


No. 1

Study Report  
on  
The Project for the Improvement  
of  
Waste Disposal Equipment  
in  
Addis Ababa  
in  
The Federal Democratic Republic of Ethiopia

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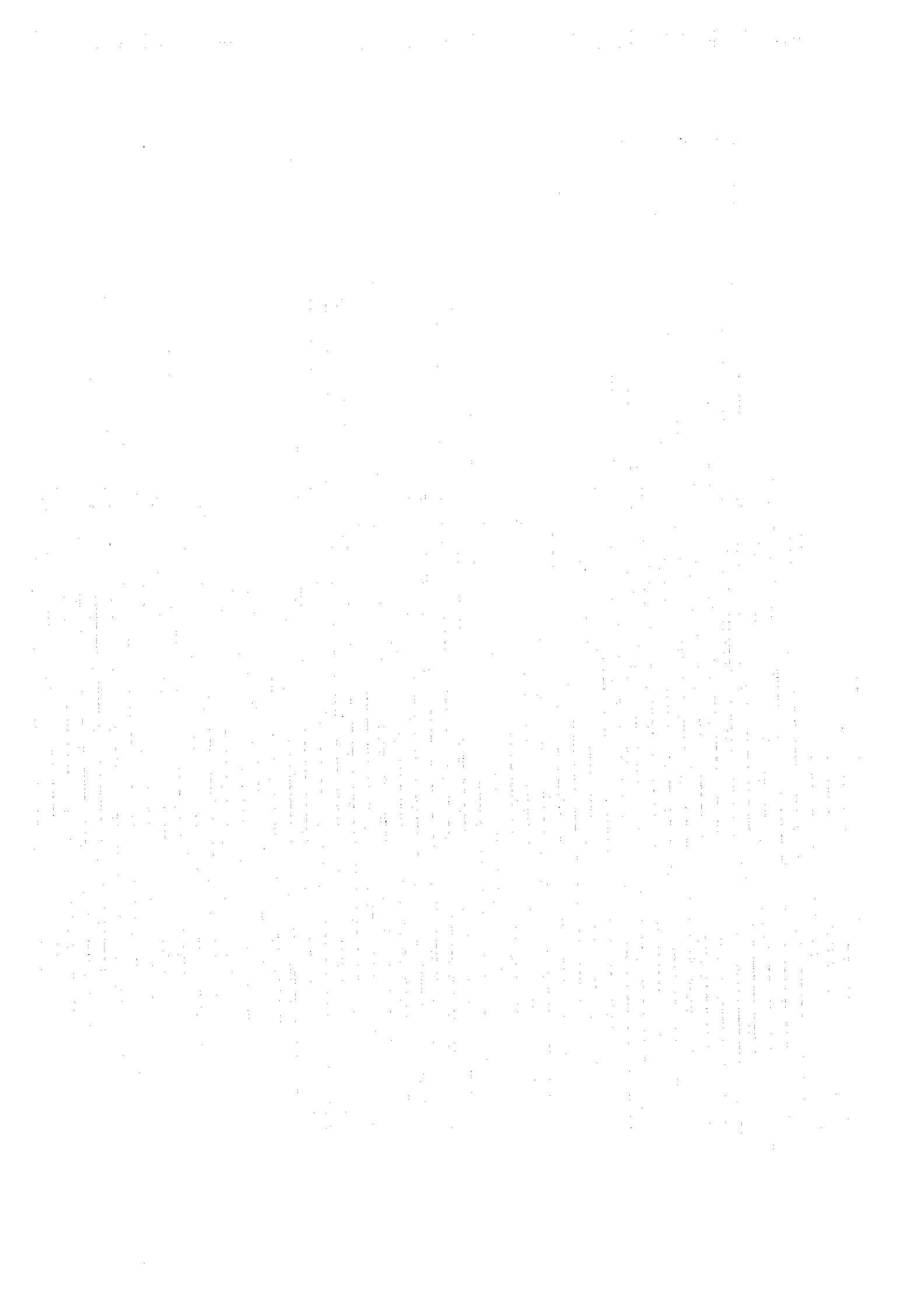
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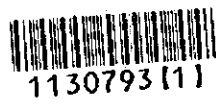
Japan International Cooperation Agency

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## PREFACE

In response to a request from the Government of the Federal Democratic Republic of Ethiopia, the Government of Japan decided to conduct a basic design study on the Project for the Improvement of Waste Disposal Equipment in Addis Ababa and entrusted the Japan International Cooperation Agency ( JICA ) to conduct the study with the assistance of the Japan International Cooperation System ( JICS ).

