) Ltd	no data - small - assumed 25 workers	25
2) First Adili Bank Corporation	no data - small - assumed 25 workers	25
3) East African Development Bank	data from CRE, June 1996	40
4) Euroafrica Bank (T) Ltd	data from CRE, June 1996	25
5) Greenland Bank (T) Ltd	no data - small - assumed 25 workers	25
6) Standard Chartered bank	data from CRE, June 1996	96
7) Stanibic	no data - small - assumed 25 workers	25
8) Trust Bank (T) Ltd	no data - small - assumed 25 workers	25
Total Institutions: 9	**Total Workers:**	**286**

The names of the private banks was obtained from MOT; the number of employees from the CRE unit at the Bureau of Statistics. All banks for which there was "no data" are known to be small and were assumed to have 25 workers each.

5) The CRE data is very slow to be updated. Even though the data is for June 1996, it is not considered to be very accurate. There are some major changes currently underway affecting the government, town council, district council and parastatal sectors; namely the worker retrenchment programme and the sale of some parastatal companies. These changes will alter the above data in these categories. BOS staff stated that they try to keep pace with such changes but they rely on District Statistics Officers being informed of such changes by the affected institutions who in turn will inform the BOS central staff. This process takes a long time to happen.

6.2.3 Markets

The procedure used to determine the amount of market waste generated was more complicated due to discrepancies in the number of market operators between the data obtained from market representatives during the market survey of May 1996 and DCC market data for 1995 as described in Section 2.2.6 of the M/P Main Report. In order to resolve these discrepancies, a Market Census survey was carried out to determine the number of wholesale and retail operators in the 19 markets surveyed during the original market survey. Section a describes the Market Census survey and compares the results obtained with existing DCC market data and the previous market survey data. Section b

uses the DCC and Market Census data to estimate the total number of wholesale and retail operators in official markets in DSM.

a. Market Census Survey

a.1 Terminology and Results

Each of the 19 markets were revisited and a census carried out on the number of operators and the different types of goods being sold. The original market survey used the concepts of a "shop" and "stall" to classify market operators. The scope of the Market Census survey was widened to use six categories for classifying market operators as defined in the notes following Table 6-17. Each trading activity in any of these categories is termed an "operation" and each operation is run by an "operator". Hence the number of operators is equivalent to the number of operations while the actual number of workers will be higher. The survey results are set out in Table 6-17.

Table 6-17: Market Census Survey Data

Market	Stall	Can-teen	Meat But.	Fresh Fish	Chick-ens	Shop	Recy-cling	Other	Whole -sale	TOTAL Census	TOTAL DCC
1. Kariakoo	232	1	(*a)	(*a)	(*a)	73	(*a)	0	1,500	1,806	---
2. Kisutu	143	17	5	0	90 1-sl	3	0	2-mk	4	265	390
3. Kivukoni Ferry	77	240	2	90	0	23	10-pa	7-mk	2	451	178
4. Ilala	478	29	6	16	33	12 206-mi	0	12-ta	15	807	711
5. Buguruni	299	14	0	4	13	17	2-bo	1-ba	9	359	480
6. Magomeni	421	44	12	5	11 12-sl	60	12	1-hr 3-mk	1	582	495
7. Manzese	197	17	1	7	17	0	3	0	0	242	218
8. Ubungo	117	11	5	0	13	10	0	0	0	156	85
9. Kinondoni Tx	88	3	1	0	0	9	1	6-mk 10-sh	0	118	no data
10. Mwana-nyamala	178	24	6	32	0	57 31-mi	0	12-mk	7	347	164
11. Mtambani	193	27	9	4	36 6-sl	51	7	8-mk	5	346	245
12. Tandale	224	55	12	5	9 1-sl	28	1-pa	0	100	435	216
13. Mwenge	58	0	0	0	4	1	0	1-mk	0	64	58
14. Mbagala	131	31	5	33	3	24	2-me 1-pa	0	0	230	195
15. Madenge	132	11	15	9	0	24	1-pa	0	0	192	117
16. Mtoni	102	13	10	26	0	4	1-pa 1-ct	3-mk 1-wo	0	161	175
17. Temeke	20	18	5	0	0	16	0	2-ba 1-mk	0	62	69
18. Keko	238	30	8	12	4	10 11-fu	0	1-ba 1-mk	0	315	215
19. Tandika	285	15	20	57	38	29	1-dr 1-me 3-pa	2- pl	100	551	621
TOTAL	3613	600	122	300	291	699	47	74	1743	7489	4632

