restoration of the landfill on its completion. The creation of a waste hill will restore the original site topography with the quarry being eliminated. The hilly nature of the final landform will resemble other natural hills in Salasala to the west of the site.

b.2 Refuse Collection Vehicles

Delivery of waste will involve the movement of refuse collection vehicles to and from the disposal site which may result in a negative visual impact on passersby. It is predicted that during the period 2000 - 2005 refuse collection vehicles will constitute 4.9 - 12.5% and 13.3 - 29.7% of total traffic at stations A1 (near Mwenge) and A2 (near the disposal site) respectively. As refuse collection vehicles make up a relatively small percentage of total traffic near Mwenge, the negative visual impact is considered to be negligible. However, near the disposal site, the corresponding percentage is much higher and so too will be the resulting negative visual impact. This is still considered to be a minor negative impact as 30% of the normal traffic (i.e. without counting refuse vehicles) consists of large vehicles and areas within the vicinity of the disposal site are very sparsely populated.

c. Aftercare

Proper management of the site after the completion of landfilling activities will greatly contribute to the quality of the landscape and visual amenity of the site. The planned planting of trees and development of the site for agricultural or recreational use will all improve the landscape and visual quality of the site to a level far higher than that of the original derelict land.

6.5.3 Pollution

6.5.3.1 Air Pollution

Pollution caused by exhaust/toxic gases, dust, smoke, etc. from refuse collection vehicles and the disposal site.

Offensive odour is discussed separately in section 6.5.3.5.

a. At the Disposal Site

aa. Construction

Construction activities will be largely confined to the site and will take place within the quarry apart from construction of the reception area and access road. They will involve a small number of earthmoving machines, dump trucks, rollers, asphalt finishers and a few light vehicles.

The main sources of air pollution will be dust generated from the construction activities and exhaust gases from construction vehicles. Significant quantities of dust may be produced during the dry season but the regular use of water sprays and the control of vehicle movements should minimise dust production. The effect of exhaust gases from construction vehicles is considered to be negligible.

These forms of air pollution will have a low negative impact as they will mainly affect construction workers and hence appropriate equipment should be worn (e.g. face masks). As very few houses are located close to the site and the prevailing winds (north-east and north-west) will disperse airborne pollutants away from the nearest

residential settlement at Mtongani-Kunduchi, no adverse impacts are expected to occur beyond the site boundary.

ab. Operation

Generally, it is expected that the site will have a low negative impact on air pollution. No significant adverse impacts will occur beyond the site boundary due to a buffer zone of 50 m being maintained around the site, very few residential buildings being located within a 250 m radius of the site and the prevailing north-east and north-west winds dispersing pollutants away from the nearest residential settlement at Mtongani and from areas to the north, east and west which are proposed for future residential development.

aba. Landfill Gases

The biological decomposition processes in a landfill with municipal solid waste results in the generation of landfill gas (a water saturated mixture of methane (CH_4, 45 - 60 vol. %), carbon dioxide (CO_2, 40 - 60 vol. %), nitrogen (N_2, 2 - 5 vol. %) and small quantities of oxygen, ammonia, sulphides, carbon monoxide and trace constituents. The theoretical quantity of biogas generated during the degradation of kitchen waste is estimated to be 150 - 200 l/kg of dry waste.

Under normal conditions, landfill gas production rates reach a peak within the first 2 years and then slowly taper off, continuing in many cases for periods of up to 25 years or more. In most cases, over 90% of the gas volume produced is methane and carbon dioxide. Both of these gases have been found in concentrations of up to 40% at lateral distances of up to 120 m from the edges of landfills[17]. If vented to the atmosphere in an uncontrolled manner, methane can accumulate below buildings or in other enclosed spaces on, or close to, a sanitary landfill. When methane concentrations in the air are between 5 - 15%, it is explosive.

Carbon dioxide, being heavier than air, tends to migrate downwards, often leading to high concentrations of carbon dioxide in the lower portion of a landfill for many years. Ultimately, it can move downwards through the underlying strata, until it reaches the groundwater, where it will usually lower the pH.

The landfill shall be furnished with installations for controlled ventilation of landfill gas to the atmosphere with gas being collected and vented from the top and sides of the landfill and subsequently dispersed by the wind. Under these conditions neither methane nor carbon dioxide should detrimentally affect air quality near the site.

However, methane and carbon dioxide are both greenhouse gases and hence their emission from the site will make a very small contribution to the greenhouse effect.

abb. Dust

Significant quantities of dust may be generated during the dry season due to landfill equipment and refuse vehicles movements but this can be controlled through the use of water sprays and by controlling vehicle movements. The impact should be minimal.

[17] "Environmental Engineering"; Peavy et al; McGraw-Hill Book Company; 1986; pg 633

abc. Exhaust Fumes

The impact of vehicle fumes on air pollution is considered negligible due to the relatively small number of vehicles operating within the landfill site at any one time. Regular maintenance of vehicles will help to minimise this problem.

abd. Fires

The landfill will be operated with a relatively small tipping front, the waste will be compacted and daily soil cover will be applied. These practices will help to minimise the possibility of any spontaneous fires breaking out, which can produce large quantities of smoke and environmentally harmful gases, including dioxins. Any fire which does break out must be extinguished immediately.

ac. Aftercare

As discussed above, landfill gases will continue to be produced in gradually diminishing volumes for periods of up to 25 years or more. On closure, the landfill gas ventilation facilities will remain in place and should be regularly inspected and maintained for a period of around 25 years or until it is determined that landfill gas emissions are negligible and no longer pose a safety threat.

All sections of the landfill will be capped, grassed and planted. Hence, no adverse impact on air quality from dust, fumes or fires is expected during the aftercare stage.

b. Refuse Collection Vehicles

ba. Construction and Aftercare

No impact from refuse collection vehicles is expected on air quality during these periods.

bb. Operation

bba. Vehicle Emissions

Pollution loads of carbon monoxide, nitrogen oxides and sulphur dioxide produced in a 13 hour period (0600 -1900) by all vehicles travelling along New Bagamoyo Road between Sam Nujoma Road and the disposal site were predicted using gas pollution factors[18] for different types of vehicles (motorcycles, small vehicles and large vehicles) for normal traffic (i.e. without including refuse collection vehicles) and normal traffic and refuse collection vehicles (see Appendix 1.5).

The results are presented in Figure 6-24 - Figure 6-26 and summarised in Table 6-23, together with the average gas concentrations of these gases measured during the air quality survey. Details of the calculations are found in Appendix 1.5.

[18] "Rapid Assessment of Sources of Air, Water, and Land Pollution"; WHO; Genevea; 1982; pg. 38

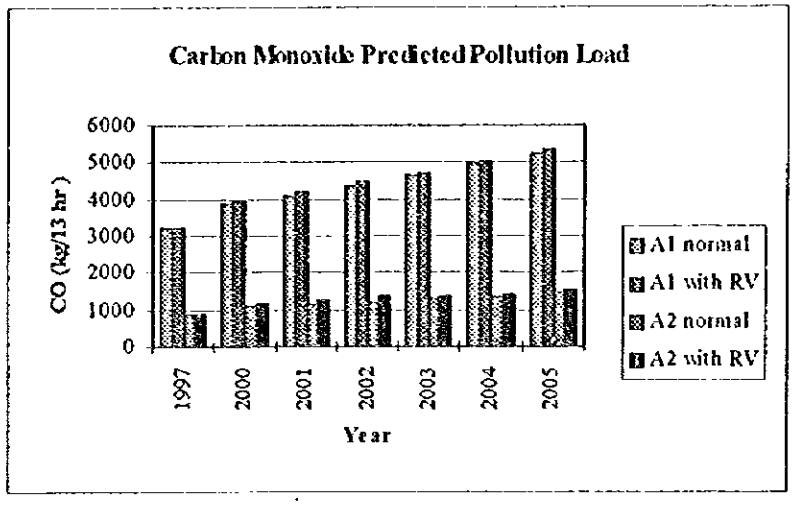

Figure 6-24: Predicted Pollution Load for Carbon Monoxide

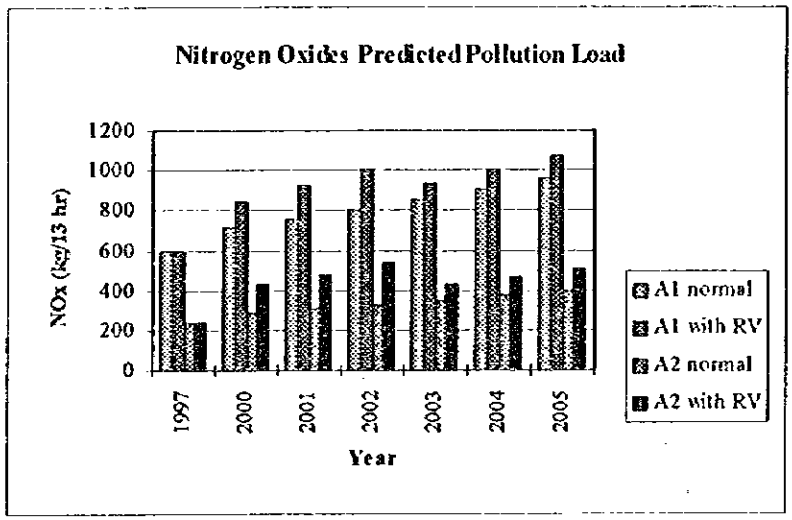

Figure 6-25: Predicted Pollution Load for Nitrogen Oxides

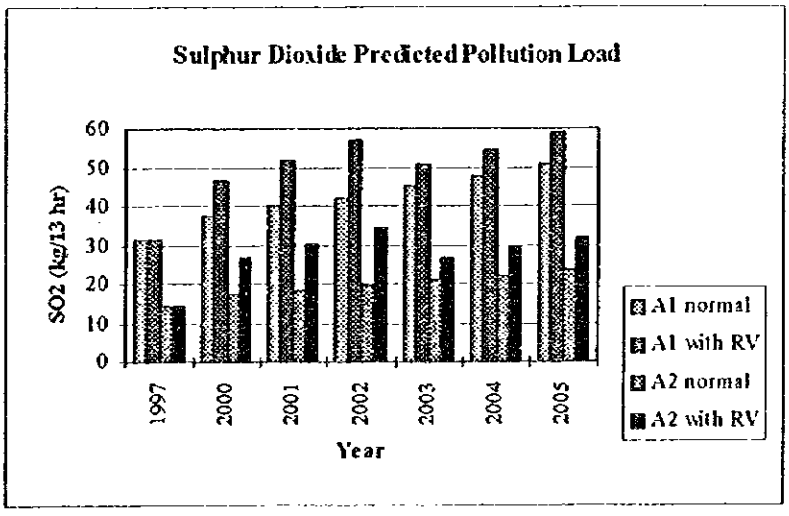

Figure 6-26: Predicted Pollution Load for Sulphur Dioxide

Table 6-23: Air Quality Results Summary and Predicted Pollution Loads

		Measured Concentration (13 hr average)	Pollution Load (kg/13 hr)			Range in annual % increase in pollution load due to RV during 2000 - 2005
Gas	Station	ppm	1997	2005 (normal)	2005 (with RV)	
CO	A1	3.3	3220	5260	5330	1.0 - 2.8
	A2	1.87	900	1460	1530	3.7 - 10.2
NO_x	A1	0.04	590	960	1080	9.3 - 25.6
	A2	0.01	240	400	510	22.6 - 62.3
SO_2	A1	0.06	31	51	59	12.6 - 34.6
	A2	0.05	14	24	32	27.1 - 74.7

Before discussing these results, two provisos need to be stated:

- The validity of these results depends upon the appropriateness of the pollution factors, based on 1970 model cars in the USA, to Tanzanian conditions.
- These results are for pollution loads emitted by vehicles and can not be related directly to ambient gas concentrations, which are affected by various factors, including dispersion of pollutants, climatic conditions (wind, temperature, etc.), vehicle speeds, traffic flows and the condition of vehicles.

Nevertheless, the results do provide a useful indication of the possible impact on air quality due to refuse collection vehicles.

For carbon monoxide the pollution load at stations A1 and A2 is predicted to increase from 1997 to 2005 by 62 - 63% (normal traffic) and 66 - 70% (normal and refuse vehicle traffic). As the CO concentrations measured in the air quality survey were low (1.9 - 3.3 ppm), it is expected that CO concentrations will not exceed the 10 ppm Japanese standard within the period 2000 - 2005. Furthermore, comparing predicted pollution loads for normal traffic with and without refuse vehicles on an annual basis, the increase in pollution load due to refuse vehicles is minor, ranging from 1.0 - 2 .8 % and 3.7 - 10.2 % at stations A1 and A2 respectively.

For nitrogen oxides, the pollution load at station A1 is predicted to increase from 1997 to 2005 by 63% (normal traffic) and 83% (normal and refuse vehicle traffic). At station A2, the corresponding increases are 67% and 113%. Considering the measured NO_x concentrations, it is possible that NO_x concentrations may exceed the 0.06 ppm Japanese standard before the year 2005, especially at station A1. The contribution of refuse vehicles to NO_x emissions is more significant than for CO, due to the pollution factor for large vehicles being significantly greater than for smaller vehicles and ranges from 9 - 26% and 22 - 62% at stations A1 and A2 respectively.

The two oxides of nitrogen of primary concern in air pollution are nitric oxide (NO) and nitrogen dioxide (NO_2). NO is a relatively inert gas, only moderately toxic and generally present at concentrations of less than 1 ppm in the ambient air - it is not considered a health hazard. However, it is readily oxidised to NO_2, which does have biological significance, irritating the alveoli of the lungs. The results of a Chattanooga (Tennessee, USA) study[19] suggest that any city whose mean 24 hr concentrations of NO_2 are 0.06 ppm or greater for a six month period could anticipate increased incidence of respiratory disease. However, various factors (climate, population density) may invalidate such a

[19] "Environmental Engineering"; Peavy et al; McGraw Hill Book Co.; 1986; pg. 456

prediction. Furthermore, the nitrogen oxide concentrations measured in this study are for both NO and NO_2, are 13 hour rather than 24 hour average values and the area alongside New Bagamoyo Road, north of Sam Nujoma road is sparsely populated. The graph of the variation in NO_x concentrations with time (see figure in section 4.8) shows that NO_x concentrations are lowest before 7am and after 6pm - hence, the 24 hour averages will be much lower than the 13 hour average values. Nevertheless, NO_x levels should be monitored at regular intervals and any increase in the incidence of respiratory diseases among residents in this area should be investigated.

For sulphur dioxide, the pollution load at station A1 is predicted to increase from 1997 to 2005 by 64% (normal traffic) and 90% (normal and refuse vehicle traffic). At station A2, the corresponding increases are 71% and 129%. SO_2 concentrations already exceed the 0.04 ppm Japanese standard and SO_2 concentrations will probably be much higher by 2005 (around 0.08 - 0.12 ppm). However, no detectable response in human health is expected until SO_2 concentrations exceed 0.6 ppm[20].The contribution of refuse vehicles to SO_2 is more significant in this case, again due to the pollution factor for large vehicles being significantly greater than for smaller vehicles and ranges from 12 - 35% and 27 - 75% at stations A1 and A2 respectively.

In summary, these results suggest that:

- CO levels will probably remain within acceptable levels over the period 2000 - 2005 and the contribution of refuse vehicles to the CO pollution load is small.
- Refuse vehicles will make a significant contribution to NO_x and SO_2 pollution loads.
- NO_x levels may arise above 0.06 ppm which could lead to the increased incidence of respiratory diseases.
- SO_2 levels already exceed the standard of 0.04 ppm and will probably increase to 2-3 times this level by 2005. However, no negative impact on human health should result.
- Based on the pollution load results, it is inferred that the overall negative impact of refuse vehicles on air quality will be moderate.

bbb. Other

Refuse vehicles are unlikely to cause increased production of dust along New Bagamoyo Road as the road is tarmaced and in good condition.

6.5.3.2 Water Pollution

Pollution caused by inflow of sand, silt, leachate and runoff from the disposal site into rivers and groundwater.

[20] "Environmental Engineering"; Peavy et al; McGraw Hill Book Co.; 1986; pg. 450

c. Surface Water Pollution

ca. Construction

The major construction activities will take place within the quarry site, in which all surface water runoff is trapped, thus creating large water pools in the pits during the rainy season, with water subsequently evaporating or infiltrating into the ground.

Outside the quarry site, the main construction activities are construction of the access road and reception area. These works will produce small quantities of sand and silt and will have a negligible impact on surface water pollution.

cb. Operation

Pollution of surface water sources by sand, silt and runoff is unlikely.