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

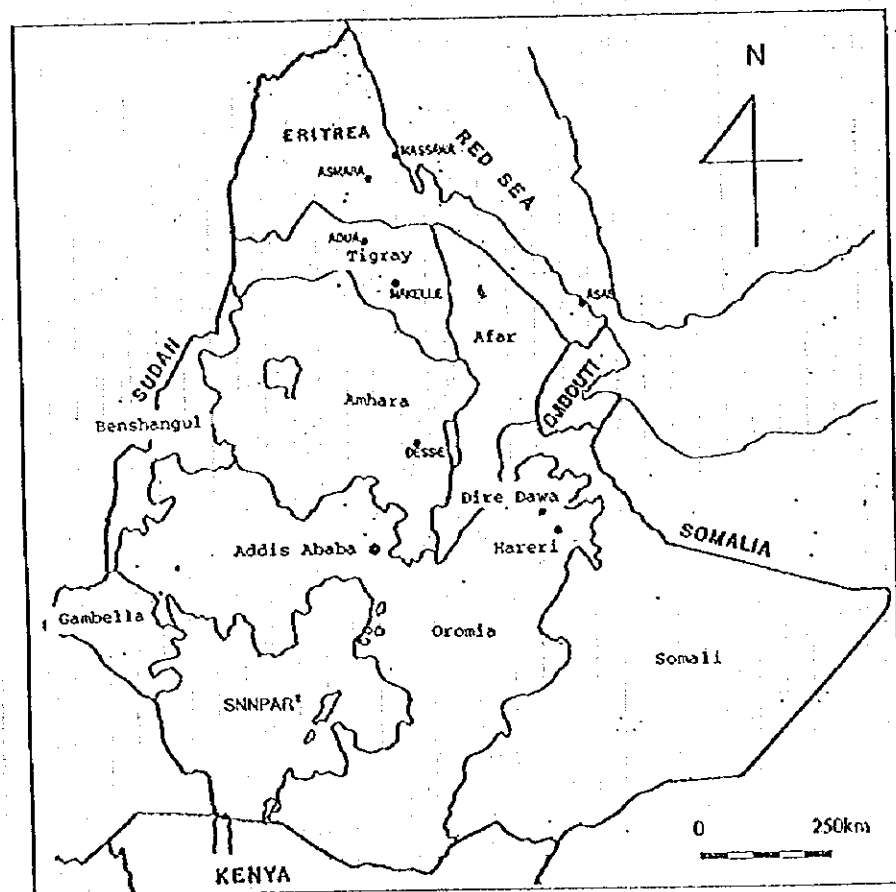
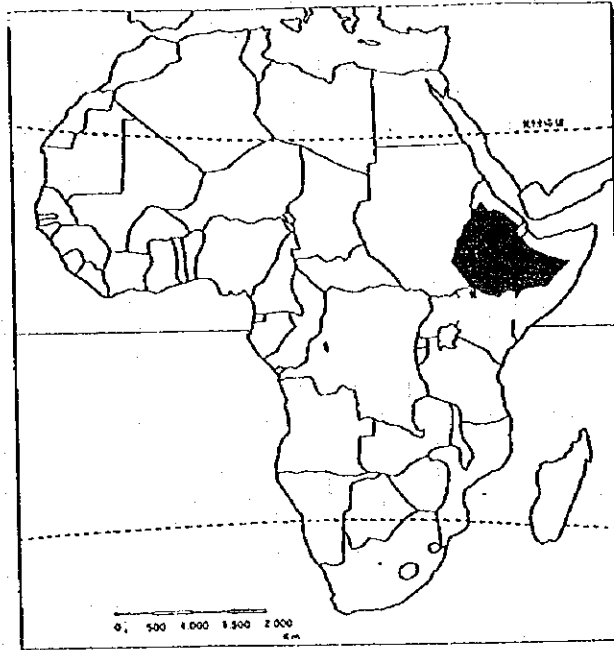
I wish to express my sincere appreciation to the officials concerned of the Government of the Federal Democratic Republic of Ethiopia for their close cooperation extended to the team.