Note: 1) The following categories were used for describing operations:
a) Canteens: This covers small seated eating places ("mamantilie" and "migahawa" in swahili) and barbecue operators (meat kebabs/chips/eggs).
b) Fish, Chicken and meat: These have been specified separately with an additional distinction being made between chicken traders and chicken slaughterhouses.
c) Recycling: These are stalls selling paper, glass and plastic bottles, kitchen utensils, etc. made from recycled materials. The number stated is approximate only.
d) Shops: These are kiosks and small shops selling mainly non-food items (household items, etc.) and/or packaged food items (bread, tins, bottles of oil, etc.). Used clothes traders are also included in this category. These operations should generate a small amount of market waste.
e) Stalls: These are tables selling vegetables, fruit, rice, flour, beans, dried fish, etc. (i.e. all fresh produce).
f) Other: This covers vendors selling fuel (wood, charcoal) and other items not covered by the above categories.
2) ba = bar; bo = glass bottles; But. = butcher; ct = cans/tins; dr = drums; fu = furniture; hr = hair saloon; mi = used clothes; mk = charcoal; pa = paper; sh = shells; sl = chicken slaughterhouses; ta = tailor; wo = wood.

a.2 Notes

These notes clarify points from this survey and the Market Survey of May 1996. [Mkt = market]

1) Mkt 1 - Kariakoo: (*a) The number of meat butchers, fresh fish, chicken and recycling operators is included in the total for stalls. Kariakoo has 2,235 registered wholesale operators for 1995/96. However, their operations are seasonal and the number of wholesale operators present at any one time is much less than the number registered. The KMC Wholesale section manager stated that the number of wholesale operators present during different times of the year are: 1500-2000 for the peak months of Nov.-Jan.; 1000-1500 for Feb.-July and 800-1000 for Aug.-Oct. inclusive. As June is one of the busier months within the Feb.-July period a figure of 1,500 wholesale operators is stated in Table 6-17.

2) Mkt 2 - Kisutu: There is a large chicken slaughterhouse here which generates a lot of waste.

3) Mkt 3 - Kivukoni Ferry: This market mainly deals with the reception and sale of fish. There are over 200 fishermen who supply fish to this market. Data was supplied to us by Vusha Fisheries Co-operative who carried out a census of the market on our behalf. They listed the number of canteens as 60 but further research indicated that each canteens is made up of four smaller canteens. Hence we have stated the number of canteens as 240.

4) Mkt 4 - Ilala. This has a large number of used clothes sellers.

5) Mkt 6 - Magomeni. 59 of the stalls are located on CCM land and are not officially part of the market. However, as these stalls merge with those of the official market, they have been included in our census.

6) Mkt 7 - Manzese. This market is approximately 100m towards the city centre from the Konoike overbridge.

7) Mkt 8 - Ubungo: this market's official name is Ubungo Mizani.

8) Mkt 10 - Mwananyamala: this market's official name is Mwananyamala Map.

9) Mkt 12 - Tandale: 52 stalls and 40 canteens are outside of the official market but merge with the official market and hence have been included in our census. The number of wholesale traders is variable and hence the stated figure of 100 is only approximate.

10) Mkt 14 - Mbagala: This market's official name is Mbagala Kizuiani.

11) Mkt 15 - "Madenge": This market was incorrectly named in Progress Report (1) as "Yombo". It's real name is "Madenge". The location also differs from that originally stated.

12) Mkt 17 - Temeke: This market's official name is Temeke Mwisho.

13) Mkt 18 - Keko: This market's official name is Keko Magurumbasi. Note that the DCC data is for Keko Magurumbasi and Mwanga together (two different markets). No DCC data for Keko Magurumbasi alone is available.