The landfill will be developed within the quarry area and will be divided into four sections. As each section is developed, it will be separated from the other sections by embankments, at least 1.5 m in height with leachate drains being constructed along the embankments, thus preventing the seepage of leachate as well as silt and sand into areas not yet opened for waste disposal.

On completion of each section of the landfill, the final elevation will be above the surrounding ground level and the section will be capped with a final 1 m thick layer of soil, grassed and planted, in order to minimise stormwater infiltration, silt and sand erosion. All stormwater runoff from completed sections of the landfill will be collected and channelled to the runoff control system serving areas surrounding the landfill.

For areas surrounding the disposal site, clean runoff will be diverted away from the disposal area by a system of drains constructed along the edge of the quarry excavation towards the nearby seasonal stream in the western valley. An embankment will also be constructed between the seasonal pond to the south of the site and the New MECCO quarry to prevent water from overflowing into the quarry from this source during flood events with the water being diverted towards the western valley. However, most of the diverted runoff water will evaporate or infiltrate before reaching the stream.

Thus, only clean runoff should enter surface water sources and silt and sand will be retained. Furthermore, meteorological data shows that due to high evaporation rates and the seasonal nature of the rainfall, runoff occurs, if at all, only during the three wettest months of the year: April, May and June.

cc. Aftercare

All sections of the landfill will be capped, grassed and planted. Slopes will be less than 1:3 to avoid soil erosion during heavy rains. However, until grass and plants are established small amounts of soil may be eroded by rain but the overall impact will be negligible and can be minimised by landscaping prior to or after the heavy rains (April - May).

d. Groundwater Pollution

da. Construction

During the construction stage, earthworks and other construction works may have a minor effect on infiltration flows but no leachate will be produced and there will be no negative impact on groundwater quality.

db. Operation

Groundwater pollution will be caused by infiltration of leachate from the landfill either by:

- infiltration of rain water into the sections of the landfill containing waste (operational and capped) and subsequent permeation of the resulting leachate through the strata underlying the landfill. Dirty runoff and dirty wash water from the vehicle wheel wash facility will also be diverted to the landfill.
- permeation of leachate into the underlying strata from the leachate reservoirs. These collect leachate from the leachate drains along the embankments in each section of the landfill.

The impact of leachate infiltration on groundwater pollution is assessed by estimating the annual leachate generation and the composition of leachate.

dba. Leachate Generation Forecast

The major benefit of adopting a four stage conceptual design for the landfill is that it will reduce leachate generation by minimising the total landfill area with waste open for direct penetration of rain water.

Figure 6-27 provides a forecast[21] for leachate generation. In this forecast, it is assumed that annual, average leachate generation rates are 350 mm/year from landfill sections during operation and 50 mm/year from landfill sections that are furnished with final soil cover and vegetation.

[21] "The Study on Solid Waste Management for Dar es Salaam, Conceptual Design for the New Landfill in Kunduchi, Draft Final Report"; Kokusai Kogyo Co., Ltd.; May 1997

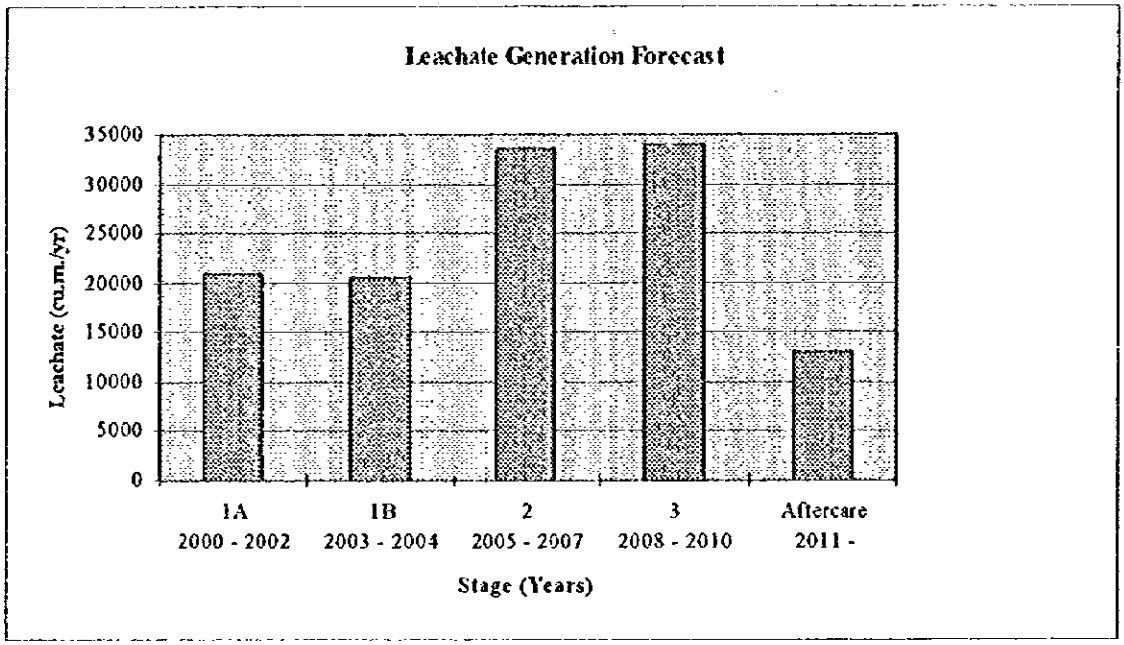

Figure 6-27: Forecast for the Annual Leachate Generation.

Figure 6-27 shows that leachate generation is approximately the same during stages 1A and 1B (20,500 - 21,000 m^3/yr), greatest during Stages 2 and 3 (33,500 - 34,000 m^3/yr) and then will decrease dramatically on closure of the landfill to 13,000 m^3/yr.

However, the actual situation is more complicated than this, as:

- annual leachate generation may vary considerably from dry to wet years.
- leachate generation varies dramatically during the year due to the seasonal nature of the rainfall, with an estimated 50 - 100% of leachate being generated during April and May.
- some of the generated leachate will evaporate from the leachate reservoirs and hence the amount of leachate which infiltrates to the groundwater will be reduced.

dbb. Leachate Composition

Table 6-24 presents the typical composition of "young leachate" from 2-5 year old landfill sections and "old leachate" from older landfill sections, based on experience from Japanese and European sanitary landfills receiving municipal solid waste only, i.e. mainly household waste. Comparative results showing the variation in leachate composition at Vingunguti disposal site from April - July 1996 and water quality data for borehole 13, drilled within the EIA study area, are also included in Table 6-24.

A substantial variation in leachate composition is usual from landfill to landfill, depending on the actual type of waste being disposed of. It is assumed that the composition of leachate from the landfill in Kunduchi will be similar to the leachate composition at the Vingunguti disposal site although the concentration of heavy metals and trace organics may be reduced due to the policy of prohibiting hazardous, toxic, infectious, radioactive and liquid wastes from the landfill. The composition is also

assumed to vary with age in a similar fashion as indicated by the 'young' and 'old' leachate data.

Table 6-24: Leachate Composition Data and Groundwater Quality at BH13

Typical leachate composition		'Young leachate'	'Old leachate'	Leachate Composition at Vingunguti disposal site	Average Groundwater Quality at BH13
pH		6 - 7	7 - 8	7.3 - 8.6	7.1
BOD_5	mg/l	15,000	200	910 - 1,400	630
COD	mg/l	21,000	2,000	1,020 - 1,940	940
NH_4-N	mg/l	900	900	not measured	23
Total-N	mg/l	1,000	1,000	420 - 750	160
Total-P	mg/l	max. 15	max. 15	11 - 25	not measured
Chloride, Cl^-	mg/l	2,000	2,000	3,500 - 5,940	8,330
Sodium, Na^+	mg/l	1,500	1,500	not measured	2,170
Calcium, Ca^{2+}	mg/l	1,200	100	not measured	450
Sulphate, SO_4^{2-}	mg/l	500	20	110 - 160	7,140
Iron, Fe	mg/l	500	25	12 - 16	97
Zinc, Zn	mg/l	max. 10	max. 0.5	not measured	not measured
Lead, Pb	mg/l	max. 0.5	max. 0.05	0.05 - 0.18	0.22
Chromium, Cr	mg/l	max. 0.5	max. 0.05	0.00 - 0.37	0.025
Cadmium, Cd	mg/l	max. 0.1	max. 0.01	0.004 - 0.12	0.05

Note:
1. Values for 'young leachate' and 'old leachate' are based on RAMBOLL's (Danish consultancy company) experience from supervision of many landfills receiving municipal solid waste (i.e. not including cinders/fly ash from waste incineration). Reference is also made to DS-Recommendation DS/R 466 table C1.1.
2. Vingunguti disposal site data comes from a water quality survey of the Vingunguti stream and the nearby Msimbazi stream conducted from 24 April - 9 July, 1996 as part of the JICA Study on Solid Waste Management in DSM (see Progress Report (2)).
3. Other parameters and their values measured in the Vingunguti water quality survey include: dissolved oxygen: 0.05 - 1.10 mg/l, suspended solids: 130 -12590 mg/l, faecal coliforms: 4,000 - 280,000 count/100 ml; manganese: 0.021 - 0.196 mg/l, cyanide: 0.009 - 0 .15 mg/l, tetrachloroethylene: 0.00 mg/l, trichloroethylene: 2.00 -2.60 mg/l, trichloroethane: 0.00 mg/l

As leachate migrates downwards through the strata underlying the landfill, many of the chemical and biological constituents originally contained in it will be removed by the filtering and adsorptive action of the material composing the strata. Heavy metals and trace organic compounds, the two constituents of greatest concern, are primarily removed by ion exchange reactions and adsorption respectively. In general, the extent of this action depends on the characteristics of the soil, especially the clay content, as clay is able to adsorb and retain many of the chemical constituents found in leachate.

The strata underlying the landfill site at Kunduchi shows considerable variation and geologic inconsistency, consisting of coralline limestone with thin lenses of clay, silt and sand in varying proportions. The permeability of different soil layers varies from as high as 1×10^{-5} m/s to as low as 2.0×10^{-11} m/s . Some attenuation of the constituents in the leachate, including heavy metals and trace organic compounds, will occur as leachate permeates through this strata but it is not possible nor justified to quantify the extent of attenuation.

dbc. Impact on Groundwater Quality

No data is available on groundwater flows beneath the landfill site towards the Indian Ocean. However, the leachate will be significantly diluted on reaching the groundwater.

The groundwater quality data for borehole 13, drilled near the salt pans about 1,400 m to the east of the site's eastern boundary near the Indian Ocean, shows that the groundwater is badly polluted and saline.

It is concluded that the negative impact of leachate on groundwater quality will be moderate considering the current badly polluted nature of the groundwater, attenuation of chemical constituents in the leachate during permeation through the strata and dilution on entering the groundwater.

Furthermore, the naturally high salinity (a chloride concentration of about 8,330 mg/l) of the groundwater makes it unsuitable for human consumption and residents around the proposed landfill area have access to the piped municipal water supply so that no impact on public health is expected from the small deterioration in groundwater quality predicted.

On reaching the sea, the groundwater will be massively diluted and the negative impact of the leachate in the groundwater on marine water quality will be low to negligible.

dc. Aftercare

Leachate will continue to be produced after the landfill is closed due to the infiltration of rainwater into capped sections of the landfill. However, the generation rate is greatly reduced compared with during operation (see Figure 6-27) and the composition of most chemical constituents in the leachate will reduce with time, as indicated by the 'young' and 'old' leachate data in Table 6-24, so that the impact of leachate on groundwater quality is diminished relative to during the operation stage.

Hence, the negative effect on groundwater quality during aftercare will be negligible.

6.5.3.3 Soil Contamination

Contamination of soil by leakage and diffusion of ash, leachate, etc. from the disposal site.

The baseline soil contamination survey results showed that the indigenous soil at both the New and Old MECCO quarry sites contains levels of cadmium, lead, iron, copper and manganese typical of naturally occurring deposits.

a. Construction

During this stage, soil contamination may occur due to possible spillage of oil from construction equipment and vehicles and leakage of fuel. However, the contamination will be negligible because of the small numbers of construction equipment and vehicles.

b. Operation

As the landfill will be constructed without any base liner, soil contamination by substances present in the leachate from the deposited refuse will occur. However, contamination will be minor as over 60% of the deposited refuse will be organic in nature and the disposal of hazardous, toxic, infectious, radioactive and liquid wastes at the new landfill is prohibited. Hence, during the operation stage, the extent of contamination of the soil caused by the deposited waste is expected to be low.

Spillage of oil from operational equipment and vehicles and the spillage of fuel may occur, but the impact on soil contamination is likely to be negligible.

c. Aftercare

During this stage, soil contamination is not likely to be aggravated, because of the exclusion of certain wastes as discussed in (b) and the fact that leachate production is significantly reduced and its composition is characteristic of 'old leachate'.

6.5.3.4 Noise and Vibration

Noise and Vibration generated by refuse collection vehicles and landfill site equipment.

a. General

Within the vicinity of the proposed landfill site, problems associated with noise and vibration during the construction and operation periods are not expected due to the nature of the site; i.e. it is located in an old quarry, the base being at least 5 metres below the natural surface. Thus, much of the construction and operation noise and vibration is expected to be damped by the earth. Moreover, currently there are few buildings located close enough to the site or to the access road to be adversely affected. Construction and operational works will be carried out during the daytime further reducing the adverse affects of noise and vibration.

Only construction and landfill site workers, especially heavy equipment drivers and those working near such vehicles, will be subject to high noise levels but they should be provided with suitable protective equipment (e.g. ear muffs).

The increase in noise and vibration levels due to the movement of refuse collection vehicles to and from the site along New Bagamoyo Road is not significant. Furthermore, noise levels due to all traffic (normal and refuse vehicles) have been estimated over the period 2000 - 2005 and are within acceptable levels. By inference, vibration levels will also be acceptable.

b. Noise

ba. At the Landfill Site

baa. Construction

As previously described, construction will proceed in three stages - in 1999 (sections 1A and 1B), 2004 (section 2) and 2007 (section 3). Construction works include clearing of the site; construction of the reception area, access road and buildings; excavation of the bottom area and embankments and construction of drainage systems. Major sources of noise and associated power levels[22] for the construction stage of the proposed works are listed in Table 6-25. Only construction workers, especially those operating heavy vehicles/equipment or working near such equipment will experience these high noise levels - they should be provided with suitable protective equipment.

[22] "Environmental Impact Assessment of the Solid Waste Disposal Sites of Panteh Acheh, Kuala Muda and Pulau Burong"; JICA; 1989; pg 5-10

Table 6-25: Noise Levels from Construction Machinery

Construction Activity	Machines to be used	Noise Level (Power level) (dB)
excavating	backhoe, loader, dump truck	100 - 110
levelling	bulldozer, scraper, dump truck	100 - 110
roadbed preparation	bulldozer, roller	100 - 110
paving	asphalt finisher, roller, dump truck	100 - 110
Concrete placing	small mixer	100

Presently, there are very few buildings located within a radius of 250 m of the site boundary. The nearest buildings are located about 40 metres from the site boundary and include a small brick factory within a walled compound and 2-3 other buildings. There are also a few residential buildings, located about 100 m away. From now until 2007, when construction activities will be completed, some degree of residential, commercial and industrial development in the vicinity of the site will occur. The land to the north, east and west is proposed for residential development and the area to the south is set aside for industrial development. As a buffer zone of 50 metres will be maintained around the site, the following equation[23] for predicting the change in sound pressure (noise) level with distance from a point source was used to calculate the expected noise level at a distance of 50 m from the site:

$$L_p = L_w - 20 \log_{10} r - 8$$

where: L_p = noise level at source (dB) = 100 -110 dB
r = distance between source and receiving point (m) = 50 m
L_w = noise level at receiving point (dB)

Applying this equation gives an expected noise level at these receiving points of 58 - 68 dB. In some cases, the noise level may be higher than the Japanese standard of 65 dB for daytime noise levels in mixed residential, commercial and industrial areas. However, differences of up to 5 dB between measured and accepted levels are of only marginal significance. Moreover, it is expected that very few buildings will be constructed within a 100 m radius of the site boundary and hence the negative impact of construction noise will be low.

bab. Operation

The recommended permanent equipment for the sanitary landfill consists of two bulldozers, one excavator, two tip trucks and a water tanker. Maximum noise levels will be produced when two bulldozers are operating simultaneously (worst case scenario). Using the noise levels of 100 - 110 dB from Table 6-25, maximum noise levels can be calculated using the following standard equation:

$$P = 10 \log_{10} \sum 10^{P_i/10}$$

where: P = resulting noise level (dB) from a number of sources
P_i = noise level from each source

[23] "Technology, Laws and Regulations for the Prevention of Environmental Pollution - Noise"; MITI, Environmental Protection and Industrial Location Bureau; 1995.