February 1996

Kimio Fujita

President

Japan International Cooperation Agency

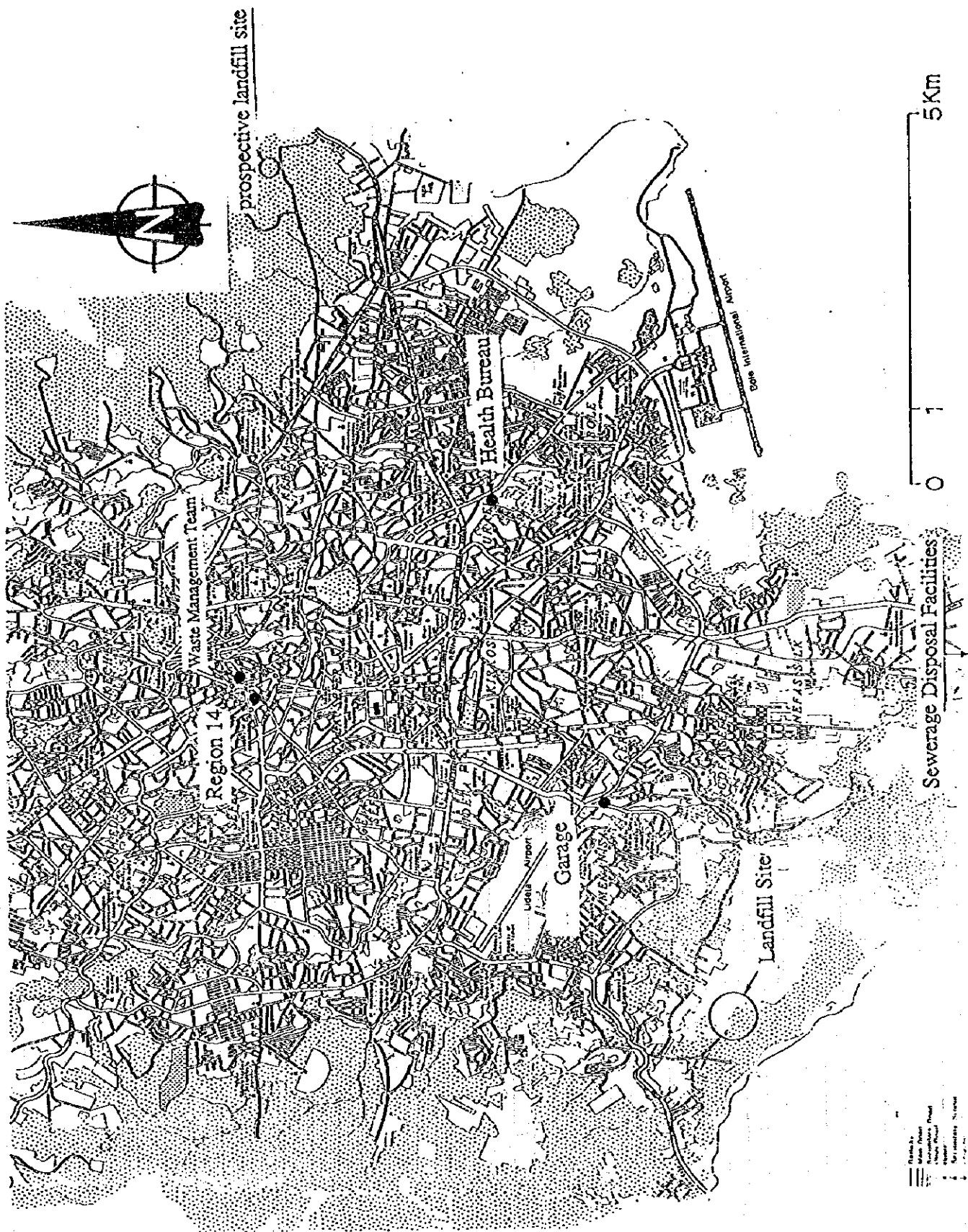


<sup>1</sup> SNNPAR

(Southern Nations and Nationalities, People's Administrative Region)

Location Map





Municipality of Addis Ababa and Location of Related Facilities

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## CHAPTER 1 BACKGROUND OF THE PROJECT

The municipality of Addis Ababa i.e., Region 14, is the capital and the center of social and economic activities of Ethiopia with a population of 2.42 million. It is generating about 1,600 m<sup>3</sup> of solid wastes per day. Its population is increasing at a rate exceeding 4 %, owing to the high birth rate and influx from rural areas. Consequently, the rate of generation of solid waste is forecasted to reach 2,600 m<sup>3</sup> per day in 10 years.

The equipment for collection, transportation and landfill, possessed by the Health Bureau who is in charge of solid waste management, are mostly old and not enough in number. The city is collecting only less than 50 % of generated solid wastes.

About 30 % of household of the city lacks toilet. An estimated 200 tons of human waste is excreted in the open areas, causing health and sanitary problems. Public toilets are playing an important roll, but collection of waste from public toilets is not adequately done due to insufficient number of collection vehicles owned by the Health Bureau, who is in also responsible for management of public toilets.

Under these circumstances the Government of Federal Democratic Republic of Ethiopia requested the Government of Japan to implement its plan for improving the waste collection equipment for Region 14. The plan was made with an objective of improving the urban environment through reinforcing the collection capacity for solid wastes and human wastes. The plan also aims at improving the landfill works at the disposal site.

A preliminary study was conducted during the period of October and November, 1995, in order to clarify the following with regard to this plan; (1) master plan of Region 14, (2) present status of waste management, (3) organization and management capabilities, and (4) demarcation with the World Bank.

## CHAPTER 2 CONTENTS OF THE PROJECT

### 2-1. OBJECTIVES OF THE PROJECT

According to the target set by the Municipality of Addis Ababa, the rate of collection of solid waste will be raised to 70 % and incrementally to 90 %. The target also aims at no more overflowing from public toilets, and extending free human waste collection services to the poor comprising 5 % of the population. The objectives of this project are to achieve the above target through procurement of equipment for collection, transportation, and disposal of solid wastes and human wastes.

### 2-2. BASIC CONCEPT OF THE PROJECT

#### 2-2-1. Preliminary Study to Review the Content of Request

The study team for the preliminary study has conferred with the Ethiopian Side about the contents of the Project. Finally the components classified for priorities were confirmed as shown in Table 2-1. The priority "C", meaning an equipment that can be virtually deleted, was assigned in view of the following.

- (i) At the beginning the Ethiopian Side had an intention of allocating equipment to the newly planned landfill sites. Owing to the inadequacy of the new planned sites and lack of a definite plan, the request was not responded by this project. Thus, bulldozers, backhoes, and weigh bridges were considered to be eliminated from the list.
- (ii) Sanitary landfill is a preferred method. For the following reasons, however, it has been agreed that equipment for sanitary landfill were not introduced;
  - The methods of sanitary landfill has not been presented.
  - Lack of technology.
  - The Ethiopian Side considers that natural burning is also a form of effective landfill use.

Then, backhoes and dump trucks were removed from the list.

- (iii) Considering the demarcation with the World Bank, it has been settled that weigh bridges, i.e., truck scales, and two pickups are to be procured by the World Bank credit.
- (iv) Excess two units of cesspool emptier, i.e., vacuum trucks, were eliminated from the list.