14) Mkt 19 - Tandika: The market chairman stated that the number of wholesalers is variable so that the stated figure of 100 is only approximate. These people come with their goods by truck, sell them at the market but then leave. Typically, most of the wholesale business is conducted in the morning. The Market Master stated that the DCC data is too high as a lot of stalls have been demolished since last year.

a.3 Comparison of Market Census and DCC Data

The complete DCC market data and market survey data of May 1996 are set out in Annex 2. DCC data for the markets resurveyed in the Market Census is presented in Table 6-17 next to the total number of operators column. Agreement between the two sets of data is poor.

Furthermore, reference to the market survey data of May 1996 shows that there are many anomalies between this data and the Market Census results, meaning that the original data obtained from market representatives (May 1996) was very inaccurate.

b. Estimation of Total Number of Operators in Official Markets in DSM

The census survey covered 19 of the 69 official markets in DSM (68 DCC markets and the independent Kariakoo (KMC) market whereas the DCC data covers 18 of the 19 markets surveyed and the remaining 50 official markets in DSM. However, for 8 of these 50 markets, the DCC data lists their name only without any numerical data. Hence it is necessary to include the number of operators from these unsurveyed markets in our census in order to estimate the total number of operators in official markets in the city. Based on the census survey results, the DCC data underestimates the total number of operators for all markets and must be adjusted accordingly. This was done on a pro rata basis as follows:

1) Adjust the census total number of stalls to exclude Kariakoo and Kinondoni Tx markets for which DCC has no data: Adjusted total = 7,489-(1806+118) = 5,565.

2) Calculate a data correction factor = adjusted census total/DCC total = 5,565/4,632 = 1.20.

3) Determine the number of markets and number of operators not surveyed in the census from the DCC data. These results are shown in Table 6-18.

4) Adjust the number of operators in these markets using the correction factor. Adjusted number of stalls = 1,649 x 1.20 = 1,980.

5) There are 8 official markets included in the DCC list, all of which are small, for which no numerical data was stated. The number of operators in these 8 markets is estimated to be 100, giving a total of 2,080 operators.

Table 6-18: Unsurveyed official markets and Number of operators

District	No of markets in DCC list without operator data	No of markets in DCC list with operator data	No of operators in the 42 DCC markets having data
Ilala	2	11	304
Kinondoni	5	22	953
Temeke	1	9	392
TOTAL	8	42	1,649

6) Based on discussions with the KMC Market Superintendent, the number of wholesale operators amongst the total of 2,080 operators is estimated to be 60. The remaining 2,020 operators are assumed to be retail operators.

7) Calculate the overall number of operators in official markets in the city. This is shown in Table 6-19.

Table 6-19: Total Number of Wholesale and Retail Operators in Official Markets

Source	No of markets	Wholesale operators	Retail operators	Total no of operators
Market census survey	19	1,743	5,746	7,489
DCC adjusted data				
- markets with data	42	60	1,920	
- markets without data	8		100	2,080
TOTAL	69	1,803	7,766	9,569

Note: 1. Unofficial markets are not included in the estimation of the total number of operators as these are included in the informal sector data.

6.2.4 Trunk Road Maintenance Operations

a. Responsible Agencies and Cleaning Operations

There are two agencies other than Multinet which are responsible for street and road maintenance operations throughout the city.

1. Dar es Salaam City Commission (DCC)

Source: Mr Massoro, DCC Engineering Section.

Details: The City Commission is responsible for the sweeping of all non-trunk roads throughout the city. Multinet, under contract to DCC, carries out this work in the wards in which it is operating, as previously explained. Street sweeping of other non-trunk roads is carried out in some other parts of the city but on an irregular basis. There is a separate Gardening section which has an office near Karimjee Hall that is responsible for maintaining the four botanical gardens within DSM.

2. Ministry of Works

Source: Mr Kajiro, Trunk Roads Engineer, Ministry of Works

Details: The Regional Engineer/Ministry of Works is responsible for cleaning on all the trunk roads in DSM. They carry out four different types of operation, as described in Table 6-20.