This gives maximum noise levels of 110 - 113 dB at the source. Only landfill site workers, especially those operating heavy equipment or working near it, will experience these high noise levels and they should be provided with suitable protective equipment.

Using the equation in section a.1, the expected noise levels at the edge of the buffer zone (r = 50 m) will be 61 - 71 dB, so that in some cases, noise levels will be greater than the Japanese standard of 65 dB. In reality, the maximum noise levels will be less than this as landfilling will take place within the quarry and operational noise levels will be attenuated by the quarry walls until refuse levels approach the original ground surface.

The landfill is expected to be in operation for 11 years, during which time some degree of residential, commercial and industrial development will occur around the site although it is expected that very few buildings will be constructed within 100 m of the site boundary. Hence no negative impact from operational noise within the landfill site is expected within these areas.

bac. Aftercare

No impact from noise is expected.

bb. Refuse Collection Vehicles

bba. Construction and Aftercare

As there will be no refuse collection vehicles bringing refuse to the site during the construction and aftercare stages, no impact from noise and vibration is expected.

bbb. Operation

The impact of noise from refuse collection vehicles from 2000 - 2005 was estimated using a theoretical equation, as set out in Appendix 1.6, to predict the noise levels from (a) normal traffic and (b) normal traffic and refuse collection vehicles at a distance of 10 m from the source, this being the **minimum** distance (conservative case) from source to nearest residence. Observation has shown that most residences are further away from the road. The results of these predictions are set out in Table 6-26.

Table 6-26: Prediction of Noise Levels from Normal Traffic with/without Refuse Vehicles

Station A1

Year	SV+MC	LV	RV	L_{50} (dB)		% increase due to RV
				Normal	with RV	
1997	7954	1746	0	66.0	66.0	0.0
2000	9555	2098	652	67.3	68.2	1.3
2001	10155	2229	826	67.7	68.8	1.6
2002	10793	2369	1016	68.0	69.3	1.9
2003	11476	2519	392	68.4	68.9	0.7
2004	12197	2677	474	68.8	69.3	0.7
2005	12967	2846	560	69.1	69.7	1.2

Station A2

Year	SV+MC	LV	RV	L_{50} (dB)		% increase due to RV
				Normal	with RV	
1997	2086	894	0	52.3	58.2	11.3
2000	2507	1074	652	53.9	62.2	15.4
2001	2666	1142	826	54.4	63.1	16.0
2002	2830	1213	1016	54.9	63.9	16.4
2003	3007	1289	392	55.5	62.6	12.8
2004	3201	1372	474	56.0	63.3	13.0
2005	3401	1458	560	56.5	63.9	13.1

Note: SV = small vehicle; MC = motorcycle; LV = large vehicle; RV = refuse vehicle

The predicted normal traffic noise levels agree reasonably well with the average L_{50} values in the noise survey at stations A1 and A2 of 64.2 dB and 58.8 dB respectively (measured at 7.4 m from the road edge).

At station A1, as traffic volumes increase with time, the noise levels rise and slightly exceed the Japanese L_{50} standard of 65 dB[24]. However, the predicted values are less than 5 dB above the accepted levels (65 dB) which is of only marginal significance and as most residences are located further away from the road, the effect is not significant. More importantly, the increase in noise levels due to refuse collection vehicles is 0.7 - 1.9 % which is negligible.

At station A2, refuse collection vehicles increase noise levels by 11 - 16% but as all noise levels are less than 65 dB, the impact is low.

Thus, it can be concluded that the impact of refuse collection vehicles on noise levels along New Bagamoyo Road from Sam Nujoma Road to the site is low.

c. Vibration

Vibration levels due to landfill equipment and refuse collection vehicles have not been estimated by any theoretical or empirical method. Instead, the noise level results are considered to be indicative of vibration levels. In fact, noise generated by heavy machinery is often used as a surrogate measure for many of the other nuisances caused by such vehicles including interference with other traffic, fumes and vibration.

[24] standard for mixed residential, commercial and industrial areas during the daytime

ca. At the Landfill Site

Vibration is not expected to affect surrounding residences or wildlife either in the construction or operational stages for the following reasons:

- the proposed site is isolated and there are very few buildings located close to the site or to the access road.
- the site is located within an old quarry, the base being at least 5 m below the natural ground surface. Thus vibration is expected to be heavily damped by the earth.
- construction and operational works will be carried out only during the daytime.

No impact due to vibration is expected during the aftercare stage.

cb. Refuse Collection Vehicles

The traffic volume and average L_{50} and L_{10} vibration levels are shown in Table 6-27 for stations A1 and A2. The vibration levels are significantly below the Japanese L_{50} standard of 70 dB.

Table 6-27: Comparison of Traffic Volume and Vibration Survey Results

Station	% of different vehicles			No. of Vehicles per 13 hrs	Average Vibration Levels (dB)	
	MC	SV	LV		L_{50}	L_{10}
A1	2	80	18	9,700	26.1	36.6
A2	2	68	30	2,980	20.7	30.7

Note: 1) Japanese L_{50} standard is 70 dB for mixed residential/commercial/industrial areas during the daytime
2) L_{50} and L_{10} is used as an indicator of the average level of vibration and of the upper limit of fluctuating vibration such as that from road traffic respectively.

Furthermore, these vibration levels were measured at a distance of one metre from the edge of the road - as walkways and areas further away from the road are not paved, the vibrations experienced by residents and passersby will be significantly less than the measured values due to heavy damping.

Even though traffic volumes will increase significantly the overall vibration levels are expected to remain significantly lower than 75 dB. The increase in vibration levels attributable to refuse collection vehicles is expected to be negligible based on the predicted noise level results and the low percentage increase in total traffic due to refuse collection vehicles.

No impact is expected during the construction and aftercare stages.

6.5.3.5 Offensive Odour

Generation of offensive odours from the landfill site, associated treatment facilities and during transportation of refuse.

a. Construction

During this stage, the production of offensive odours from construction activities, especially exhaust fumes from earth moving equipment and trucks will not be significant

due to the open nature of the area and relatively high wind speeds which will facilitate the dispersion of exhaust fumes.

b. Operation

A low negative impact may result from waste delivery and the handling of waste at the disposal site.

A large proportion of the waste to be disposed of at the site (over 60%) will be organic in nature and considering the high temperature and humidity in DSM it will decompose quickly. However, the planned waste collection frequency is twice per week, and this should be sufficient to prevent offensive odours being produced during waste collection and delivery. Furthermore, 20% of skip containers will have lids, thus containing any odours produced. The remaining 80% of skip containers and all tip trucks will be covered with "fish net" covers during waste delivery which will not prevent the escape of any offensive odours produced.

At the disposal site, the tipping front will be relatively small and waste will be deposited, compacted and covered with soil daily. These practices should minimise odour problems.

Offensive odour will also result from the production of leachate and landfill gas. Some leachate will be collected within the leachate reservoirs from where it will evaporate or permeate into the ground. However, most of the leachate will permeate directly through the sub-strata to the groundwater below the landfill site and subsequently to the Indian Ocean. Hence, offensive odour from leachate should not be problematic. Similarly, landfill gases should not cause a significant odour problem as they will be ventilated in a controlled manner and will be dispersed by the wind.

The wheel wash facility will ensure that any soil or waste materials stuck to the wheels of refuse collection vehicles, some of which may be odorous, does not leave the site with them. The wash water from this operation will be treated as leachate and discharged into the landfill, thus minimising the occurrence of offensive odours.

c. Aftercare

Leachate and landfill gases will continue to be produced during the aftercare stage although production rates and strengths will diminish with time as previously explained. Leachate and landfill gases will be discharged as described above. Some offensive odours may be experienced from the venting of landfill gases, although this effect is likely to be minor.

6.5.3.6 Litter

Scattering of litter from the disposal site and refuse collection vehicles

a. Construction and Aftercare

No impact from litter is expected during these stages.

b. Operation

All refuse collection vehicles bringing refuse to the site will be covered either with a "fish net" cover or permanent lid. This will prevent the littering of rubbish during waste delivery.

Littering may also occur during waste handling and waste placement as there is a likelihood of paper and other litter being blown away by the wind or scattered by other means at the disposal site before the waste is compacted and covered with soil. However, the use of movable litter fences will minimise this problem, meaning the resultant negative impact is low.

Table 6-28: Environmental Assessment Matrix

Environmental	Social Environment					Natural Environment					Pollution					
Item	Economic Activity	Traffic and Public Facilities	Public Health	Waste	Hazards / Risks	Topo-graphy and Geology	Ground-water	Hydro-logical Situation	Flora and Fauna	Landscape / Aesthetics	Air Pollut-ion	Water Pollut-ion	Soil Contam-ination	Noise and Vibration	Offen-sive Odour	Litter
CONSTRUCTION																
Landfill	+1	0	-1	+1	-1	0	0	0	+1	+2	-1	0	0	-1	0	0
Surrounding Areas	+1	0	0	0	0	0	0	0	+1	-1	0	0	0	0	0	0
OPERATION																
Landfill	+2	0	-1	+1	-1	+2	-1	0	+2	+3	-1	-1	-1	-1	-1	-1
Surrounding Areas	-1	-2	-1	0	0	-1	0	0	-1	-1	-1	-1	0	-1	-1	0
AFTERCARE																
Landfill	+1	0	-1	0	0	+2	-1	+1	+1	+2	0	-1	-1	0	0	0
Aftercare	0	+2	0	0	0	0	0	0	+1	0	0	0	0	0	0	0

IMPACT: -3 = high negative; -2 = moderate negative; -1 = low negative; 0 = nil (negligible); +1 = low positive; +2 = moderate positive; +3 = high positive

6.6 Mitigation Measures

Mitigation measures for each environmental item are discussed in this section.

Some of the mitigation measures have already been included in the conceptual design of the landfill, summarised in section 6.3. Most of these measures relate to landfill policies, good sanitary landfill practices and monitoring of important parameters.

Some mitigation measures have also been described in section 6.5, where appropriate.

Table 6-29 summarises the mitigation measures which are common to more than one of the environmental items.

It is recommended that a detailed Operations Manual should be prepared and made available to all staff at the sanitary landfill, as well as to management and the appropriate authorities. The scope and content of this Operations Manual should be as specified in the Kunduchi Landfill Conceptual Design Draft Final Report[25], and should include, but not be limited to, the following issues: ownership of the landfill, responsibility for the proper operation of the landfill, restrictions regarding waste reception, principles for the arrangement and functioning of the landfill, operational and maintenance procedures, monitoring procedures, precautions against environmental nuisances, actions in case of accidents, etc. All landfill staff should be regularly trained on the content and implementation of this Plan.

[25] "The Study on Solid Waste Management for Dar es Salaam, Conceptual Design for the New Landfill in Kunduchi, Draft Final Report"; Kokusai Kogyo Co., Ltd.; May 1997

Table 6-29: Summary of Mitigation Measures common to more than one Environmental Item

Activity	Description	Econ	Traffic	Public Health	Waste	Haz/ Risks	Topo/ Geo	Ground water	Hydro Situat.	Flora/ Fauna	Land/ Aesth.	Air poll.	Water poll.	Soil cont.	Noise/ Vibr.	Offen. Odour	Litter
Policies	Prohibition of disposal of hazardous, toxic, infectious, radioactive, liquid wastes			Y		Y				Y		Y	Y	Y			
	Access to general public, including scavengers prohibited			Y		Y											Y
	Fires prohibited			Y		Y						Y					
Sanitary Landfill Operation	Site Fencing			Y		Y					Y				Y		Y
	Landscaping during construction (including visual shield near New Bagamoyo Road									Y	Y				Y		
	Temporary storage of construction wastes and cover soil				Y		Y										
	Covering of refuse vehicles during transit											Y				Y	Y
	Inspection of waste in incoming vehicles			Y		Y											
	Small tipping front, waste compaction, daily soil cover			Y		Y				Y		Y	Y			Y	Y
	Elimination of standing water			Y		Y				Y							
	Use of pesticides			Y		Y				Y							
	Moveable litter fences																Y
	Vehicle wheel wash facility											Y					Y
	Regular vehicle/ equipment maintenance											Y			Y		
	Construction of temporary on-site roads			Y		Y						Y					
	Water sprays for dust suppression			Y		Y						Y					
	Control on-site vehicle movements			Y		Y						Y					
	Runoff control			Y					Y				Y				
	Leachate control			Y		Y		Y		Y			Y			Y	
	Controlled ventilation of landfill gases			Y		Y				Y		Y				Y	
	Capping, restoration, final landscaping			Y		Y	Y		Y	Y	Y		Y			Y	
Worker Safety	Provision of protective clothing/equipment			Y		Y						Y			Y		
	Worker Instruction			Y		Y						Y					
Monitoring	Surface water flows/quality			Y					Y				Y				
	Groundwater flows/quality			Y				Y					Y				
	Air Quality			Y								Y					

Note: Y = yes, indicating that the stated mitigation measure will reduce the environmental impact for the environmental item indicated.

6.6.1 Social Environment

6.6.1.1 Economic Activities

Some deposits of coralline limestone (approximately 20% of the original total) are still present within the proposed disposal site, mainly in the area proposed for section 3 with smaller deposits in section 2. These will need to be excavated prior to landfilling beginning in these sections. Upon DCC acquiring the right to use the site as a landfill with construction in sections 1A and 1B scheduled for 1999, mining activities should be allowed to continue as normal in sections 2 and 3 of the proposed landfill site until construction is due to begin in these sections (2004 and 2007). This will result in the natural cessation of quarrying works, on the exhaustion of the coralline limestone in these areas, by the mining companies and small scale miners involved and hence these mining operators will not experience any negative economic impact. Consultation and discussions will be required between DCC and the affected mining operators (some companies and small scale miners) to develop and implement such a system.

Scavengers will be prohibited from the new disposal site at Kunduchi, resulting in a loss of income and employment to scavengers and middlemen now operating at the Vinguguti disposal site and a reduction in the amount of waste materials recycled. Discussions with representatives of the scavengers and middlemen now working at this site should be held well in advance of the closure of the Vinguguti landfill to inform them of the landfill's closure, the policy of prohibiting scavenging within the new landfill, and of any assistance which will be given to the recycling sector, as discussed below. As the scavengers/middlemen have a collective wealth of experience concerning informal recycling in DSM, their input and ideas should be sought and encouraged on how the adapted recycling system could work and how to minimise the resulting negative economic impact on scavenging/recycling.

As the market for recyclable materials will remain and given the resourcefulness of Tanzanians, other opportunities for recycling waste materials disposed of at the new disposal site will arise. Ideally, other recycling opportunities should be planned rather than allowed to develop informally. Hence, it is proposed in the SWM Master Plan that recycling should be promoted by segregation of waste at source to mitigate these negative impacts. Generation sources must be educated and motivated to separate waste at source into recyclable (plastic, glass, paper, metal, etc.) and non-recyclable items. Scavengers could then collect recyclable goods directly from generation sources or alternatively from collection points or recycling depots to which the segregated recyclable materials are brought. To do this will require financial resources for education and motivation of the public and possibly also for the provision of recycling collection points and associated work.

If scavengers are to be encouraged to collect recyclable materials from source or local collection points instead of from the final disposal site, the major factor hindering their work will be transportation. Possibly, some handcarts and vehicles could be made available to scavengers and/or middlemen at low hire rates to assist them in the collection of recyclable materials and their transportation to end users (micro-industries, factories ,etc.). Alternatively, a recycling fund could be established which people engaged in collecting recyclable materials could apply to for assistance (grants, low

interest loans, etc.) for purchasing handcarts, tools and other equipment. Various donor agencies, such as UNDP and ILO, could be approached for funding such schemes.

The public awareness pilot project conducted during "Beautify Dar es Salaam" month as part of the Study on the Solid Waste Management for DSM included cinema and cultural shows which attracted large audiences every performance. In particular, the cinema show was shown to be a very cost effective measure for public education. The SWM Master Plan allocates some funds for the purchase of a vehicle, video equipment and large portable screen to enable DCC to continue public education via this medium as well as to cover operational costs of this system. It is recommended that this equipment should be utilised for public education concerning recycling.