Table 2-1 Requested Items

Item	Spec.	Q'ty/Priority				Remarks
		A	B	C	Total	
Multi Loader	8 m <sup>3</sup> container	10			10	Compatible with the existing containers
Container	8m <sup>3</sup>	100			10	compatible with the existing vehicles
Side Loader	9m <sup>3</sup>	20			20	Equivalent to the existing vehicles
Packer	12m <sup>3</sup>	10			10	Rough road specs. are to be developed. Safety precaution.
Bulldozer		1		1	2	To be used only for the existing landfill site.
Backhoe				2	2	To be used for sanitary landfill.
Dump truck	7 t			6	6	To be used for sanitary landfill
Jet Cleaner	2-3m <sup>3</sup>		1		1	To be used for cleaning public toilet and landfill equipment. To be reviewed after returning to Bank
Weigh Bridge			1	1	2	Installation in included. Redundant with World Bank
Cesspool Emptier	8m <sup>3</sup>	4		2	6	Collection of public toilet
Pickup	Double cab	4		4	8	Patrolling.
Spare Parts		1set			1set	25% is requested.

### 2-2-2 Scope of Cooperation by This Project

This project aims at expanding the solid waste collection capability of the Municipality of Addis Ababa(Region 14) to 70% of an estimated total solid waste generation in the year 1997 when the project is completed by providing necessary collection vehicles.

Cesspool emptiers will be procured to provide complete collection services to all of the 69 public toilets in the city. Cesspool emptiers will also be servicing poor household and communities which can not bear the fee for collection. Directly benefited population of Addis Ababa in 1997 is estimated as 2.65 million.

This project is only dealing with solid wastes generated by private homes and installations, and night soils. Medical wastes and industrial wastes are not considered by this project. Equipment used for sanitary landfill, i.e., earth cover, excavation, and transportation, are not included due to unpreparedness on the side of recipient.

### 2-2-3 Determination of Vehicles

Based on the framework of preliminary study, this study has determined the combination and number of vehicles as follows, perusing the collected data, and taking the project objectives and preparedness of the Ethiopian Side into consideration.

#### (i) Determination of the Target for Solid Waste Collection Capability

The target set by the recipient ranges from 70 to 90% of the total generation of wastes. If a target of 90% collection rate is set, too many number of equipment will overload the maintenance and operation cost. The lower bound of 70% was then set as an appropriate target. The target quantity of collection is 1465.8 m<sup>3</sup> per day at the time of project implementation.

The project assumes that all the vehicles of more than 10 years old are scrapped. The target will be achieved with the remaining vehicles plus the five collection vehicles purchased by the World Bank credit in the next year in addition to the vehicles procured by this project.

#### (ii) Combination of Waste Collection Vehicles

The required number of vehicles was determined by assuming the following conditions;

- The holding capacity of containers and vehicles are equal to the existing ones as request.
- The working hours are the same as the current practice, one shift for 6 days a week.
- The data obtained from the previous analysis were used for determining the rate of operational days and the number of trips made by each type of vehicle. No operational strains are introduced by this assumption of the same ongoing conditions in this study.
- The number of containers is 100 as proposed by the recipient. The number of multi loaders, i.e., container lifters with two arms, for transportation of containers was determined as 10, so as to keep the same vehicle to container ratio of 1 to 18 after implementation of this project.

- The quantity of door to door collection is the balance of the target total collection quantity and the quantity by container collection. Door to door collection will be done by a combination of conventional side loaders and compactor type loaders, i.e., packers. If it is comprised all by side loaders, the number of vehicles will become large due to their small loading capacity, resulting in increasing the maintenance cost. If all are consisted of packers, some difficulties in durability may be encountered in the rough road areas because of their more complex mechanism. An optimum combination of vehicles could be made if as yet to be specified areas of door to door collection are indicated. The ratio between the two types of vehicles is 1 to 1, considering the general road conditions. Assignment of each type of vehicle to each particular collection area will be made after procurement. Consequently the vehicles for door to door collection comprise 16 side loaders and 8 packers. Although the total number of vehicle is six units less than the request, still sufficient collection capacity will be provided.

(iii) Equipment for Landfill

A bulldozer will be procured for spreading and compaction of solid wastes at the landfill site. The number of bulldozer was determined by taking the operational efficiency and the life of the existing ones into consideration. In spite of the request from the Ethiopian Side, the weigh bridges were removed from the list for the following reasons;

- In the drawing of Phase 1 Landfill Development Plan by the World Bank, installation of weigh bridges is indicated. Weigh bridges should be procured by the World Bank credit in order to have consistency of equipment with design and construction.
- The consultant for the World Bank credit is including weigh bridges in his proposal for Phase 2.

(iv) Cesspool Emptier

Six units of cesspool emptier as requested by the Ethiopian Side was reduced to four as a result of discussion with the recipient during the preliminary study. Four units are enough for collection of total amount of human waste of 67,242 liters from the 69 public toilets on the basis of assumed 103,449 users per day in 1997. Three more units are required to extend free of charge collection services to the poor comprising 75,554 people or 5% of private toilet users.

Though exact number and actual conditions are not known, some number of public toilets are inaccessible for collection. Some excess collection capacities are derived from this. These excess capabilities can be directed toward this free services. This reduction of vehicles concurred with the opinion of recipient that more number of units will only increase the load of maintenance.