Table 6-20: Summary of Road Cleaning Operations carried out by Ministry of Works

Task	Employment	Work details
Grass Cutting	Workers: Length workers No of workers: 188 Monthly salary: 30,000	Arrangements: Normally, each length worker works individually. Daily Allocation: 300 sq.m./person/day Total Allocation: 0.5 km/person Frequency: Workers arrange their own schedule. Payment is based on whether their allocated area is clean. Equipment: slashers, etc. provided by Min. of Works.
Sand Sweeping	Workers: Length Workers No of workers: 81 + 2 "backup" gangs of 15 workers Monthly salary: 30,000	**Length Workers:** Arrangements: two people work together as a pair normally. Daily Allocation: 86 sq.m./person/day Total Allocation: 1 km/person Frequency: Workers arrange their own schedule. Payment is based on whether their allocated area is clean. Equipment: wheelbarrow, hard broom, spade, traffic cone provided by Min. of Works. Reflective jackets are on order. **Backup gangs:** Assigned to difficult areas on an "as required" basis.
Tree & flower cutting/ pruning	Workers: Private Contractor Payment: contract basis	Arrangements: This work has been contracted out. The allocation stipulated in the contract is 5-7 trees/day/person. Frequency: Contractor arranges their own schedule. Payment is based on whether the work is completed as specified in the contract. Equipment: supplied by Contractor themselves.
Silt Removal from Trunk Road Drainage Systems	Workers: Min. of Works employees No of workers: 47 Monthly salary: 30,000	Arrangements: Min. of Works gangs carry out this task on a rotating road by road basis. Daily Allocation: 70m/person/day for open channels during the wet season; (100m - dry season) Total allocation: approx. 1 km/group/day but depends on degree of silting and type of drainage system. Frequency: approximately 2 months; blocked channels are cleaned as soon as possible Equipment: provided by Min. of Works

Note: 1. Activities like grass cutting and sand cleaning have been contracted to "length workers". All unit rates and allocation of areas has been built up on the basis of practical work/research. For example, with grass cutting, each length worker has been assigned a daily allocation of 300 sq.m. and been given a 0.5 km stretch to take care of permanently. The salary is 30,000/- per month on the condition that the area must be clean. In addition, there are two "backup units" for sand cleaning who are assigned to clean troublesome areas on an "as required" basis.

2. Tree/flower cutting and pruning along trunk roads has been contracted out to a private company: Klein & Associates Construction Co. Ltd, P.O. Box 3455, Dodoma. [The contractor has an office in DSM and may be contacted through Mary Boba, CDA, IPS Building, near Askari monument].

3. The cleaning of drainage systems is carried out by the Ministry of Works itself. Different parts of the city have different drainage systems. For example, most of the trunk roads within the city centre (Bibititi Mohamed, Samora, Azikiwe, Nkurumah) have a "gully" system. Outside the city centre some trunk roads have US drains (Ali Hassan Mwinyi Rd); others have open channel drainage (Morogoro) and some have none (parts of Nelson Mandela Rd). The total length of trunk roads in DSM is 240 km.

b. Quantities of Waste Produced

For Multinet's street sweeping operations, the amount of waste produced per km per day in the 5 wards in which it was operating in June 1996 was measured in WACS as previously described. The quantities of waste produced by DCC and Ministry of Works cleaning operations were estimated through interviews with DCC garden staff and engineers and Ministry of Works length workers, gangs, truck drivers and engineers as described below.

Engineering staff at the Ministry of Works stated that it is their policy to collect all grass cutting and sand sweeping waste for subsequent disposal. However, they only have two vehicles assigned to this task which is inadequate to cover the whole city. These two vehicles tend to be assigned to critical areas, especially for the collection of waste from trunk roads in the city centre and collecting the large quantities of waste produced by the backup gangs work. Grass cutting waste is usually not collected.

b.1 Grass Cutting

Three Grass cutting length workers were interviewed. Generally, the grass height is kept low so that a small quantity of grass is produced per day, especially during the dry season. Two of the length workers who work along Nyerere Rd confirmed this. The third who works on Nelson Mandela Rd estimated the quantity of grass to be equal to 0.8 cu.m. during the wet season while the dry season quantity was quite small. Ministry of Works Engineering staff stated that some roads yield large quantities of grass, especially Nyerere, Nelson Mandela and Morogoro Road. Based on these interviews the quantity of grass cutting waste produced per length worker per day was estimated to be 0.4 cu.m. during the wet season and 10% of this quantity during the dry season. Using a density for grass waste of 100 kg/m^3 and knowing that the number of length workers is 188 the amount of grass waste generated is calculated below:

Season	Quantity of Grass waste (kg/person/d)	Grass Waste Generation (t/d)
Wet	40	7.52
Dry	4	0.75

The length workers arrange disposal of the grass cutting waste themselves. All 3 interviewees dump this waste at the side of the road near their working area and this is common practice. 2 of them stated that it is not collected while the third believes that it is collected but was not able to confirm this. In some places, Ministry of Work staff stated that other people take the grass waste for free or at a small price and use for animal feed.

b.2 Sand Sweeping

1) Ministry of Works: Two sand sweeping length worker pairs were interviewed. The quantity of sand sweeping waste collected per pair per day is estimated by taking the average number of wheelbarrows of waste collected by these two pairs. The volume of a wheelbarrow was measured as 0.080 cu.m. and density of sand as 1500 kg/cu.m. Assuming each wheelbarrow is filled to 90% capacity this gives a mass of 108 kg of sand per wheelbarrow. Using this figure and knowing that the number of length worker pairs is 41 the amount of sand waste generated is calculated below:

Season	Quantity of Sand Sweeping waste (t/pair/d)	Sand Waste Generation (t/d)
Wet	2.16	88.6
Dry	1.40	57.6

The quantity of sand collected per day by the two Backup gangs must also be considered. In this case the quantity of waste depends more on the condition of the area cleaned than the season. 20 t of sand were collected for the 2 groups on the day of the interview from a "difficult" area. The corresponding quantity of sand waste from an "easy" area was estimated to be 10 t/d. Hence an average value of **15 t/d** of waste is used.

In general, the workers heap the sand waste at the side of the road from where it is collected by Min. of Works trucks. The waste is usually used for earth filling in low lying areas or on construction sites or to prevent erosion on an "as requested" basis. Alternatively it is sometimes used to fill potholes in roads. This was confirmed by one of the two sand sweeping pairs interviewed who stated that Min. of Works trucks do collect the sand waste but the second pair commented that due to the infrequency of this collection, they now just throw the sand they collect at the side of the road. The backup gangs interviewed usually have at least one truck assigned to them for sand waste collection.

2) DCC: The amount of street sweeping waste collected by Multinet has already been calculated in WACS. No data is available on the DCC's other street sweeping operations and it is assumed that the amount of waste produced from this source is negligible due to the poor coverage of other parts of the city and the irregularity of the DCC's cleaning operations.

b.3 Tree and Flower Cutting/Pruning

This work is carried out by two agencies:

1) Klein & Associates Construction Co. Ltd, the contractor to the Ministry of Works for tree cutting/pruning along trunk roads, has not yet been contacted. Waste disposal is arranged by the Contractor themselves and the Ministry of Works believes that the waste is disposed of by burning/burial although this has not been confirmed (assumed to be proper self-disposal). The amount of waste produced from this source is estimated to be **1 t/d and 0.6 t/d** during the wet and dry seasons respectively.

2) DCC Garden Section. Information has been obtained for the main botanical garden at Karimjee Hall. There are 24 labourers working in this garden with responsibilities for cutting, planting, raising seedlings, watering, sweeping, etc. They estimated that approximately 5 wheelbarrow loads of waste are currently collected (dry season) per day. Assuming a density of 200 kg/cu.m. for garden waste and using the calculated wheelbarrow volume of 0.08 cu.m. this gives a daily quantity of waste of 80 kg. The waste is disposed of in a pit within the botanical garden and this is considered to be proper self-disposal (waste is organic and garden area is large). It is thought that this practice is followed in all four botanical gardens and it is assumed that the quantity of waste produced in each is the same giving a total of **320 kg/d**. The equivalent wet season figure is taken to be **480 kg/d**.

This waste generation amount is small and does not enter the waste stream now nor is it anticipated it will do so in the foreseeable future as no change in disposal practice is envisaged. Hence, this waste amount is neglected.

b.4 Silt Removal from Drainage Systems

It is assumed that the rate of silt buildup is the same on all trunk roads. Based on a daily allocation of 1km per gang, a cleaning frequency of once every two months and 2 t/km and 1 t/km of silt being obtained from drainage channels during the wet and dry seasons respectively [Source: Ministry of Works] the amount of silt waste generated is summarised below:

Season	Quantity of Silt waste (kg/km/d)	Silt Waste Generation (t/d)
Wet	33.3	8.0
Dry	16.7	4.0

b.5 Summary

The amounts of trunkroad maintenance waste (wet and dry seasons) generated from the different sources described above are summarised in Table 6-21 below together with a weighted average waste generation amount, which is calculated based on the wet and dry seasons being of 3 and 9 months duration respectively.