In terms of educational materials, the video "Pendezesha Jiji Lako", prepared as part of this campaign, could be revised and expanded to address recycling issues and educate the public about segregation of waste at source. Other videos could also be utilised including "A Matter of Habit", a video concerning SWM in Ecuador which addresses many of the same SWM issues that exist in DSM, including recycling, and which has already been dubbed in Swahili. However, funds have not yet been forthcoming to pay the dubbing costs and hence this video has not been released for use.

6.6.1.2 Traffic and Public Facilities

Normal traffic volumes are predicted to increase above the road carrying capacity along New Bagamoyo Road at station A1 near Mwenge, which may lead to congestion problems along this section of the road. The passage of refuse collection vehicles along this road to the disposal site will increase traffic volumes by an estimated 5 - 13%. Short and long term road development plans should be implemented as soon as practicable to minimise this potential problem. In any case, if traffic congestion does prove to be a problem, the hourly traffic flows along New Bagamoyo Road should be resurveyed and the scheduling of refuse collection vehicles and their routes could be rearranged in order to avoid peak hour traffic flows, which in this study were found to occur approximately from 7am - 9am and 4pm - 6pm (see section 6.4.6.1).

The access road to the site will also be constructed so that it contains an approximately 150 m long asphalt access road, parallel to New Bagamoyo Road, for refuse trucks to queue on while waiting to complete weighbridge entry procedures, thus avoiding obstructing traffic flows on New Bagamoyo Road.

Increased traffic flows due to the passage of refuse collection vehicles will have an impact on the incidence of accidents along New Bagamoyo Road. In section 6.5.1.2, the entrance/exit to the disposal site was identified as a potential accident trouble spot. This T-junction should be constructed to allow refuse vehicles entering and leaving the site to do so without impeding traffic flows. The road could possibly be widened at this point to create an exit lane for vehicles entering the site. As average speeds are high along New Bagamoyo Road, speed ramps could also be installed in the immediate vicinity of the site to reduce traffic speeds locally. Road signs should also be erected near to the site warning vehicles to be cautious due to large vehicles turning.

6.6.1.3 Public Health

The policy of prohibiting of hazardous, toxic, infectious, radioactive and liquid wastes from the landfill should be implemented by inspection of incoming wastes by the weighbridge staff and again at the tipping front by landfill site workers.

The policy of prohibiting the general public, including scavengers, from access to the landfill must be enforced. Fencing around the site will help to restrict access.

Fires are prohibited.

Pathogens, vectors and vermin; especially flies, mosquitoes and rats; should be controlled primarily through following good sanitary landfill practices, including operating with a relatively small tipping front, compacting the waste, applying daily soil cover and the elimination of standing water. Pesticides may also be used, if these measures are not sufficient to keep the populations of pathogens, vectors and vermin under control.

Dust production during construction and operation should be controlled within acceptable levels using water sprays, the construction of temporary on-site roads as required and by controlling vehicle movements on site.

Construction, site and refuse vehicle workers should be provided with adequate protective clothing and safety equipment (e.g. face masks, boots, gloves, etc.) to minimise the risk of accident and injury. These workers should also be instructed on appropriate working practices and safety procedures.

Leachate, runoff and landfill gas emissions should be controlled as discussed in section 6.3.

Capping, restoration, grassing and planting of completed sections of the landfill will minimise any risk to public health on the landfill's closure.

Monitoring of air (near the disposal site and along New Bagamoyo Road, north of Sam Nujoma Road), groundwater and surface water pollution should be undertaken regularly to determine the extent of pollution and any consequent public health threat. In particular, NO_x vehicle emissions should be closely monitored to assess the likelihood of any increase in respiratory diseases.

Public health statistics from the Mtongani dispensary and for Kinondoni district may also be collected as a secondary monitoring tool and compared with baseline health statistics obtained during this survey to monitor any increases in the incidence of diseases that could be attributable to refuse vehicle movements and landfill operation.

6.6.1.4 Waste

The generation of construction wastes and debris will be minimised by reusing or disposing of these waste materials within the landfill site. Alternatively, suitable materials may be sold.

It may not be possible to use such wastes immediately. Hence, space should be allocated for the temporary storage of such wastes until they can be used or disposed of.

In particular, soil from the excavation works to be carried out in sections 2 and 3 of the landfill prior to their utilisation for landfilling should, ideally, be used for covering material. As it is planned that these excavation works will be conducted by the mining companies and small scale miners concerned, an agreement must be reached between these parties and DCC for the excavated soil and other waste material to be used for waste covering material.

6.6.1.5 Hazards/Risks

At the new landfill, hazardous, toxic, infectious, radioactive and liquid wastes such as those from industry and hospitals will not be accepted for disposal, thus eliminating the potential hazards and risks posed by such wastes. A list of banned wastes must be drawn up so that this policy can be implemented and landfill staff will be made responsible for its strict enforcement. Furthermore, an alternative disposal place for these prohibited types of waste will be required.

The site will be fenced and the general public, including scavengers, will be prohibited from entering, thus preventing them from being exposed to the hazards and risks on-site.

No fires are permitted on-site.

In the sections (2 and 3) of the site where major excavation works will be carried out before these areas are used for landfilling, conventional machinery will be used for this work rather than explosives, thus reducing the risks/hazards associated with explosives.

During construction, workers will be provided with appropriate safety equipment, proper construction practices and safety procedures will be followed and construction activities will be supervised by suitably qualified and experienced personnel to minimise the risk of accidents and injury to workers.

Site workers should be provided with proper clothing and handling equipment (e.g. gloves, boots) to minimise the risk of accident and injury. They should also be instructed in the hazards and risks associated with landfill sites.

Pathogen, vector and vermin control measures and dust suppression procedures will be used, as described in section 6.6.1.3.

Landfill gases will be ventilated in a controlled manner to the atmosphere, thus minimising this risk of self-ignited fires, explosions and damage to vegetation. These facilities will be inspected and maintained at regular intervals during the aftercare period.

6.6.2 Natural Environment

6.6.2.1 Topography and Geology

Soil cover for the landfill must be obtained from different sources, preferably close to the proposed landfill site. Ideally, soil cover should come from quarrying works that will continue in sections 2 and 3 of the landfill prior to their development and other quarries in the area.

If this is not possible and some or all soil cover must be obtained from virgin, unspoilt areas, standards/procedures for soil procurement works should be specified and used.

Capping, restoration and landscaping of completed sections of the disposal site will ensure that the site topography is restored.

6.6.2.2 Groundwater

Little impact on groundwater level is expected as explained in section 6.5.2.2.

Groundwater levels will be monitored annually.

6.6.2.3 Hydrological Situation

Runoff will be prevented from entering the landfill by a series of diversion drains constructed along the edges of the quarry excavation. An embankment will also be constructed between the seasonal pond, directly south of the landfill site, and the New MECCO quarry to prevent water overflowing from this pond into the quarry during flood events.

Runoff from the landfill site will gradually increase over the life of the landfill as different sections are completed and capped. The impact on surface water sources is expected to be small and the adoption of a hilly landform for the landfill will mitigate the impact further, as runoff from the completed landfill will be diverted to different catchments. Furthermore, completed sections will be grassed and planted thus reducing runoff further.

Very few buildings exist close to the site so drains will not cause problems. Caution, however should be applied so as not to locate surface drains in positions that may cause problems for future development. Furthermore existing drains crossing New Bagamoyo Road to the north and east may need to be cleaned so as not to cause flooding of the road in the rainy season.

Surface water sources will be monitored around and downstream of the site annually and after heavy rainfall events.

6.6.2.4 Flora and Fauna

Landscaping during construction will benefit flora and fauna around the disposal site.

Growth in the populations of vectors and vermin, such as flies, mosquitoes, cockroaches and rats, will be minimised by following sanitary landfill practices (see section 6.6.1.3).

If seagulls prove to be a nuisance at the landfill site, these may be controlled by the use of noise makers, the use of recordings of the noises made by birds of prey and the use of overhead wires. The last method is probably the most practical in this case. The wires (typically 50 kg monofilament fishing line) are attached to poles usually spaced 15 - 25 m apart with line spans from 150 - 400 m. Criss-crossing improves the effectiveness of the wire system. As seagulls descend in a circular pattern when landing, it appears that the wires may interfere with the birds' guidance mechanism.

Although the impact of leachate in the groundwater on the mangroves near the salt pans at Kunduchi is expected to be mild, as mangroves are protected under the Forest Ordinance (see section 6.2.2.3) and are species of recognised biological and ecological importance, it is recommended that these mangroves should be inspected on an annual basis.

The controlled ventilation of landfill gases should be sufficient to mitigate against potential harm to flora and fauna within the vicinity of the site.

Once sections of the landfill are completed, capping and restoration should be carried out promptly followed by grassing and planting. Landscaping should be inspected regularly and any problems (e.g. minor erosion, grass seed not taking) rectified until the vegetation is well established.

6.6.2.5 Landscape/Aesthetics

The landscaping measures, planned to take place during the construction of the landfill, should be carried out as early and promptly as possible. Of particular importance is the creation of a visual barrier of plants and trees between the landfill site boundary and New Bagamoyo Road. Tree species, such as *Eucalyptus spp.*, should be selected that grow rapidly and reach heights of at least 5 m. The establishment of this barrier will mitigate against the mounds of waste and landfill equipment which may be visible from New Bagamoyo Road towards the end of filling in each section of the landfill and the site's skewed appearance due to the staged nature of landfilling.

On completion of landfilling, the site must be properly restored, landscaped and managed to ensure that the greatly improved quality of the landscape and site's visual amenity are maintained.

Some measures may need to be taken to protect plants and trees until they become established and to prevent trees from being cut down for fuel by residents in the area.

6.6.3 Pollution

6.6.3.1 Air Pollution

All fires are prohibited on site, thus minimising emissions of smoke and other gases associated with fires, including dioxins. The outbreak of spontaneous fires will be minimised by operating with a relatively small tipping front, compacting the waste and applying daily soil cover. Furthermore, fire prevention and fire fighting procedures should be prepared and landfill staff instructed in their use.

All refuse collection vehicles bringing refuse to the site should be covered to prevent dust and other particulate matter being produced. On leaving the site, these vehicles should use the wheel wash facility, as required, to remove dust, dirt and other small particles, picked up while in the site.

During construction and operation, dust production should be minimised by the regular use of water sprays, construction of temporary on-site roads and the control of vehicle movements. Furthermore, construction and landfill site workers should be provided with appropriate protective equipment such as face masks.

Air pollution, due to landfill gases, will be mitigated by furnishing the landfill with installations for the controlled ventilation of landfill gas from the top and sides of the landfill.

Exhaust gases from normal traffic are the main source of air pollution along New Bagamoyo Road. Air pollution can be reduced if appropriate legislation and policies are

developed and implemented by the Tanzanian government, including regular vehicle inspections and emission control measures.

In the context of this study, refuse vehicles do contribute to exhaust gas emissions and hence they should be inspected and maintained regularly in order to reduce such emissions. Furthermore, it is recommended that refuse vehicles should be fitted with appropriate devices for reducing vehicle exhaust emissions.

Monitoring of air quality along New Bagamoyo Road, north of Sam Nujoma Road, should be conducted for CO, NO_x and SO_2 at regular intervals (approximately every two years).

6.6.3.2 Water Pollution

The prohibition of certain types of waste from disposal at the landfill will reduce water pollution.

Major earthworks should be timed to avoid the rainy season.

The construction of embankments between operational and non-operational sections of the landfill and runoff diversion drains along the edges of the quarry excavation around each section of the landfill and an embankment near the seasonal pond directly south of the landfill site will minimise the production of dirty runoff and thus surface water pollution.

The division of the landfill into four sections, each of which is filled before filling of a new section begins, minimises the total landfill area with waste open for direct penetration of rain water, thus keeping the generation of leachate to a minimum. Proper sanitary landfill operation with a relatively small tipping front, compaction of waste and provision of daily soil cover will also help to minimise leachate production.

As no impermeable bottom liner will be provided, pollution of the groundwater by leachate will occur but this is not considered to be significant (see section 6.5.3.2). However, it is possible to reduce the amount of leachate which infiltrates into the sub-strata by lining the relatively small leachate reservoirs with an impermeable clay liner. As part of the conceptual design of the landfill[26], it was found that a bentonite clay and sand mixture with a clay content as low as 25% would be suitable for use as an impermeable liner. However, lining the leachate reservoirs would increase the construction costs while the resulting reduction in groundwater pollution is expected to be small. Furthermore, the average residence time of leachate in the reservoirs would increase which may lead to odour problems. Hence, this option is not considered to be viable.

Dirty wash water from the vehicle wheel wash facility is treated as leachate and will be diverted to operational sections of the landfill. Refuse vehicle drivers and landfill staff using this facility should be instructed to minimise water usage and thus reduce leachate production.

Completed sections of the landfill shall be capped, grassed and planted as soon as practicable in order to minimise soil and silt erosion.

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[26] "The Study on Solid Waste Management for Dar es Salaam, Conceptual Design for the New Landfill in Kunduchi, Draft Final Report"; Kokusai Kogyo Co., Ltd.; May 1997

The quality of groundwater and surface water sources will be monitored annually. Groundwater monitoring boreholes should be installed prior to construction in order to get baseline data.

6.6.3.3 Soil Contamination

The prohibition of certain types of waste, especially toxic and hazardous wastes, from the landfill will reduce soil contamination.

However, the permeation of leachate into the sub-strata means that some soil contamination will occur. Mitigation measures are not considered practical nor necessary to counter this impact.

If at a later time, it is decided to use some of the waste brought for disposal for compost production, the waste selected must be carefully sorted and screened to avoid contamination of the compost and thus the land on which it will be subsequently used.

6.6.3.4 Noise and Vibration

Construction of a planted screen between the landfill site and New Bagamoyo road, although primarily done for visual reasons, will also reduce noise emissions.

Landfill equipment and refuse collection vehicles should be regularly inspected and maintained in order to reduce noise levels.

Construction and landfill site workers, particularly those operating heavy machinery or working near such equipment will experience high noise levels and should be provided with earmuffs.

6.6.3.5 Offensive Odour

Offensive odour during transit to the site should be minimised if the twice weekly collection frequency is maintained and the waste in all refuse vehicles is covered.

At the site, offensive odour will be minimised by operating with a relatively small tipping front, compacting the waste and applying daily soil cover. If any particular odorous loads arrive, these should be deposited and immediately covered with other waste or cover material.

Some odour may be produced from the leachate which is retained in the leachate reservoirs. These must remain uncovered to allow leachate to evaporate. Hence, these reservoirs should be located appropriately to minimise offensive odours causing a nuisance.

The controlled ventilation of landfill gases will also reduce the occurrence of offensive odours.

Capping and restoration of completed sections of the landfill will ensure that all waste is well covered with soil, thus minimising the occurrence of offensive odours.

6.6.3.6 Litter

The provision of site fencing and restriction of public access to the site, means that waste materials will not be collected and taken off the site by the general public, particularly scavengers. This will reduce the amount of litter spread outside the site.

All refuse collection vehicles bringing waste to the site will be covered, thus reducing littering.

The landfill will be operated with a small tipping front, compaction of waste, the provision of daily soil cover and moveable litter fences, suitably located near the tipping front, thus reducing littering.

Use of the wheel wash facility by refuse vehicles will also prevent dust, dirt and other small particles from being spread outside the site.

6.7 Conclusions

The Environmental Impact Assessment Matrix shows that the project will have various positive and negative impacts, however, all negative impacts will be minor except those regarding traffic (occurrence of traffic jam, and increase of traffic accident and exhaust gas) and can be minimised through appropriate mitigation measures such as implementation of traffic lane expanding plan in the congested areas, strengthening traffic regulation, and improvement of collection vehicles. Therefore, the result of EIA showed that all negative impact can be within the tolerance level by taking appropriate measures.

The major benefit of the project will be the provision of a sanitary landfill which will be used as the final disposal site for DSM city from 2000 - 2002 and then for Kinondoni district[27], from 2003 - 2010. There is an urgent need for a new landfill as the remaining capacity of the Vinguguti landfill is 1-2 years, moreover, waste is being disposed of by open dumping at Vinguguti, thus currently creating many environmental problems in the immediate and surrounding areas.

The conceptual design concept for the landfill is considered to be appropriate. Furthermore, the operational policies and procedures proposed in the conceptual design will minimise the negative environmental impacts associated with the project. The absence of an impermeable bottom liner and consequent infiltration of leachate into the primary groundwater between the site and Indian Ocean is considered to be acceptable as it has been assessed that the leachate will have a minimum impact on potential groundwater resources in the area due to the site's proximity to the ocean. The groundwater is saline, already badly polluted and is not being used for human consumption.