(v) Other Equipment

- Most public toilets have an unlined pit. Seepage of water into the ground will increase the viscosity of night soil. Unless the storage tanks are cleaned, collection of night soil is difficult.
- The landfill site is extremely dusty. Periodic cleaning of equipment will prolong the life of landfill equipment. These are the reasons for the introduction of a jet cleaner.
- One each pickup will be distributed to each Zone for the needs of patrolling and transportation of personnel, materials and equipment. Six Zones of the city will require six pickups. Two pickups which are to be procured by the World Bank are also counted among the six.

2-2-4 Calculation of Required Number of Equipment

Foregoing target and combination of equipment were calculated as follows.

(1) Solid Waste Collection Equipment

(i) Target Quantity of Solid Waste Collection

Parameters assumed for the calculation are;

Population in 1997:	$2,651 \times 10^3$
Generation rate of domestic waste:	0.17 kg/man/day
Density of waste:	0.31 ton/m <sup>3</sup>
Type of waste:	81% of domestic and 19% of institutions

Amount of solid waste generated in 1997, m<sup>3</sup>

$$\begin{aligned}
 &= (\text{population})(\text{per capita domestic waste generation}) / (\text{Density of waste}) \\
 &= (2,651 \times 10^3)(0.17) / (0.31) \\
 &= 1,453.8 \text{ m}^3/\text{day}
 \end{aligned}$$



Since domestic waste is 81% of the total, the total solid waste which have to be collected by the Health Bureau is;

$$\text{Total solid waste generation} = 1,453.8 / 0.81 = 1,794.8 \text{ m}^3/\text{day}$$

Therefore;

The target amount of collection

$$= (\text{Total solid waste generation})(70\%)$$

$$= (1,794.8)(0.7)$$

$$= 1,256.4 \text{ m}^3/\text{day}$$

Assuming 6 days a week working days;

$$\text{Target collection per working day} = (1,256.4)(7/6) = 1,465.8 \text{ m}^3/\text{day}$$

(iii) Number of Container Collection Vehicles

Parameters for the calculation are;

Number existing containers: 393

Number existing vehicles: 21 units of 1993 model  
(21 units out 28 are used for container collection)

4 units of 1976 model

Operational efficiency of vehicles: 91% for 1993 model  
67% for 1976 model

Operational efficiency of vehicles in 1997: 60% for 1993 model  
80% for the new vehicles procured by this project  
(1976 trucks are scrapped.)

Vehicle efficiencies are assumed as 80% for 0 to 2 years old, 70% for 2 to 4 years old, and 60% for 4 to 6 year old.

The assumption of the same vehicle to container ratio before and after the procurement is expressed as;

$$\frac{(\text{Number of existing container})}{(\text{Number of existing operable vehicles})}$$

$$= \frac{(\text{Number of containers after adding new ones})}{(\text{Number of operable vehicles after adding new ones})}$$

where the number of operable vehicles equals the number vehicles multiplied by the efficiency.

Then;

Number of existing operable vehicles

$$\begin{aligned} &= (\text{Number existing vehicles})(\text{Operational efficiency of vehicles}) \\ &= (21)(0.91) + (4)(0.67) \\ &= 21.79 \end{aligned}$$

Therefore, the number of containers per each existing operable vehicle is;

$$393/21.79 = 18.04$$

Assuming that 10% of the existing containers are scrapped, the total number of containers after adding 100 new ones will be;

$$(393)(0.9) + 100 = 453.7$$

Then;

$$\text{Number of operable vehicles after adding new ones} = 453.7/18.04 = 25.1$$

While on the other hand the number of newly added vehicles, x, will be expressed as;

$$\text{Number of operable vehicles after adding new ones} = (x)(0.8) + (28)(0.6)$$

Solving above two equations for x;

$$x = 10$$

(iii) Number of Door to Door Collection Vehicles

Parameters required for the calculation are;

Container capacity:	8 m <sup>3</sup>
Volumetric efficiency a container:	90 %
Number of trips for container collection:	4.4 times/day/truck
(Calculated from the operation record of October 1995)	
Holding capacity of a side loader:	9 m <sup>3</sup>
Volumetric efficiency of a side loader:	90 %
Number of trips for door to door collection:	2.8 times/day/truck
Holding capacity of a rotary type loader:	12 m <sup>3</sup>
Efficiency of a rotary type loader:	90 %
Number of trips made by a rotary type vehicle:	2.6 times/day/truck
Holding rapacity of a packer:	12 m <sup>3</sup>
Volumetric efficiency of a packer:	150 %
Number of trips made by packer:	2.6 times/day/unit

As a packer compresses the density of waste from 0.31 to 0.5, the volumetric efficiency of 0.9 is replaced with  $(0.5/0.31)(0.9) = 1.5$ .