Table 6-21: Estimated Daily Quantities of Trunk Road Maintenance Waste

Cleaning Operation	Wet Season Qty. of Waste (t/d)	Dry Season Qty. of Waste (t/d)	Weighted Average (t/d)
Grass cutting	7.50	0.75	2.44
Tree cutting	1.00	0.60	0.70
Sand Sweeping	103.60	72.60	80.35
Silt Removal	8.00	4.00	5.00
Total	**120.58**	**78.27**	**88.49**

c. Grass Cutting Interviews Summary

Questions
1) how many of you work together? 2) how many days do you work per month?
3) what distance do you cover on average in 1 day during the rainy and dry seasons?
4) how much grass cuttings do you collect in 1 day during the rainy and dry seasons?
5) What do you do with this waste?

Interview Results

G1
Location: Nelson Mandela Road
Number of People: 1
Number of Days work per month: 26 days (every day except Sun)
Distance Covered per day: approximately 1km (all seasons; both sides of road and median strip)
Amount of grass cutting waste collected per day - rainy season: 1 small pickup load
- dry season: small amount
Disposal of Waste: it is never collected. The waste is thrown along the side of the road.

G2
Location: Nyerere Road
Number of People: 2 people working as a pair

Number of Days work per month: 26 days (every day except Sun)
Distance Covered per day: approximately 1km for the pair (both sides of road and median strip)
Amount of grass cutting waste collected per day: not known
Disposal of Waste: they leave the grass waste in a particular area. They believe that Ministry of Works trucks collect the grasses (usually in their absence). They don't know where the wastes are taken to.

G3
Location: Nyerere Road
Number of People: 2 people working as a pair
Number of Days work per month: 26 days (every day except Sun)
Distance Covered per day: 1km (both sides of road and median strip)
Amount of grass cutting waste collected per day: the amount of waste produced is small.
Disposal of Waste: Normally, they throw the waste at the side of the road and it is not collected.

d. Sand Sweeping Interviews Summary

Questions
1) how many of you work together? 2) how many days do you work per month?
3) what distance do you cover on average in 1 day during the rainy and dry seasons?
4) how much sand/street waste do you collect in 1 day during the rainy and dry seasons?
5) What do you do with this waste?

Interview Results

SS1
Location: Ali Hassan Mwinyi Rd, from Oyster Bay Police Station to St Peter's Roman Catholic Church
Number of People: 2 working in a pair
Number of Days work per month: 26 days (every day except Sun)
Distance Covered per day: approximately 1km (both sides) for the pair.
Amount of Sand/street waste collected per day - rainy season: 10 wheelbarrows
- dry season: 6 wheelbarrows
Disposal of Waste: the waste is placed in piles at the roadside. It is collected from here by Ministry of Works trucks 2-3 times per week. They do not know where the waste is subsequently disposed.

SS2
Location: Rashidi Kawawa Road
Number of People: 2 working in a pair
Number of Days work per month: 26 days (every day except Sun)
Distance Covered per day: 1 km (both sides) from Morocco traffic lights to Kinondoni B bus station.
Amount of Sand/street waste collected per day - rainy season: 30 wheelbarrows
- dry season: 20 wheelbarrows
Disposal of Waste: in the past, they placed the waste in piles at the roadside and it was removed from here by Ministry of Works trucks. However, due to the infrequency of the collection service, presently they throw the sand waste at the side of the road.

SS3
Location: Nelson Mandela Road - Ubungo Traffic lights
Number of People: 15 people per group. At the time of the interview there were two groups working (straightening the road edges and sand collection) on different sides of the road.
Number of Days work per month: 26 days (every day except Sun)
Distance Covered per day: they have no specified roads to work on. They are assigned to any road which is in a very bad condition. Hence, the distance covered per day depends upon the conditions of the road. For example, on the day of interview, each group covered one side of the road for a distance of 180m from Ubungo traffic lights (Morogoro Rd) to the riverside bridge (Nelson Mandela Road). According to their experience, this was a very small distance but the road was in a bad condition, overgrown with grass and much sand.