During operation, some temporary negative environmental impacts on site topography and landscape/aesthetics due to landfilling, will be experienced. However, longer term permanent improvements in the topography, landscape/aesthetics, and flora and fauna will provide far greater positive impacts on the site. Similarly, the provision of land for

[27] The percentage of the DSM population living in Kinondoni district is projected to be 41% in 2003 and to decrease by around 1% per year (Source: The Study on Solid Waste Management in DSM; JICA, 1996).

agricultural or recreational activities is another major positive impact and will benefit the residents in surrounding areas.

Negative economic impacts at the site will be minimised by allowing mining companies and small scale miners to continue mining in sections 2 and 3 until 2004 and 2007, by which stage the coralline limestone should be exhausted, while sections 1A and 1B are being constructed and operated. Furthermore, economic activity in the area around the site will be increased during construction and operation, especially the business of food vending.

The policy of prohibiting scavenging at the new disposal site will result in a loss of income and livelihood for scavengers and middlemen currently operating at the Vingunguti disposal site, a decrease in the amount of waste materials recycled, and a major upset to the recycling system in the city. However, the negative impacts will be minor because the number of scavengers impacted will be only less than 100. Furthermore, the SWM Master Plan proposes to promote recycling by segregation at the source in order to mitigate these negative impacts and also to improve the recycling rate.

The transit of refuse collection vehicles will have a low negative impact on traffic volumes and the incidence of accidents along New Bagamoyo Road between Sam Nujoma Road and the disposal site. This negative impact will be mitigated by expanding traffic lanes in the congested areas and strengthening traffic regulation. Although increase of pollution load of SO_2 and NO_x can be expected, it is recommended that refuse collection vehicles should be fitted with appropriate devices for reducing vehicle emissions. Furthermore, monitoring of exhaust gas concentrations should be conducted.

It is recommended that this project should be approved and implemented according to the proposed timetable because the considerable positive impacts far outweigh the negative ones.

ACKNOWLEDGEMENTS

The JICA Study Team would like to acknowledge the following staff of the University College of Land and Architectural Studies (UCLAS), Department of Environmental Engineering, DSM, who collaborated with the JICA Study Team in this Environmental Impact Study:

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APPENDIX

1 Detailed Results and Calculations

1.1 Traffic Survey Results

Table 1-1: Traffic Survey Results - Station A1

Station A1	From Mwenge to Bagamoyo				From Bagamoyo to Mwenge				Total			
Time	21-Jan	22-Jan	23-Jan	Avg	21-Jan	22-Jan	23-Jan	Avg	21-Jan	22-Jan	23-Jan	Avg
0600-0700	209	208	196	204	334	325	305	321	543	533	501	526
0700-0800	393	418	449	420	394	420	448	421	787	838	897	841
0800-0900	365	373	375	371	446	473	454	458	811	846	829	829
0900-1000	373	315	371	353	379	324	375	359	752	639	746	712
1000-1100	378	350	375	368	352	296	353	334	730	646	728	701
1100-1200	339	386	345	357	350	326	355	344	689	712	700	700
1200-1300	373	407	401	394	352	331	377	353	725	738	778	747
1300-1400	304	407	348	353	324	348	366	346	628	755	714	699
1400-1500	385	513	364	421	354	414	355	374	739	927	719	795
1500-1600	371	382	345	366	378	358	349	362	749	740	694	728
1600-1700	445	589	426	487	370	374	329	358	815	963	755	844
1700-1800	411	414	398	408	365	362	346	358	776	776	744	765
1800-1900	405	531	429	455	342	381	355	359	747	912	784	814
Average	**365**	**407**	**371**	**381**	**365**	**364**	**367**	**365**	**730**	**771**	**738**	**746**
Total	**4751**	**5293**	**4822**	**4955**	**4740**	**4732**	**4767**	**4746**	**9491**	**10025**	**9589**	**9702**

Table 1-2: Traffic Survey Results - Station A2

Station A2	From Mwenge to Bagamoyo				From Bagamoyo to Mwenge				Total			
Time	28-Jan	29-Jan	30-Jan	Avg	28-Jan	29-Jan	30-Jan	Avg	28-Jan	29-Jan	30-Jan	Avg
0600-0700	67	57	45	56	78	71	64	71	145	128	109	127
0700-0800	139	132	128	133	119	113	107	113	258	245	235	246
0800-0900	106	117	142	122	125	107	143	125	231	224	285	247
0900-1000	152	113	168	144	107	109	163	126	259	222	331	271
1000-1100	110	97	114	107	126	134	121	127	236	231	235	234
1100-1200	135	132	125	131	108	140	157	135	243	272	282	266
1200-1300	82	95	125	101	121	113	138	124	203	208	263	225
1300-1400	84	87	103	91	99	134	114	116	183	221	217	207
1400-1500	95	121	107	108	126	103	145	125	221	224	252	232
1500-1600	126	137	101	121	122	147	131	133	248	284	232	255
1600-1700	136	91	90	106	158	150	119	142	294	241	209	248
1700-1800	104	101	99	101	103	135	126	121	207	236	225	223
1800-1900	82	125	99	102	63	123	116	101	145	248	215	203
Average	**109**	**108**	**111**	**109**	**112**	**121**	**126**	**120**	**221**	**230**	**238**	**229**
Total	**1418**	**1405**	**1446**	**1423**	**1455**	**1579**	**1644**	**1559**	**2873**	**2984**	**3090**	**2982**

Table 1-3: Traffic Survey Results by Vehicle Category

Station A1				
Date	**SV**	**LV**	**MC**	**Total**
21-Jan	7501	1777	213	9491
22-Jan	7966	1835	224	10025
23-Jan	7701	1673	215	9589
sub-total	23168	5285	652	29105
%	**0.80**	**0.18**	**0.02**	**1.00**
Station A2				
28-Jan	2029	794	50	2873
29-Jan	2020	912	52	2984
30-Jan	2064	966	60	3090
sub-total	6113	2672	162	8947
%	**0.68**	**0.30**	**0.02**	**1.00**
Total	29281	7957	814	38052
%	**0.77**	**0.21**	**0.02**	**1.00**

Note: MC = motorcycles; SV = small vehicles; LV = large vehicles

1.2 Noise Levels Results

Table 1-4: Noise Levels Results - Station A1

Station A1: Bagamoyo Road, 150m north of Sam Nujoma Road

Time	L_{95}				L_{50}				L_5			
	21-Jan	22-Jan	23-Jan	average	21-Jan	22-Jan	23-Jan	average	21-Jan	22-Jan	23-Jan	average
06:00-06:10	47.4	48.2	49.3	48.3	58.4	56.6	58.3	57.8	74.9	71.5	70.6	72.3
07:00-07:10	57.0	54.2	55.4	55.5	68.1	63.3	64.8	65.4	81.6	74.5	75.3	77.1
08:00-08:10	55.3	56.6	58.4	56.8	68.4	64.7	66.7	66.6	80.7	75.5	77.4	77.9
09:00-09:10	54.4	56.3	55.2	55.3	66.8	65.5	64.1	65.5	78.4	76.1	73.9	76.1
10:00-10:10	54.3	54.9	55.7	55.0	64.5	62.7	63.3	63.5	77.7	72.8	74.5	75.0
11:00-11:10	56.3	55.2	56.5	56.0	65.2	64.0	64.6	64.6	75.1	73.6	74.9	74.5
12:00-12:10	53.5	52.7	57.1	54.4	64.2	62.2	65.7	64.0	74.9	74.2	75.3	74.8
13:00-13:10	53.4	54.9	57.4	55.2	63.2	64.0	65.3	64.2	77.0	77.1	77.0	77.0
14:00-14:10	53.6	53.6	55.9	54.4	64.5	63.1	65.1	64.2	75.9	75.3	78.4	76.5
15:00-15:10	56.3	52.8	56.3	55.1	63.9	64.2	64.5	64.2	76.0	75.1	74.5	75.2
16:00-16:10	56.2	56.5	57.6	56.8	64.7	65.7	65.2	65.2	76.0	76.2	74.3	75.5
17:00-17:10	58.5	57.9	57.1	57.8	66.6	65.7	63.3	65.2	75.6	74.8	77.0	75.8
18:00-18:10	55.8	58.1	55.3	56.4	64.2	65.2	65.1	64.8	74.6	75.8	73.9	74.8

Table 1-5: Noise Levels Results - Station A2

Station A2: Bagamoyo Road, near to the proposed disposal site on the south-east side

Time	L_{95}				L_{50}				L_5			
	28-Jan	29-Jan	30-Jan	average	28-Jan	29-Jan	30-Jan	average	28-Jan	29-Jan	30-Jan	average
06:00-06:10	38.5	36.0	40.7	38.4	46.2	47.1	51.5	48.3	60.9	67.1	68.5	65.5
07:00-07:10	48.6	45.6	49.6	47.9	56.5	54.6	58.1	56.4	70.4	71.3	73.3	71.7
08:00-08:10	51.3	50.5	52.4	51.4	60.1	59.7	60.1	60.0	73.5	73.5	72.1	73.0
09:00-09:10	52.1	51.5	53.0	52.2	59.4	61.8	60.9	60.7	74.0	75.9	73.1	74.3
10:00-10:10	51.2	50.4	50.4	50.7	58.8	59.8	59.6	59.4	73.1	73.7	74.9	73.9
11:00-11:10	49.3	53.9	53.5	52.2	56.1	61.8	60.8	59.6	73.9	75.6	75.7	75.1
12:00-12:10	49.1	50.7	51.8	50.5	57.8	58.1	63.6	59.8	72.2	74.8	76.1	74.4
13:00-13:10	53.4	51.2	55.0	53.2	59.3	62.0	62.8	61.4	74.7	75.8	74.0	74.8
14:00-14:10	51.4	52.6	52.0	52.0	59.7	62.5	61.7	61.3	75.2	74.4	75.6	75.1
15:00-15:10	49.5	49.5	48.2	49.1	57.4	60.4	58.0	58.6	71.5	76.6	73.3	73.8
16:00-16:10	51.6	50.5	50.6	50.9	58.7	60.4	60.4	59.8	73.8	77.5	76.3	75.9
17:00-17:10	49.2	50.2	50.9	50.1	58.8	57.9	61.7	59.5	74.0	72.0	78.2	74.7
18:00-18:10	51.1	49.4	51.9	50.8	60.2	59.1	59.3	59.5	73.3	73.5	73.2	73.3

1.3 Vibration Levels Results

Table 1-6: Vibration Levels Results - Station A1

Station A1: Bagamoyo Road, 150m north of Sam Nujoma Road

Time	L_{50}				L_{10}			
	21-Jan	22-Jan	23-Jan	average	21-Jan	22-Jan	23-Jan	average
06:00-06:10	26.6	25.0	25.0	25.5	35.4	32.2	32.0	33.2
07:00-07:10	25.0	25.0	26.0	25.3	35.3	35.9	36.3	35.8
08:00-08:10	27.9	26.2	29.5	27.9	36.6	36.1	39.2	37.3
09:00-09:10	24.7	25.9	25.9	25.5	35.0	37.1	36.9	36.3
10:00-10:10	23.2	25.9	24.4	24.5	35.5	36.9	35.2	35.9
11:00-11:10	26.6	26.4	25.4	26.1	37.5	37.1	37.0	37.2
12:00-12:10	27.6	25.2	27.0	26.6	37.8	36.8	37.0	37.2
13:00-13:10	25.8	25.7	26.5	26.0	36.8	38.2	36.6	37.2
14:00-14:10	26.6	25.0	26.3	26.0	37.6	36.2	37.6	37.1
15:00-15:10	26.2	25.9	24.0	25.4	37.3	38.4	36.6	37.4
16:00-16:10	26.8	28.2	27.0	27.3	38.6	39.0	36.5	38.0
17:00-17:10	27.6	25.0	27.4	26.7	38.3	36.0	37.5	37.3
18:00-18:10	24.7	27.0	26.1	25.9	35.5	36.6	36.4	36.2

Table 1-7: Vibration Levels Results - Station A2

Station A2: Bagamoyo Road, near to the proposed disposal site on the south-east side

Time	L_{50}				L_{10}			
	28-Jan	29-Jan	30-Jan	average	28-Jan	29-Jan	30-Jan	average
06:00-06:10	15.0	20.3	15.0	16.8	19.8	21.1	23.1	21.3
07:00-07:10	15.7	16.6	17.3	16.5	26.7	28.6	30.0	28.4
08:00-08:10	19.9	23.7	21.4	21.7	31.2	24.7	30.6	28.8
09:00-09:10	18.8	22.1	23.0	21.3	30.4	31.8	31.9	31.4
10:00-10:10	21.1	20.8	20.9	20.9	31.3	32.2	32.0	31.8
11:00-11:10	25.0	21.6	23.7	23.4	31.4	33.1	33.0	32.5
12:00-12:10	22.0	21.2	23.3	22.2	31.0	33.9	33.4	32.8
13:00-13:10	23.5	23.8	23.2	23.5	31.6	31.8	32.0	31.8
14:00-14:10	22.1	22.1	22.2	22.1	33.0	33.9	32.3	33.1
15:00-15:10	20.4	21.2	19.2	20.3	29.1	34.9	29.5	31.2
16:00-16:10	21.9	21.9	20.7	21.5	31.2	34.5	31.3	32.3
17:00-17:10	20.5	18.9	20.3	19.9	31.9	31.1	33.2	32.1
18:00-18:10	19.1	16.5	21.1	18.9	31.5	30.1	31.3	31.0

1.4 Air Quality Results

Table 1-8: Air Quality Results

Station A1

Time	CO		
	21-Jan	22-Jan	23-Jan
06:00-06:10	2.5	2.0	2.0
07:00-07:10	5.0	3.0	3.0
08:00-08:10	4.0	3.0	3.0
09:00-09:10	5.0	4.0	3.0
10:00-10:10	4.5	4.0	3.0
11:00-11:10	4.0	2.0	4.0
12:00-12:10	2.0	2.0	3.0
13:00-13:10	2.0	3.0	3.0
14:00-14:10	3.0	3.0	4.0
15:00-15:10	4.0	3.0	4.0
16:00-16:10	4.0	3.0	4.0
17:00-17:10	5.0	4.0	3.0
18:00-18:10	5.0	3.0	2.0

Station A2

Time	CO		
	28-Jan	29-Jan	30-Jan
06:00-06:10	1.0	2.0	1.0
07:00-07:10	2.0	4.0	2.0
08:00-08:10	2.0	2.0	1.0
09:00-09:10	2.0	2.0	3.0
10:00-10:10	3.0	2.0	2.0
11:00-11:10	2.0	3.0	2.0
12:00-12:10	1.0	1.0	2.0
13:00-13:10	1.0	3.0	1.0
14:00-14:10	1.0	1.0	3.0
15:00-15:10	2.0	2.0	2.0
16:00-16:10	2.0	1.0	2.0
17:00-17:10	2.0	2.0	1.0
18:00-18:10	1.0	2.0	2.0

Time	SO_2		
	21-Jan	22-Jan	23-Jan
06:00-06:10	0.00	0.10	0.11
07:00-07:10	0.02	0.13	0.13
08:00-08:10	0.01	0.13	0.14
09:00-09:10	0.00	0.14	0.09
10:00-10:10	0.00	0.12	0.05
11:00-11:10	0.00	0.00	0.10
12:00-12:10	0.00	0.10	0.03
13:00-13:10	0.00	0.11	0.01
14:00-14:10	0.00	0.00	0.01
15:00-15:10	0.00	0.00	0.12
16:00-16:10	0.00	0.10	0.07
17:00-17:10	0.00	0.12	0.12
18:00-18:10	0.00	0.16	0.15

Time	SO_2		
	28-Jan	29-Jan	30-Jan
06:00-06:10	0.10	0.05	0.13
07:00-07:10	0.05	0.11	0.10
08:00-08:10	0.00	0.00	0.07
09:00-09:10	0.00	0.01	0.06
10:00-10:10	0.01	0.00	0.12
11:00-11:10	0.00	0.00	0.00
12:00-12:10	0.12	0.00	0.00
13:00-13:10	0.00	0.00	0.00
14:00-14:10	0.13	0.11	0.01
15:00-15:10	0.00	0.10	0.02
16:00-16:10	0.00	0.02	0.25
17:00-17:10	0.11	0.12	0.30
18:00-18:10	0.04	0.12	0.31

Time	NO_x		
	21-Jan	22-Jan	23-Jan
06:00-06:10	0.02	0.02	0.02
07:00-07:10	0.04	0.04	0.04
08:00-08:10	0.04	0.06	0.06
09:00-09:10	0.02	0.04	0.04
10:00-10:10	0.06	0.04	0.04
11:00-11:10	0.04	0.04	0.04
12:00-12:10	0.02	0.06	0.06
13:00-13:10	0.04	0.08	0.06
14:00-14:10	0.04	0.04	0.08
15:00-15:10	0.02	0.08	0.04
16:00-16:10	0.04	0.04	0.04
17:00-17:10	0.04	0.04	0.04
18:00-18:10	0.02	0.02	0.02

Time	NO_x		
	28-Jan	29-Jan	30-Jan
06:00-06:10	0.00	0.00	0.00
07:00-07:10	0.00	0.00	0.00
08:00-08:10	0.00	0.02	0.02
09:00-09:10	0.02	0.02	0.04
10:00-10:10	0.00	0.04	0.04
11:00-11:10	0.00	0.02	0.02
12:00-12:10	0.02	0.00	0.04
13:00-13:10	0.02	0.02	0.00
14:00-14:10	0.02	0.00	0.00
15:00-15:10	0.02	0.00	0.04
16:00-16:10	0.02	0.02	0.06
17:00-17:10	0.02	0.02	0.02
18:00-18:10	0.00	0.00	0.00

1.5 Estimation of Pollution Loads of Different Gases

The following equations were used to predict the pollution loads of different gases from all vehicles (mobile combustion sources) passing along New Bagamoyo Road from Sam Nujoma Road to the disposal site. The results are presented in Table 1-10.