Ten units of new container collection vehicles will be added by this project. Then;

Number of operable container collection vehicles in 1997

$$\begin{aligned} &= (\text{Number of new vehicles})(\text{Operation efficiency in the first year}) \\ &\quad + (\text{Number of existing vehicles})(\text{Operation efficiency in 1997}) \\ &= (10)(0.8) + (28)(0.6) \\ &= 24.8 \end{aligned}$$

and then;

Total quantity of container collection

$$\begin{aligned} &= (\text{Number of operable container collection vehicles in 1997}) \\ &\quad \times (\text{Container capacity})(\text{Volumetric efficiency}) \\ &\quad \times (\text{Number of trips for container collection}) \\ &= (24.8)(8)(0.9)(4.4) \\ &= 785.7 \text{ m}^3/\text{day} \end{aligned}$$

Therefore;

Target quantity of door to door collection

$$\begin{aligned} &= (\text{Target total collection}) - (\text{Container collection}) \\ &= 1,465.8 - 785.7 \\ &= 680.1 \text{ m}^3/\text{day} \end{aligned}$$

As the World Bank is supplying five(5) units of rotary type vehicles;

Quantity of door to door collection by the World Bank vehicles

$$\begin{aligned} &= (\text{Number of units})(\text{Efficiency of vehicle})(\text{Capacity}) \\ &\quad \times (\text{Volumetric efficiency})(\text{Number of trips}) \\ &= (5)(0.8)(12)(0.9)(2.6) \\ &= 112.3 \text{ m}^3/\text{day} \end{aligned}$$

Therefore;

Target quantity of door to door collection by the this project

$$\begin{aligned} &= (\text{Target quantity of door to door collection}) \\ &\quad - (\text{Quantity of door to door collection by World Bank vehicles}) \\ &= (680.1) - (112.3) \\ &= 567.8 \text{ m}^3/\text{day} \end{aligned}$$

Half of this quantity is collected by side loaders. Then, the number of side loaders is expressed by the equation below;

$$\begin{aligned}
 & 567.8/2 \\
 & = (\text{Number of side loaders})(\text{Operation efficiency})(\text{Capacity}) \\
 & \quad \times (\text{Volumetric efficiency})(\text{Number of trips}) \\
 & = (\text{Number of side loaders})(0.8)((9)(0.9)(2.8)
 \end{aligned}$$

Therefore;

$$\text{Number of side loaders}=16$$

While on the other hand, the number of compactor type vehicle is expressed by the equation below;

$$\begin{aligned}
 & (\text{Number of compactor type vehicle})(\text{Operation efficiency}) \\
 & \quad \times (\text{Capacity})(\text{Volumetric efficiency})(\text{Number of trips})=283.9
 \end{aligned}$$

Therefore;

$$\text{Number of compactor type vehicle}=8$$

## (2) Equipment for Landfill

### Bulldozer

One of the two existing bulldozer is considered to be scrapped, because, made in 1963, its economical life has been long expired. The other bulldozer, procured by the World Bank in 1993, is reportedly operating at an efficiency of 50%. Therefore, supplement by another bulldozer is necessary. In accordance with a general standard shown in Table 2-2, the proper bulldozer for the target waste collection rate of 1465.8 m<sup>3</sup>/day, or 1465.8 $\times$ 0.31=454 t/day, is judged as a 225 HP class.

Table 2-2 Waste Disposal Rate and Proper Bulldozer Size

Waste disposal (ton/day)	0~50	50~150	150~250	250~350	350~500	500~750	750~
Bulldozer	70 HP	80 HP	120 HP	165 HP	225 HP	285 HP	370 HP

## (3) Equipment for Human Waste Collection

### (i) Target Quantity of Human Waste Collection

The parameters required for calculation are listed below;

Number of persons who use the public toilet in 1995	97,550 men/day
Rate of population growth:	4.6%
Total quantity of collection from June 1994 to May 1995	11,192 kl
	70
Number of public toilets:	(one of which is a flush toilet)
Number of toilets serviced for collection:	31
Number of years;	2

Assuming that the number of persons who use the public toilet will increase with the same rate of population growth;

Benefited population

$$=(\text{Number of public toilets less flush toilet})$$

$$\times (1 + \text{Rate of population growth})^n$$

$$=(97,550)(1+0.046)^2$$

$$103,449 \text{ (men/day)}$$

where n is the number of years.

The quantity of human waste generation by this benefited population is expressed by the equation below;

Quantity of human waste generation

$$=(\text{Benefited population})(\text{Unit rate of human waste generation})$$

According to the Health Bureau the unit rate of human waste generation is 0.3 liter/day, while in Japan it is generally assumed as 1.4 liters/day. The difference between the two is too great. It was then determined as follows, based on the actual Health Bureau collection data for a year;

Unit rate of human waste generation

$$=(\text{Average daily quantity of collection})$$

$$/ (\text{Number of persons who use the public toilet})$$

As a total of 11,192 kl was collected in the past one year, the daily collection rate is calculated with a volumetric efficiency of 90%;

$$\text{Average daily quantity of collection} = (11,192 \times 103)(0.9)/365$$

$$=27,597 \text{ liter/day}$$

As 31 out of 69 or 45% of public toilets are serviced for collection;

Number of people who use the public toilets serviced for collection

$$=(94,550)(45/100)$$

$$=42,548 \text{ men}$$

Using the above figures;

Unit rate of human waste generation

$$= 27,597/42,548$$

$$= 0.65 \text{ liter/man/day}$$

Then;

Total daily quantity of human waste generation

$$=(0.65)(103,449)$$

$$=67,242 \text{ liter/day}$$

#### (ii) Required Number of Collection Vehicles

Parameters for calculation;

Tank capacity:  $8\text{m}^3$

Volumetric efficiency 90%

Number of trips 2.9 trips/day/truck

(Based on the operation record during June 1994 and May 1995.)