Amount of Sand/street waste collected per day: highly variable; the quantity of waste depends upon the condition of the road as well as the season. On the day of interview, 20 tonnes of waste were removed by trucks for the two groups.
Disposal of Waste: They normally load Ministry of Work trucks with waste. The truck driver was interviewed and stated that the sand is normally used for earth filling in low lying areas or on construction sites or on land with erosion problems on an "as requested" basis. Sometimes, it is used to fill potholes in roads around DSM.

6.2.5 Informal Sector

The procedure used to determine the informal sector waste generation amount is explained in detail in this section.

a. Definition of the Informal Sector

The definition of the informal sector adopted by the Planning Commission of the Government of Tanzania is used in this Study. This definition is based on the resolution adopted by the 15th International Conference of Labour Statisticians (ICLS) held in January 1993 but its specifications were adapted to suit the situation in Tanzania. According to this definition[11], the informal sector is considered:

a) as a subset of household enterprises or unincorporated enterprises owned by households. They are enterprises which:
- are not separate legal entities independent of households or of household members which own them;
- do not have a complete set of accounts;
- may or may not employ paid labour;
- may be carried out inside or outside the owner's home.

b) to comprise of informal own account enterprises as well as enterprises of informal employers.

c) to include enterprises which render professional or business services (e.g. doctors, lawyers, etc.) if they meet the requirements of (b).

d) to include small-scale and/or unregistered agricultural, livestock keeping, bee-keeping and fishing activities.

b. Informal Sector Data

DSM Informal Sector Data for 1995 was obtained from the Planning Commission[12] and is shown in Table 6-22.

[11] "Promoting Productivity and Social Protection in the Urban Informal Sector"; J.B. Mwimuka; ILO, May 1996
[12] "Data Compilation, 1995 DSM Informal Sector Survey"; J.B. Mwimuka, Planning Commission, DSM, 1996 (unpublished). A Informal Sector Survey report is currently being written and should be published at the end of 1996.

Table 6-22: No. of Informal Sector Operators and Workers by Industrial Sector

Industry	Industrial Sub-Sectors	No of Operators		No of Workers	
		Sub-Sector	Sector Total	Sub-Sector	Sector Total
Agriculture/ Livestock	Livestock	683		1,141	
	Fishing	2,622		369	
	Other agriculture	4,451	7,756	3,639	5,149
Mining & Quarrying		927	927	89	89
Manufacture	Food Processing	895		280	
	Local Beer Brewing	5,691		2,026	
	Cloth making	10,446		921	
	wood products	8,632		3,939	
	paper products	617		0	
	clay products	701		749	
	vehicle/machine repair	1,827		1,022	
	other manuf.	1,267	30,076	434	9,371
Construction		15,375	15,375	5,666	5,666
Trade/ Restaurant/ Hotel	Shops - general	1,423		1,076	
	fruit/vege./fish/meat	88,841		10,979	
	cooked food sale	63,022		9,718	
	other trading	123	153,409	61	21,834
Transport	Bus/taxi - passenger	2,038		989	
	other transport	1,922	3,960	136	1,125
Finance/Insurance /Real Estate	business services	342	342	1	1
Community & Personal Services	Medical/health - other	1,982		85	
	art and music	1,052		0	
	shoe repair/other leather goods	1,492		29	
	electrical repair	769		268	
	other repair services	1,001		0	
	laundry services	1,123		61	
	barber/beauty shops	1,631		25	
	other services	2,020	11,070	52	520
TOTAL			222,915		43,755

Note: 1. "Operator" refers to the owner of an enterprise. Hence the number of operators = number of owners of enterprises = number of enterprises.

2. "Worker" refers to those employees employed by operators including paid permanent, paid temporary, paid casual, home worker, paid apprentice, unpaid apprentice and other unpaid employees. Workers does not include unpaid family helpers. These workers were not included in the survey at all which differs from the 1991 survey where such workers were included. This also means the data from the two surveys can not be directly compared.