Normal Pollution load (kg/13 hr) = (MC x A_{MC} + SV x A_{SV} + LV x A_{LV}) x 9.6/1,000

Pollution load with RV (kg/13 hr) = (MC x A_{MC} + SV x A_{SV} + (LV+RV) x A_{LV}) x 9.6/1,000

where:

1. MC, SV, LV and RV = the number of motorcycles small vehicles, large vehicles and refuse collection vehicles respectively measured in the traffic volume survey over a 13 hour period.
2. A_i = pollution factors for different gases according to vehicle type as shown in Table 1-9.
3. 9.6 km is the length of road from Sam Nujoma Road to the disposal site.

Table 1-9: Pollution Factors for different Gases

Type of Vehicle	Pollution Factors (A_i) (kg per 1,000 km)		
	CO	NO_x	SO_2
motorcycle	17	0.07	0.02
small vehicle	40	3.2	0.08
large vehicle	12.7	21	1.5

Note: 1. Source: "Rapid Assessment of Sources of Air, Water and Land Pollution"; WHO; Geneva; 1982; pg. 38
2. The pollution factors are all based on 1970 model cars in the USA.
3. Small vehicle and large vehicle pollution factors apply to light-duty, gasoline powered vehicles and heavy-duty, diesel powered vehicles respectively.

Table 1-10: Predicted Pollution Loads of Different Gases

A1	No. of Vehicles per 13 hr					Pollution Load								
						CO			NOx			SO2		
Year	MC	SV	LV	RV	Total	norm.	with RV	% rise	norm.	with RV	% rise	norm.	with RV	% rise
1997	194	7760	1746	0	9700	3224	3224	0	591	591	0	31	31	0
2000	233	9322	2098	652	11653	3874	3953	2.05	709	841	18.53	37	47	25.10
2001	248	9907	2229	826	12384	4117	4217	2.45	754	920	22.09	40	52	29.92
2002	263	10530	2369	1016	13162	4375	4499	2.83	801	1006	25.56	42	57	34.63
2003	280	11196	2519	392	13995	4652	4700	1.03	852	931	9.28	45	51	12.56
2004	297	11899	2677	474	14874	4944	5002	1.17	905	1001	10.55	48	55	14.29
2005	316	12650	2846	560	15813	5256	5325	1.30	963	1076	11.73	51	59	15.89

A2	No. of vehicles per 13 hr					Pollution Load								
						CO			NOx			SO2		
Year	MC	SV	LV	RV	Total	norm.	with RV	% rise	norm.	with RV	% rise	norm.	with RV	% rise
1997	60	2026	894	0	2980	897	897	0	243	243	0	14	14	0
2000	72	2435	1074	652	3581	1078	1157	7.38	291	423	45.10	17	27	54.10
2001	76	2589	1142	826	3808	1146	1247	8.79	310	476	53.73	18	30	64.45
2002	81	2749	1213	1016	4043	1217	1341	10.18	329	534	62.25	20	34	74.67
2003	86	2921	1289	392	4296	1293	1341	3.70	350	429	22.60	21	26	27.11
2004	91	3110	1372	474	4573	1376	1434	4.20	372	468	25.68	22	29	30.80
2005	97	3304	1458	560	4859	1462	1531	4.67	395	508	28.55	24	32	34.25

1.6 Estimation of Road Traffic Noise

The following equation was used for the estimation of road traffic noise (source: "Road Environmental Improvement Manual", Japan Road Association):

$$L_{50} = L_w - 8 - 20\log_{10}l + 10\log_{10}(\pi l/d \times \tanh(2\pi l/d)) + \alpha_d - \alpha_l$$

where $L_w = 87 + 0.2v + 10\log_{10}(a_1 + 10a_2)$

L_{50} = average noise level which is exceeded 50% of the time (dB)
L_w = average power level per vehicle (dB)
v = average vehicle velocity (kph) = 50 kph (based on vehicle travel survey results for Sam Nujoma Road - Nelson Mandela Road - Kilwa Road in "The Study on Dar es Salaam, Road Development Plan, Final Report"; JICA; 1995).
a_1 and a_2 = percentage of small and large vehicles respectively (%).a_1 and a_2 are obtained from the traffic survey results in this study. For normal traffic, at station A1, a_1 = 82%, a_2 = 18%; at station A2, a_1 = 70%, a_2 = 30%. When refuse collection vehicles are included a_1 and a_2 must be calculated for each year using the number of units of refuse collection vehicles as tabulated below.
l = distance from noise source to nearest residence (m) = 10 m. (minimum value as most residences are further away).
N = average actual number of vehicles per hour
d = 1000v/N (m)
α_d and α_l are factors. In this case $\alpha_d = 0$ and for l = 10 m, α_l = -2.5

Table 1-11: Estimated Traffic Noise Levels with and without refuse collection vehicles

Station A1 a) Normal Traffic

Year	Proj. Traffic	No./ 13h	Avg Veh/h	d (m)	L50 (dB)
1997	10480	9700	746	67.01	66.05
2000	12590	11653	896	55.78	67.27
2001	13380	12384	953	52.49	67.66
2002	14220	13162	1012	49.39	68.03
2003	15120	13995	1077	46.45	68.40
2004	16070	14874	1144	43.70	68.76
2005	17085	15813	1216	41.10	69.10

b) Normal Traffic and Refuse Vehicles

SV+ MC	LV	RV	Total	Avg Veh/h	a1	a2	d(m)	Lw (dB)	L50 (dB)
7954	1746	0	9700	746	0.82	0.18	67.01	101.18	66.05
9555	2098	652	12305	947	0.78	0.22	52.82	101.79	68.22
10155	2229	826	13210	1016	0.77	0.23	49.20	101.69	68.76
10793	2369	1016	14178	1091	0.76	0.24	45.65	101.98	69.28
11476	2519	392	14387	1107	0.80	0.20	45.18	101.50	68.89
12197	2677	474	15348	1181	0.79	0.21	42.35	101.55	69.30
12967	2846	560	16373	1259	0.79	0.21	39.70	101.58	69.70

Station A2 a) Normal Traffic

Year	Proj. Traffic	No./ 13h	Avg Veh/h	d (m)	L50 (dB)
1997	3545	2980	229	218.12	52.31
2000	4260	3581	275	181.51	53.89
2001	4530	3808	293	170.69	54.42
2002	4810	4043	311	160.76	54.94
2003	5110	4296	330	151.32	55.45
2004	5440	4573	352	142.14	55.99
2005	5780	4859	374	133.78	56.51

b) Normal Traffic and Refuse Vehicles

SV+ MC	LV	RV	Total	Avg Veh/h	a1	a2	d(m)	Lw (dB)	L50 (dB)
2086	894	0	2980	229	0.7	0.3	218.12	102.68	58.24
2507	1074	652	4233	326	0.59	0.41	153.55	103.69	62.19
2666	1142	826	4634	356	0.58	0.42	140.27	103.83	63.07
2830	1213	1016	5059	389	0.56	0.44	128.47	103.96	63.91
3007	1289	392	4688	361	0.64	0.36	138.66	103.26	62.59
3201	1372	474	5047	388	0.63	0.37	128.79	103.33	63.26
3401	1458	560	5419	417	0.63	0.37	119.95	103.39	63.89

Note: 1) Proj. Traffic = projected traffic volumes per 12 hour period; No./13h = actual traffic per 13 hour period
2) MC = motorcycles; SV = small vehicles; LV = large vehicles; RV = refuse collection vehicles

Chapter 7

Implementation Plan

7 Implementation Plan

7.1 Outline of the First Priority Project

The outline of the first priority projects which was proposed to materialise the targets are described as follows.

7.1.1 Improvement of Waste Collection, Transport and Disposal System

a. Improvement of Waste Collection and Transport

- The number of main equipment to be procured are shown below.

		1999	2000	2001
6 ton tipper truck	units	40	5	5
8 ton skip truck	units	31	16	20
8 m^3 skip container with lid	nos.	62	32	40
8 m^3 skip container without lid	nos.	248	128	160

- The number of main equipment to be operated are shown below.

		2000	2001	2002
6 ton tipper truck	units	40	45	50
8 ton skip truck	units	31	47	67
8 m^3 skip container with lid	nos.	62	94	134
8 m^3 skip container without lid	nos.	248	376	536

b. Development of the New Kunduchi Disposal Site

- To construct 2 landfill section of 4 sections in 1999.
- To start the landfill operation in 2000.
- Landfill sanitary level: Level 2 (Sanitary landfill without a liner for the prevention of leachate percolation)
- Total landfill capacity is 3.5 million m^3. The capacity of the 2 landfill sections to be developed in 1999 is 1.6 million m^3.
- Main facilities to be constructed in 1999: access road, office, landfill sections, drainage work, etc.
- Landfill equipment to be procured in 1999: 2 bulldozers, 1 backhoe, 3 tipper truck, 1 pickup

c. Improvement of Street Sweeping

- Procurement schedule of main equipment: 4 ton tipper truck, 3 units in 1999, 1 units in 2000 and 2001

d. Improvement of the Nyerere Workshop

- To furnish the office in 1999 and to start its operation in 2000.

- Facility improvement: drainage system, water tank, electricity
- Procurement of machinery for maintenance, mobile workshop, etc.

e. Improvement of Administrative System

- Improvement of the office for WMA and procurement of office equipment
- Institutional building

7.1.2 Improvement of Night Soil Collection and Transport System

- The type of night soil collection equipment: 6 m3 cesspit empty trucks
- The number of trucks to be procured and to be operated are as follows.

Cost Item	1999	2000	2001	2002
Number of trucks to be procured	8	4	4	0
Number of trucks to be operation	-	19	21	22

7.2 Financial Plan

7.2.1 Parameters and Presumptions for the Financial Plan

The financial parameters as well as the revenue forecast for the municipal tax, on which the financial plan for the feasibility study shall is totally based, was estimated in the same manner as those for the Master Plan.

7.2.2 Scenarios for the Financial Case Studies

a. Senarios

For the financial analysis several cases are set up regarding the following 3 aspects:

- Financial sources: Financial sources for the investment of the project cost
- Revenue source 1: RCC system
- Revenue source 2: Special Fund to be allocated from revenue from the city's tax revenue

a.1 Financial Sources for the investment of the project cost

The following 3 cases were presented as financial sources.

Case	Description
A	All of the project costs are covered by a loan.
B	The investment in 1999 for the construction of the final disposal site and landfill equipment is granted by foreign aid.
C	All investment in 1999 for the construction of the final disposal site, landfill equipment, refuse collection vehicles, machinery for the maintenance workshop, etc. are granted by foreign aid.

a.2 Refuse Collection Charge System

Following two cases were assumed for the refuse collection charge system.

Case 1	Joint billing with water supply and sewerage fee by DAWASA
Case 2	Special RCC collected by DCC

a.3 Special Fund to be allocated from the city's tax revenues

Following three cases were assumed for the total amount of special fund allocated from the city's tax revenues.

Case a	Most optimistic scenario of increase in city tax revenue and allocation ratio for solid waste management
Case b	Most likely scenario of increase in city tax revenue and allocation ratio for solid waste management
Case c	Most pessimistic scenario of increase in city tax revenue and allocation ratio for solid waste management

b. Refuse Collection Charge (RCC)

Various conditions regarding the RCC system are set up as below.

b.1 Joint billing with water supply charge by DAWASA

b.1.1 Household waste

Target people	All households that receive refuse collection services
Amount of RCC	Tsh. 1,250 per household per month (according to the interview on willingness to pay)
Billing rate	30 %: (present provision rate of water supply (40%) x present billing rate of water supply charge (80%)
Collection cost rate of RCC	30%: 30% of RCC is paid to DAWASA for the collection cost

b.1.2 Wastes other than household waste

Target people	All dischargers of official, commercial and market waste that receive the service
Amount of RCC	Tsh. 20,000 per ton (approximately 1.33 times of Willingness to Pay of household waste)
Billing rate	70%: present provision rate of water supply of 80% x present billing rate of water supply charge of 90%
Collection cost rate of RCC	30%: 30% of RCC is paid to DAWASA for the collection cost.

b.2 Special RCC collected by DCC

b.2.1 Business Waste (Commercial, Market and Institutional Wastes)

Target people	All dischargers of official, commercial and market waste that receive the service
Amount collected	Tsh. 20,000 per one ton (approximately 1.33 times of Willingness to Pay of household waste)
Billing rate	80%

b.2.2 Household Waste

Concerning household waste, the special RCC is to be set up for the special refuse collection services, such as door to door collection, bulky waste collection, garden waste collection, etc., where collections costs are generally more expensive than for normal household waste.

c. Revenue

The following 3 cases out of the aforementioned 9 scenarios are set up as alternative scenarios in terms of the revenue forecast of the municipal tax for the priority project.

Table 7-1 Alternative Scenarios in terms of Revenue Forecast

unit : million Tsh.

Case	1999	2000	2001	2002	2003	2004	2005
a = Most Optimistic	598	766	964	1188	1345	1467	1587
b = Most Likely	435	494	564	649	751	876	1015
c = Most Pessimistic	323	329	334	338	342	345	347

As a result, the financial plans were formulated for the combined 18 cases (3 x 2 x 3) of the above 3 conditions of cost (3 cases), billing system (2 cases), and revenue forecast (3 cases). Table B - 1 to Table B - 18 indicate the financial planning tables for these 18 cases.

7.2.3 Proposed Tariff

Apart from the overall financial management of the alternative options, in the feasibility level, the exact tariff setting will be a critical issue to gauge the financial viability of the first priority project.

a. Tariff Setting

a.1 Tariff Setting for Joint Billing to Household Wastes

The level of the tariff for the joint billing for household wastes shall be determined based on the households' willingness to pay and the marginal cost of the priority Project.

Regarding the willingness to pay, according to the result of the public opinion survey conducted by the study team, the mean willingness to pay of all the areas stood at Tsh. 1230.4 per month per household with the 95 % confidence interval of Tsh. 165.7. Table B - 19 and Figure B - 1 illustrate the statistical summary of the public opinion survey on the willingness to pay. It could be statistically interpreted to mean that the it is 95 % probable that the mean willingness to pay of all the areas exists at a certain level between Tsh. 1,064.7 and Tsh. 1396.1.

Meanwhile, regarding the marginal cost of the priority project, it is estimated at Tsh. 762.5 per month per household, since an average household generates wastes of 1.0 ton per year which requires the marginal cost of Tsh. 9,150 per ton.