The required number of vehicles for collecting all of the 69 public toilets is calculated as follows;

Required number of vehicle

$$= (\text{Total daily quantity of human waste generation})$$

$$/ \{ (\text{Operational efficiency}) (\text{Tank capacity})$$

$$\times (\text{Volumetric efficiency}) (\text{Number of trips}) \}$$

$$= 67,242 / \{ (0.8)(8,000)(0.9)(2.9) \}$$

$$= 4.03$$

$$\approx 4 \text{ trucks}$$

The above discussion considers that only those who use the public toilets are the beneficiaries. The Health Bureau is trying to extend its services to the poor who can not afford the collection fee for private or communal toilets. The statistics says that 57% of the city population is using the private or communal toilets, and 5% of which are the poor class. Then the following

number of people have to added as beneficiaries;

$$(2,651 \times 103)(0.57)(0.05)=75,554 \text{ men}$$

With increased number of beneficiaries, the total quantity of night soil will be increased to;

$$(103,449+75,554)(0.65)=116,352 \text{ Liter/day}$$

The required number of vehicles will become;

$$116,352/(0.8 \times 8,000 \times 0.9 \times 2.9)=6.97 \approx 7 \text{ trucks}$$

As mentioned before, the Health Bureau was content with four vehicles, which do not cover the added beneficiaries. At the time of implementation of this project, not all the public toilets are serviceable for collection, though not known for their exact numbers. For the time being the excess collection capabilities for the public toilets will be used for the added beneficiaries.

## 2-3. BASIC DESIGN

### 2-3-1. Design Concept

#### (i) Concept for the Natural Conditions

- As Addis Ababa is situated at an elevation of about 2,400 m, vehicles have to be tuned to this elevation.
- Vehicles have to withstand the rough road. Most door to door collection areas are unpaved. Rocks are exposed and large potholes are found. The road becomes muddy and slippery during rainy seasons. Paved roads are not well maintained. Large potholes are found all over. Careful consideration has to be given to reinforcing the suspension and chassis, minimum ground height, and protection of overhangs.

#### (ii) Concept for the Special Necessities

- Observe the vehicle standards of the Road Transport Authority. The standards are now being revised, and may be ready at the time of detail design.
- Watch for the difference of waste density and characteristics. The density of solid waste is greater than those of advanced countries. The viscosity of night soil is higher owing to loss of water by seepage and evaporation.
- Pay attention to the safety of loading operation of the waste. Solid wastes are loaded manually by the resident themselves.
- Consider the inaccessibility of certain public toilets due to narrow roads. Vehicles have to be

equipped with distant collection from secluded toilets.

- Paint the vehicles in the standard color of orange

(iii) Concept for the Local Agent, Equipment and Material

- The local fabricator of containers can not be used, because their production capacity is too low.
- Most large trucks owned by the Health Bureau are supplied by the third countries. The setup for maintenance services provided by the local agents for those vehicles are better than Japanese manufactures. There won't be any concern for maintenance, should third country vehicles are purchased. The mechanism of a packer and a jet cleaner is complex. It is safer to choose Japanese products, unless sufficient information about third country products is obtained in the detail design.
- The local agents for the Japanese bulldozers are superior. Little merit is found in choosing third country products.
- Japanese pickups with superior quality are dominating the local market. There is no need for the third country products.

(iv) Concept for the Maintenance Capability of the Counterpart.

- The maintenance capability of the Equipment Service of Region 14 is satisfactory. This installation can manage maintenance of the vehicles which are to be introduced by this project. Considering, however, introduction of new type vehicles and the strong request from the Equipment Service, it is necessary to provide sufficient training at the time of delivery.
- The budget for maintenance is not necessarily abundant. Seeing that 10 or 20 year old vehicles were steadily maintained, they seem to satisfy the minimum requirements. Supply of excessive amount of spare parts would rather spoil their self help efforts and should be avoided.

(v) Concept for Determining the Type and Specifications of Vehicles

- The basic specifications adhere to those of the existing vehicles with regard to the multi loaders, side loaders and cesspool emptiers. Especially the interchangeability of containers is conditional. The rotary type loaders are replaced with the packers which are mechanically superior and produced by many more manufacturers.
- Existing bulldozers are not equipped with waste disposal options. So that troubles with dust



- Existing bulldozers are not equipped with waste disposal options. So that troubles with dust and others are frequent. The bulldozer has to be provided with appropriate waste disposal options.

(vi) Concept for the Schedule

- This is a single fiscal year project. Attentions have to be paid to timely execution of procurement, particularly for the complex vehicles which require seven to eight months for outfitting. Guidance about strict observance of on schedule delivery is mandatory to the third country manufacturers, who do not have the experience of grant aid by the Government of Japan. Unloading and customs clearance at the port of Assab in Eritria have to be well prepared so as not to invite any interferences.

(vii) Specifications for the Vehicles and Equipment

Concept for determining the vehicle and equipment specifications is given in Table 2-3.