3. Worker also includes business partners. However, the number of business partners is small, being only 4,343 out of a total of 43,755 workers.

4. There are a large number of young men, known as "machinga" in swahili, who sell various products at street intersections throughout the city, particularly in the city centre. Some machinga work for themselves while others are employed by certain businesses. This type of enterprise comes within the informal sector according to the definition used and hence the above data should include machinga. However, this survey was carried out at a time when the City authorities were trying to remove such operators/workers from the streets and hence it is thought that many interviewees would not have admitted to engaging in such activity.

The definition of household waste used in this Study includes waste generated from micro-business (informal sector) activities operated by a family within its house. Households participating in WACS were told to include waste from such activities in their household waste and hence the quantity of waste generated by informal sector home based activities has already been counted.

Table 6-23 shows percentages of informal sector enterprises operating in different locations for each industrial category which is used as described below to determine the number of home based and non-home based informal sector operators in each category.

Table 6-23: Percentage of Informal Sector Enterprises Operating in Different Locations by Industrial Sector

Industry	within home	structure attached to home	perm. build. other than home	mkt.	street	other temp.	constr. site	cust./ empl. home	no fixed	Total
Agric./Live.	37.4	0.0	11.2	11.8	1.4	8.1	0.4	13.7	16.0	100.(
Min / Quar.	15.1	0.0	0.0	0.0	0.0	18.5	13.2	15.4	37.8	100.(
Manuf.	44.0	0.8	27.5	2.5	7.6	4.2	4.1	1.2	8.1	100.(
Constr.	6.2	0.0	0.9	0.4	1.2	3.7	23.4	6.2	58.0	100.(
Tr./Rs./Ho.	34.6	0.9	15.8	14.1	7.3	11.7	0.6	1.3	13.7	100.(
Transport	4.5	0.8	2.6	11.4	19.0	9.4	0.8	0.0	51.5	100.(
Fin./Ins./Re.	8.0	0.0	6.7	0.0	0.0	0.0	0.0	0.0	85.3	100.(
Comm./Ps.	36.9	0.0	35.5	3.4	8.9	2.6	2.2	2.0	8.5	100.(

Note: 1. Industry Key: agric. = agricultural; live. = livestock; min. = mining; quar. = quarry; manuf. = manufacturing; constr. = construction; tr. = trade; rs. = restaurant; ho. = hotel; fin. = finance; ins. = insurance; re. = real estate; comm. = community services; ps. = personal services.
2. Location Key: perm. = permanent; build. = build.; mkt. = market; temp. = temporary; cust. = customer; empl. = employer.
3. Mkt. includes fixed and temporary stalls; kiosks; vehicles and carts.
4. Street includes fixed and temporary stalls; kiosks; vehicles and carts.

Data in Table 6-23 is used to calculate the percentages of "home based" and "non- home based" informal sector operators in each category where home based enterprises refers to the "within home" and "structure attached to home" categories while non-home based enterprises refers to all other categories. This data is then combined with operator data from Table 6-22 to calculate the number of informal sector operators in each of these four groups. The results are summarised in Table 6-24.

Table 6-24: Calculation of number of Non-Home Based Operators in each Group

Group	Industry Sub-Sector	% of non-home based operators	No. of Operators	No. of non-home based operators	non-home based operators as % of total operators
Reusable Wastes	Agric./Live. Min /Quar.	62.6 84.9	7,756 927	4,855 787	
	Sub-total		8,683	5,642	65.0
Manuf. & Constr. Wastes	Manuf. Constr.	55.2 93.8	30,076 15,375	16,602 14,422	
	Sub-total		45,451	31,024	68.3
Trading Wastes	Tr./Rs./Ho.	64.5	153,409	98,949	
	Sub-total		153,409	98,949	64.5
Other Wastes	Transport Fin./Ins./Re. Comm./Ps.	94.7 92.0 63.1	3,960 342 11,070	3,750 315 6,985	
	Sub-total		15,372	11,050	71.9
TOTAL			222,915	146,665	65.6

Note: 1. The abbreviations used are defined in Table 6-23.

The amount of waste generated from the informal sector by non-home based operators is calculated for each of these four groups in Section 6.1.3 using data from Table 6-24.