Taking into consideration that the estimated mean of the willingness to pay is larger than the marginal cost, the estimated mean is an appropriate level for the tariff setting of the priority project. Considering the round figure nearby Tsh. 1230.4, Tsh. 1250 was

adopted for the tariff level for the joint billing with DAWASA charged to household wastes.

a.2 Tariff Setting for Joint Billing to Institutional, Commercial and Market Wastes and Special RCC for Institutional, Commercial and Market Wastes

Although the public opinion survey on the willingness to pay for the institutional, commercial and market wastes has not been conducted, the tariff level for the joint billing and special RCC imposed on institutional, commercial and market wastes will be separately set at Tsh. 20,000 per ton, taking into the marginal cost account.

b. Demarcation of Tariff for Collection and Transportation Fee and Tipping Fee

b.1 Demarcation of Tariff Setting for Joint Billing to Household Wastes

Table 7-2 Demarcation of Tariff Setting

Fee	Excluding Interest		Including Interest	
	Unit Cost (Tsh./ton)	Share (%)	Unit Cost (Tsh./ton)	Share (%)
Collection and Transport Fee	7,099	77.6%	12,814	80.0%
Tipping Fee	2,051	22.4%	3,210	20.0%
Total Tariff	9,150	100.0%	16,024	100.0%

Considering the above composition share of the collection and transportation fee and the tipping fee in the marginal cost of the priority project, the collection and transportation fee is estimated at Tsh. 970 per month per household, which is 80 % of the joint billing tariff, while the tipping fee is estimated at Tsh. 280 per month per household, which is 20 % of the joint billing tariff.

b.2 Demarcation of Tariff for Joint Billing to Institutional, Commercial and Market Wastes and Special RCC for Institutional, Commercial and Market Wastes

In the same manner as above, the collection and transportation fee is estimated at Tsh. 15,520 per ton, while the tipping fee is estimated at Tsh. 4480 per ton.

7.2.4 Financial Analysis

The improvement project of waste collection, transport and disposal system wchich will be as a "take-off project" of the Mater Plan, was evaluated from a financial perspective. Eighteen cases were studied as were done in Master Plan as a combination of preconditions and cases in the evaluation of the priority project. Results of the FIRR from this study are as follows.

Table 7-3: FIRRs of the Improvement of the Waste Collection, Transport and Disposal System

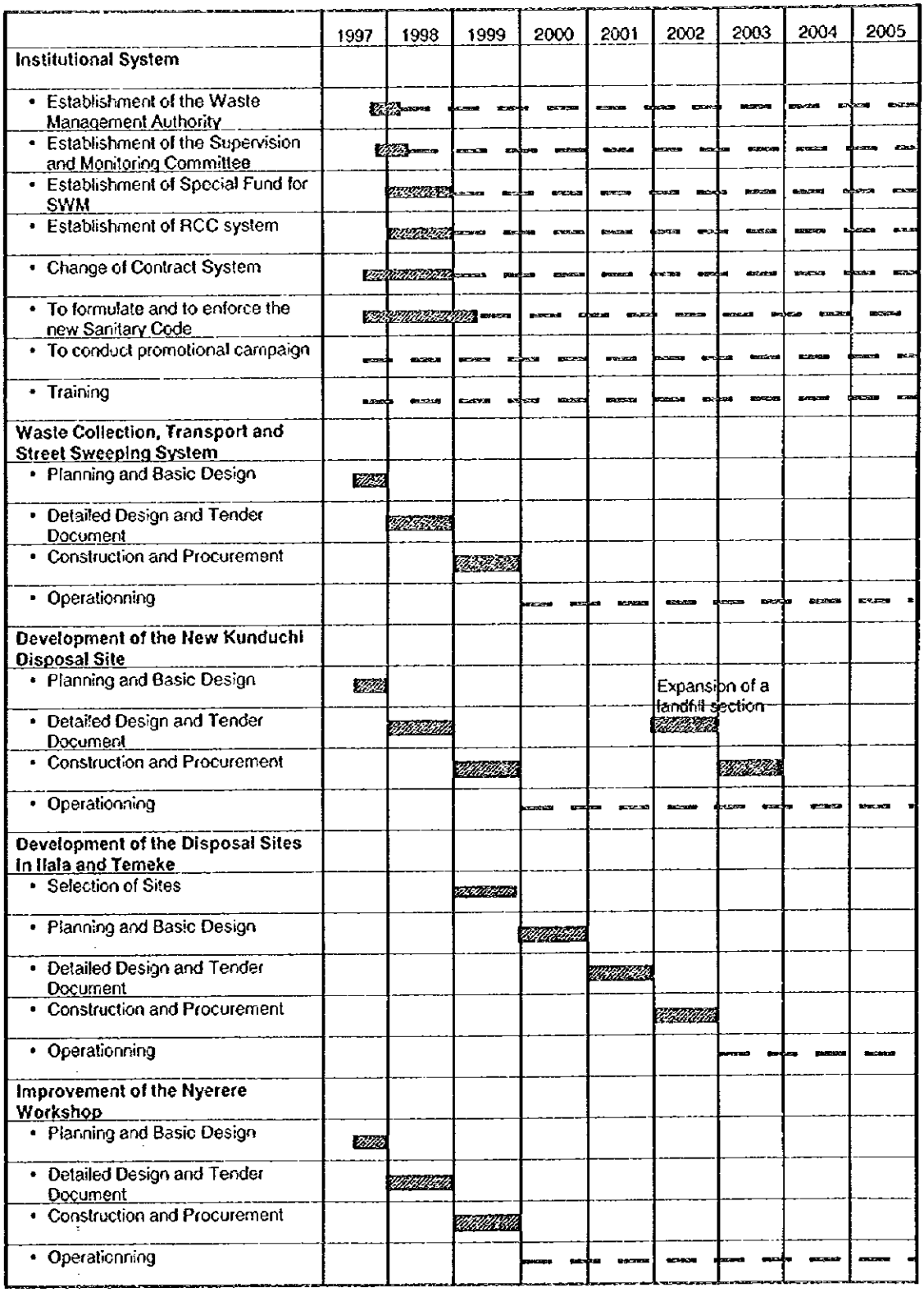
Financial Plan for Investment	Financial Source	Revenue Forecast	Case	FIRRs (%)
All loan	Tax and RCC collected by joint billing with water supply charge	Optimistic	A-1-a	2.42%
		Most Probable	A-1-b	-8.15%
		Pessimistic	A-1-c	-19.20%
	Tax and Special RCC collected by DCC	Optimistic	A-2-a	-1.83%
		Most Probable	A-2-b	-12.34%
		Pessimistic	A-2-c	-23.35%
Grant provided in 1999 for the investment in construction of the disposal site and landfill equipment	Tax and RCC collected by joint billing with water supply charge	Optimistic	B-1-a	8.13%
		Most Probable	B-1-b	-4.62%
		Pessimistic	B-1-c	-17.20%
	Tax and Special RCC collected by DCC	Optimistic	B-2-a	3.05%
		Most Probable	B-2-b	-9.42%
		Pessimistic	B-2-c	-21.81%
Grant provided for all investment in 1999	Tax and RCC collected in joint billing with water supply charge	Optimistic	C-1-a	62.99%
		Most Probable	C-1-b	24.70%
		Pessimistic	C-1-c	-6.94%
	Tax and Special RCC collected by DCC	Optimistic	C-2-a	40.92%
		Most Probable	C-2-b	10.24%
		Pessimistic	C-2-c	-14.80%

7.3 Implementation Schedule

The proposed implementation programme of the priority projects is shown in Figure 7-1.

The proposed action programme for improvement of institutional and financial system is shown in Figure 7-2.

Figure 7-1: Implementation Programme of the Priority Projects



Legend:
Implementation:
Operationing:

Item	Work Plan	Responsible Person	1997	1998	1999
1. Foundation of Waste Management Authority	1. Setting up Waste Management Pre-Committee 2. Formulation of Organisation Structure 3. Selection and Training of Authority Staff	City Commissioner, Heads of Health, Construction, and Planning	→	→	
2. Foundation of Supervision and Auditing Commission	1. Formulation of Organization Structure 2. Selection and Training of Commission Staff 3. Formulation of Financial Plan	City Commissioner, Health Commissioner	→	→	→
3. Setting Up Special Account for Solid Waste Management	1. Formulation of Special Account 2. Training of Accounting Staff 3. Enforcement of Special Account as City By-law	Finance Commissioner	→	→	→
4. Introduction of Joint Billing System with DAWASA	1. Negotiations with DAWASA 2. Formultion of Joint Billing Regulations 3. Development of Software for Joint Billing	City Commissioner, Waste Management Pre-Committee, DAWASA	→	→	
5. Formulation of Contracting Out System	1.Drafting up Guidelines for Contracting out System 2. Enforcement of Guidelines as City By-law 3. Invitation of Tendering for the Priority Project	Waste Management Pre-committee		→	→
6. Enacting Sanitary Code	1. Assessment of Present Laws and Regulations 2. Drafting up Sanitary Code 3. Enforcement of Sanitary Code as City By-law	Health Commissioner		→	→
7. Implementation of Education Program	1. Assessment of Education Needs 2. Formulation of Education Program 3. Implementation of Education Program	Waste Management Pre-Committee	→	→	→
8. Formulation of Human Resource Development Plan	1. Assessment of Present Quantity and Quality of Human Resources 2. Formulation of Human Resource Development Plan	Health Commissioner	→	→	

Figure 7-2: Proposed Action Programme for Improvement of Institutional and Financial System

Chapter 8

Project Evaluation

8 Project Evaluation

8.1 Improvement of Waste Collection, Transport and Disposal System

The first priority projects, that is improvement of refuse collection and transportation systems and development of the New Kunduchi disposal site, were evaluated in terms of their technical, social, environmental, financial and economic impacts.

8.1.1 Technical Evaluation

The proposed technical system in the first priority projects is basically the same as the present system consisting of waste collection, transport and disposal. No intermediate technology was proposed, except for on-site composting which does not require complex techniques. Therefore the issues to be considered only concern ways to ensure appropriate operation, maintenance and management.

a. Collection and Transport

Skip trucks were the proposed main collection and transportation equipment. DSM has been using skip trucks (3) since 1988 until recently when they broke down. The tipper trucks which were also obtained at the same period are still operable however. The breakdown of the skip trucks is attributed to excessive use: the number of trips made by skip trucks was 3 times greater than the tipper trucks. DCC is adequately equipped with the technical skills required for the maintenance of skip trucks and the necessary spare parts are available in DSM. These trucks cost very little to operate and are quite convenient, and they are therefore, most appropriate for DSM.

Tipper trucks were proposed for curb collection in some areas where vehicles are accessible. The use of these trucks was decided because they are not products of recent technology and will not require any sophisticated form of maintenance.

Although the Master Plan propose the use of compactor trucks for collection in the city centre, the first priority project does not propose it because maintenance problems are foreseen.

The intended number of refuse collection vehicles is 71 in 2000 and 117 in 2002. Because it is considered to be difficult for DCC to operate all vehicles directly, the total number of vehicles to be under the responsibility of DCC is to be maintained at less than 50 by contracting out 100% of refuse collection works for the urban area and 30% of the planned developed area to private refuse collection companies. It is judged to be feasible for DCC to operate about 50 vehicles because they used to operate 53 vehicles in 1987.

b. Final Disposal

The plan proposes to introduce the sanitary landfill method abandoning the present open dumping. The technical reasons as to why the sanitary landfill method is currently not employed are unavailability of coverage soil near Vingunguti and lack of loading and transport equipment. In the proposed project, enough borrow pit for daily coverage can be secured within the New Kunduchi Disposal Site. In addition, the project

includes procurement of loading and transport equipment, and therefore there will be no problems in conducting sanitary landfill operations.

The plan proposes the use of sanitary landfill with a liner for the prevention of leachate percolation into the ground because the predicted negative impacts will be abated to an acceptable level. Therefore the required technology and operation costs shall be minimal.

c. Maintenance Workshop

DCC's maintenance capability has achieved a sufficient level with the help of JICA's expert technical assistance since 1993.

Since the existing maintenance workshop and repair machinery are in a poor condition and the distance to the site where heavy landfill equipment are operating will increase, problems related to maintenance of refuse collection vehicles and landfill equipment are predicted to occur. These problems are proposed to be solved by improvement of the Nyerere workshop and procurement of a mobile workshop in the project.

d. Human Resources

The required number of people in total to be involved in the priority project, including employees in DCC and private sectors, will be about 600. In order to train these people the plan proposes to provide 20 % of all staff with training.

e. Overall Technical Evaluation

The overall technical evaluation concluded that the simplicity of the proposed technical system is very appropriate for the technical level in DSM and also that this technical system would be suitable for DSM because it is consistent with the institutional system requirements for the area, which are identified in Chapter 5, and also with the SWM objective for DSM, i.e. improvement of sanitary conditions.

8.1.2 Social Evaluation

Prior to the financial and economic evaluation, the master plan was evaluated in terms of the intangible social impacts it will incur, i.e., improvements in sanitary and public health conditions, prevention of flood, attraction of foreign investment and tourism, and increase in land value.

a. Improvements in Public Health and Sanitary Conditions

The implementation of the project will bring various benefits. Poor collection or disposal practices encourage the breeding of insects, rodents, and pathogens that can cause and transmit diseases, particularly several of the diseases in the tropical cluster: schistosomiasis, trypanosomiasis, and Bancroftian filariasis. Since the master plan intends to mitigate the effect of such diseases by the elimination of waste heaps and the introduction of sanitary landfills with proper facilities, considerable improvements in public health conditions as well as conditions in nearby illegal dumping sites and in disposal sites can be anticipated.

The number of people who will benefit from refuse collection services by the implementation of the project is approximately 640,000. As a knock-on effect, it will contribute to less drain blockages caused by refuse as well as flooding, which in turn

will increase road life and reduce water pollution of surface and ground water sources. The improved sanitary condition and landscape will generate various significantly positive impacts such as encouraging foreign investment, promoting tourist industry and increasing land prices.

The study by the World Bank suggests that 25 percent of soil transmitted diseases will be averted through feasible interventions such as covering of waste delivered to a dumpsite with fifteen to thirty centimetres of soil at the end of each day. Meanwhile, the Ministry of Health reported that 12.0 percent of the mortality rate in DSM is caused by some kind of soil transmitted diseases. The male mortality rate in DSM ranges from 19 per 1000 persons between the age of 10-14 to 535 per 1000 persons between the age of 75-79, and that the female mortality rate in DSM ranges from 16 per 1000 persons between the age of 10-14 to 455 per 1000 persons between the age of 75-79. Therefore, the calculated impact on the mortality rate ranges from 0.57 per 1000 persons at 10-14 to 16.17 per 1000 persons at 75-79.

b. Prevention of Flood

Inadequate collection and transport of wastes may also clog open drains, creating breeding grounds for malaria and dengue-transmitting mosquitoes, or causing floods in rainy seasons, which may increase human contact with pathogen-infected faeces contained in the waste. The master plan will significantly mitigate the dangers these situations may bring about through the promotion of regular road sweeping services.

c. Promotion of Investment and Tourism

In addition to the above-mentioned health effects, the proper collection, transport and disposal of wastes shall provide DSM with the favourable environment for the promotion of foreign investment and tourism. Since DSM, as the central gateway, is connected by major railroads and trunk roads to neighbouring countries, the improvement of its environment will enhance its image, and eventually contribute to attracting more investors and tourists to the area.

d. Increase in Land Value

Well-managed waste disposal services also improve the living environment which result in increased land values. A study on the correlation between the living environment and land value suggests that, other factors held constant, housing values with distance from a landfill rise at an average rate of 6.2 % a mile within a two-mile radius of the landfill, presumably because the environmental and aesthetic problems associated with living near a landfill diminish as distance from it increases[1]. Thus, the master plan with the proper sanitary landfilling measures increases the land value around the present illegal dumping sites and the disposal site.

8.1.3 Environmental Evaluation

The Environmental Impact Assessment Matrix shows that the project will have various positive and negative impacts, however, all negative impacts will be minor except those regarding traffic (occurrence of traffic jam, and increase of traffic accident and exhaust gas) and can be minimised through appropriate mitigation measures such as

[1] Beede, D.N. and Bloom, D.E. 1995, The Economics of Municipal Solid Waste, The World Bank

implementation of traffic lane expansion plans in the congested areas, strengthening traffic regulation, and improvement of collection vehicles. Therefore, the result of EIA showed that all negative impact can be within the tolerance level by taking appropriate measures.

The major benefit of the project will be the provision of a sanitary landfill which will be used as the final disposal site for DSM city from 2000 - 2002 and then for Kinondoni district[2], from 2003 - 2010. There is an urgent need for a new landfill as the remaining capacity of the Vinguguti landfill is 1-2 years, moreover, waste is being disposed of by open dumping at Vinguguti, thus currently creating many environmental problems in the immediate and surrounding areas.

The conceptual design for the landfill is considered to be appropriate. Furthermore, the operational policies and procedures proposed in the conceptual design will minimise the negative environmental impacts associated with the project. The absence of an impermeable bottom liner and consequent infiltration of leachate into the primary groundwater between the site and Indian Ocean is considered to be acceptable as it has been assessed that the leachate will have a minimum impact on potential groundwater resources in the area due to the site's proximity to the ocean. The groundwater is saline, already badly polluted and is not being used for human consumption.

During operation, some temporary negative environmental impacts on site topography and landscape/aesthetics due to landfilling, will be experienced. However, longer term permanent improvements in the topography, landscape/aesthetics, and flora and fauna will provide far greater positive impacts on the site. Similarly, the provision of land for agricultural or recreational activities is another major positive impact and will benefit the residents in surrounding areas.

Negative economic impacts at the site will be minimised by allowing mining companies and small scale miners to continue mining in sections 2 and 3 until 2004 and 2007, by which stage the coralline limestone should be exhausted, while sections 1A and 1B are being constructed and operated. Furthermore, economic activity in the area around the site will be increased during construction and operation, especially the business of food vending.

The policy of prohibiting scavenging at the new disposal site will result in a loss of income and livelihood for scavengers and middlemen currently operating at the Vinguguti disposal site, a decrease in the amount of waste materials recycled, and a major upset to the recycling system in the city. However, the negative impacts will be minor because the number of scavengers impacted will be only less than 100. Furthermore, the SWM Master Plan proposes to promote recycling by segregation at the source in order to mitigate these negative impacts and also to improve the recycling rate.

The transit of refuse collection vehicles will have a low negative impact on traffic volumes and the incidence of accidents along New Bagamoyo Road between Sam Nujoma Road and the disposal site. This negative impact will be mitigated by expanding traffic lanes in the congested areas and strengthening traffic regulation.

[2] The percentage of the DSM population living in Kinondoni district is projected to be 41% in 2003 and to decrease by around 1% per year (Source: The Study on Solid Waste Management in DSM; JICA, 1996).

Although increase in pollution load of SO_2 and NO_x can be expected, it is recommended that refuse collection vehicles should be fitted with appropriate devices for reducing vehicle emissions. Furthermore, monitoring of exhaust gas concentrations should be conducted.

It is recommended that this project should be approved and implemented according to the proposed timetable because the considerable positive impacts far outweigh the negative ones.

8.1.4 Financial Evaluation

a. FIRRs

As a "take-off project" of the Mater Plan, the proposed improvement of urban solid waste collection transport system and the new Kunduchi disposal site establishment plan was evaluated from a financial perspective among priority projects supposed to be implemented between 2000 and 2002. Eighteen cases were studied, as were done in the Master Plan, as a combination of preconditions and cases in the evaluation of the priority project. Results of the FIRR from this study are as follows.

- In the case where a loan covers the whole scheme, FIRRs of all financial cases remain much lower than the opportunity cost of capital (cut-off Rate) of Tanzania. Therefore, it is not financially feasible. It suggests that a higher external financial source such as foreign grant assistance is essential.
- In the case where grant assistance covers investment cost in 1999 for the construction of the final disposal site and landfill equipment, it is judged that all financial cases will be financially infeasible because the FIRRs are below the cut-off rate. It implies that more financial supply, not only for the final disposal site but also for other investment costs with a higher foreign grant equivalent is indispensable.
- When all required investment for 1999 is granted, the RCC is collected by DAWASA with water charge and a most probable tax forecast is used (Case C-1-b) the FIRR is 24.70 %. It concluded that the implementation of projects would be financially feasible because it exceeds the cut off rate of 11.6 %. Refer to Figure 8-1.
- When all required investment for 1999 is granted, special RCC is collected by DCC and the tax forecast taken is most probable (C-2-b), FIRR is 10.24 %. Although this value is slightly lower than the cut off rate of 11.6 %, the project implementation can be made financially feasible by DCC making additional efforts such as collecting more taxes, increase collection rate of special RCC , etc. Refer to Figure 8-2

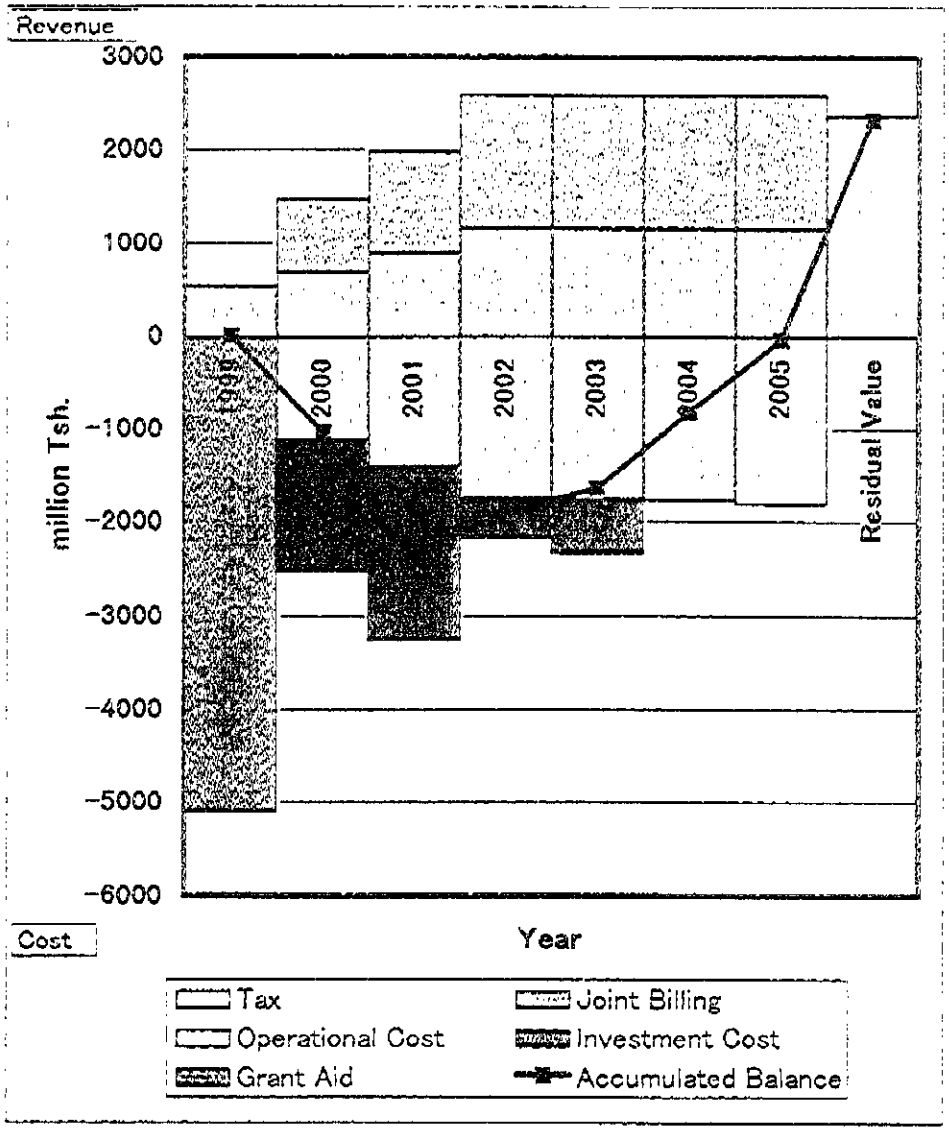


Figure 8-1: Financial Implementation Plan for Case C-1-b

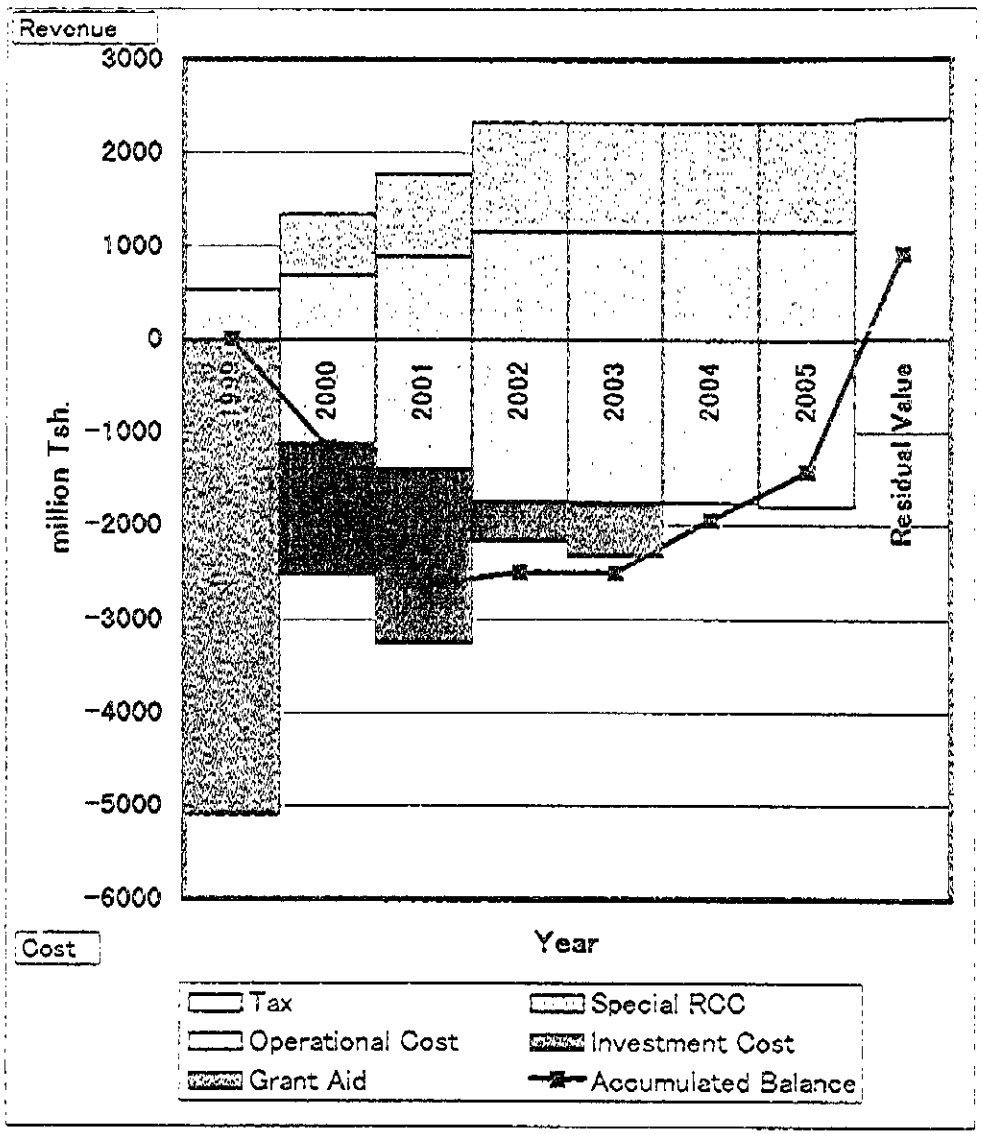


Figure 8-2: Financial Implementation Plan for Case C-2-b

Note: The revenue after the year 2001 was set to be constant because the waste collection amount will be constant
Investments in 2002 and 2003 are required for expansion of the Kunduchi disposal site. Although these works are not included in the first priority projects, they are required to be included in the financial analysis until 2005 because these works will be actually needed to continue the first priority projects.

8.1.5 Economic Evaluation

The economic evaluation has been carried out to determine the economic impact of the priority project to the whole national economy of Tanzania. The economic viability of the project shall be judged by the economic internal rate of return (EIRR). EIRR is a discount rate which makes the net cumulative benefit (the cumulative benefit minus the cumulative cost) zero.

While the financial internal rate of return (FIRR) is based on market prices, EIRR is based on economic prices, which are converted from market prices of the project by various conversion factors which correct the distortions of market prices. Since the various factors distort the price level of the costs and benefits, the financial costs and benefits will be converted as economic costs and benefits using relevant conversion factors. The locally-traded goods and services and unskilled labour force are over valued in the financial cost, various taxes and subsidies, which are mere transfers of income, should be excluded from the financial cost.

Furthermore, it is important to notice here that although FIRRs are calculated for 18 alternative cases including the partial loan scheme, EIRR is calculated only for the all loan scheme (Case A-1-b), since the EIRR represents the optimum allocation of resources which are mobilised by the project regardless of the existence of the grant assistance.

Table C - 20 indicates the calculations of the conversion factors for investment, operation and maintenance, and indirect cost. By using these conversion factors, the financial planning table is shown in Table C - 21 together with the result of the economic internal rate of return (EIRR) shown in Table C - 22. The calculation of the EIRR clearly indicates that the EIRR is well over the cut-off rate at the EIRR of 19.56 %, the priority project will never hamper the optimum allocation of scarce resources in the process of the economic development of Tanzania.

8.1.6 Overall Project Evaluation

The first priority projects, the refuse collection and transportation system improvement project and the development project of the New Kunduchi disposal site, were evaluated in terms of their technical, social, environmental, financial and economic impacts.

The technical evaluation concluded that the simplicity of the proposed technical system is very appropriate for the technical level in DSM. Although problems in vehicle and landfill equipment maintenance are foreseen to arise, they can be overcome by conducting improvements in the proposed maintenance workshop and procurement of a mobile workshop.

The social evaluation concluded that the implementation of the proposed projects, especially the refuse collection and transportation system improvement project, would generate various significantly positive intangible impacts such as improvements in public health and sanitary conditions, prevention of floods, promotion of foreign investment and tourism, increase in land value, etc.

The environmental evaluation concluded that the positive impacts the implementation of the projects, especially the refuse collection and transportation system improvement project, shall outnumber the negative impacts. The EIA of the development project of

the New Kunduchi disposal site concludes that the impacts of the disposal site on the surrounding environment will be permissible with the conditions that various mitigation measures will be done.

As for the financial evaluation, in the case that:

1. the investment costs in 1999 for the final disposal, the procurement of relevant vehicles and workshop is covered by the grant aid,
2. RCC is collected as joint billing by DAWASA, and
3. the amount of special fund to be allocated from city taxes revenue is the most likely case,

the execution of the first priority projects is financially feasible because the FIRR is 24.70 % which exceeds the opportunity cost of capital (cut-off rate, 11.6 %) in Tanzania.

The economic evaluation is done based on the EIRR (economic internal rate of return) which is calculated from total economic cost (which is calculated by economic price obtained by the modification of the distortion of domestic market price.) and total economic benefits. Therefore the evaluation is conducted in case that:

1. all the project cost are covered by loan without any grant component,
2. RCC is collected as joint billing by DAWASA, and
3. the amount of special fund to be allocated from city taxes revenue is the most likely case,

as a result, the EIRR is calculated at 19.56 % which well exceeds the cut off rate of 11.6 %. Therefore the implementation of the master plan will contribute to the national economy.

As an overall conclusion, the execution of the refuse collection and transportation system improvement project and the development project of the New Kunduchi disposal site is feasible because it contributes to:

- preservation of the environment and public health.
- sound development of the city.
- promotion and growth of the Tanzanian economy through gaining foreign investment.

8.2 Improvement Project of the Night Soil Collection and Transport System

Night soil collection and management was not included in the original scope of work. This task was added in response to the request by Tanzanian side during the study. Therefore, only determination of the required number of cesspit empty trucks for DCC to collect night soil and determination of the required charge was covered.

The results indicate that the project would be infeasible if the overall cost is subsidised by a loan, as it would incur a negative FIRR rate. However, the project would be

financially feasible if the 1999 vehicle procurement cost is subsidised by a grant and if a collection fee of 11,000 Tsh/trip is imposed.

If the vehicles to be procured in the first year are covered by a grant, and if a collection fee of 10,500 Tsh/trip is imposed, the FIRR rate shall be equivalent to the cut-off rate of 11.6%. Accordingly, the DSM municipality would be able to shoulder the operation and maintenance costs and the purchase of 3 additional vehicles either for 2000 or 2001, if the grant is used to purchase 15 vehicles in 1999, the collection fee is raised to 10,500 Tsh/trip, and if the present share of the beneficiaries of the collection and haulage services expenses is doubled.

This Improvement Project of the Night Soil Collection and Transport System was prepared in a very short time under limited conditions, and therefore the following issues should be considered before implementation.

- The examination on the disposal capacity of night soil because it has not been investigated in this Study.
- Whether the proposed night soil collection charge is accepted has to be examined because it has not been done in this Study. However, it is expected that the magnitude of willingness to pay for night soil collection charge is larger than that for RCC because night soil is too difficult to be collected and dumped by themselves and the negative impacts created when it is not collected us much larger than refuse.