Table 2-3 Concept for Determining the Equipment Specifications

No.	Equipment	Guideline
1	Bulldozer	225HP class is appropriate for disposing 450 V/day waste. Waste disposal option. Protection against dust and shock.
2	Multi Loader	Compatible with the existing containers.
3	Container	Compatible with the existing multi loaders.
4	Side Loader	9 m <sup>3</sup> trapezoidal bin similar the existing vehicle. Hopper height should be lower than 1.6 m for easy manual loading. Steps have to be provided.
5	Compaction Type Vehicle	Rear loading with internal compaction. Rear unloading by ejection. Special consideration to rough road to protect the complex hydraulic system. Safety shutdown device for the hopper to prevent from getting caught. Review the holding capacity of 12 m <sup>3</sup> , similar to the existing rotary type, if it is not too large at the time of detail design.
6	Jet Cleaner	Hose length should reach the toilet located back of the street. Nozzle type to suit the purpose. Used also for cleaning the equipment.
7	Cesspool Emptier	The water content of the waste is less than the advanced countries. Larger hose diameter of 4". The rear gate of tank is full cross section. Hose length should reach the toilet located back of the street.
8	Pickup	Most common type locally

2-3-2 Basic Design

(1) Overall Plan

Vehicles for solid waste collection, multi loaders, side loaders and compactor type loaders, and

cesspool emptiers will be parked in the prospective central depot which is going to be prepared by the Health Bureau. These will be used for collection and transport of solid waste and night soil in the Region 14. Containers will be placed along road side according to the plan made by the Region 14. The bulldozer will be used in the existing landfill site for spreading and compaction of the disposed wastes. Pickups will be distributed to the four Zonal Health Departments, primarily to be used for monitoring the collection activities, patrolling the streets for instructing the residents, and transportation of personnel and maintenance equipment.

## (2) Equipment Design

Principal specifications and uses of equipment are shown in Table 2-4.

Table 2-4 Specifications and Uses of Equipment

No.	Equipment	Specification	Q'ty	Users
1	Bulldozer	225HP class with ripper. Mfr's standard option for waste disposal.	1	Leveling and compaction of solid waste.
2	Multi Loader	8m <sup>3</sup> containers. Double arms.	10	Transportation of a large container.
3	Container	About 8m <sup>3</sup> .	100	Collection of solid waste.
4	Side Loader	About 9m <sup>3</sup> . Trapezoidal bin.	16	Collection and transportation of solid waste.
5	Compaction Type Vehicle	About 8m <sup>3</sup> . Compaction type.	8	Collection and transportation of solid waste.
6	Jet Cleaner	About 5,000-6,000 liter.	1	Cleaning of cesspool and equipment.
7	Cesspool Emptier	About 8,000 liter.	4	Collection and transportation of human waste.
8	Pickup	0.5t payload. 2WD double cab.	4	Patrol and transportation of material.

Compactor type loaders and a jet cleaner with complex mechanism and pickups should not be subjected to procurement from the third country manufacturers. The fleet of Health Bureau consists of German and Swedish vehicles. Both have a fully equipped workshop locally. The Health Bureau rates the German higher than the Swede. Though Italian vehicles are not included in the fleet, their workshop is as good as the former. Only German among three submitted both vehicle specifications and price proposals. Therefore, only German is chosen for solicitation of procurement.

Table 2-5 List of Equipment for the Third Country Procurement

Equipment	Country (Excluding Japan)	Reasoning
Multi Loader	Germany	Record of delivery and experience in maintenance.
Container	Germany	Record of delivery. Better marine transport.
Side Loader	Germany	Record of delivery and experience in maintenance.
Cesspool Emptyer	Germany	Record of delivery and experience in maintenance.

## CHAPTER 3 IMPLEMENTATION PLAN

### 3-1. IMPLEMENTATION PLAN

3-1-1 The implementation schedule is shown in Table 3-1.

Table 3-1. Implementation Schedule

	1	2	3	4	5	6	7	8	9	10	11	12
Detail Engineering (Apper.4 months)	Site survey											
			Contract									
				Evaluation/Contract								
Procurement (Apper. 8 months)	Fabrication/Procurement											
						Mill inspection						
							Transportation					

Domestic
  Site

#### 3-1-2 Obligations of Recipient Country

##### (1) General Obligations Related to Implementation of Grant Aid

- (i) Prompt execution of unloading at the port and customs clearance.
- (ii) Exemption of custom duties and domestic taxes on the equipment procured and on the activities performed for the procurement.
- (iii) Providing necessary conveniences for disembarkation and stay of Japanese nationals who engage this procurement.
- (iv) Bearing of all the necessary fees which are not covered by the Grant Aid.
- (v) Assignment of a counterpart.
- (vi) Proper maintenance and operation of procured equipment.
- (vii) Conclusion of bank agreement.

##### (2) Specific Obligations Related to Implementation of the Plan

- (i) Budgeting for the cost of maintenance and operation and employment of personnel.
- (ii) Adequate management of the existing landfill site and completion of unfinished civil works, including garage, fence and others.
- (iii) Proper response to the health and environmental issues caused the increase in the quantity of human wastes which have to be disposed.

(iv) Completion of central depot.

### 3-2. OPERATION AND MAINTENANCE PLAN

Costs of maintenance and operation of equipment for waste disposal after 1997, which require budgeting, are shown below. Major cost items include fuels, maintenance services including spare parts and consumables, and labor. Calculation of costs of fuels and maintenance services are based on the Health Bureau data of nine months in 1994 as given below.

Total truck days:	6,662 truck · days
Total fuel consumption	230,089 liters
Total oil consumption	5,507 liters
Maintenance service	525,939 Birr (1 Birr = 0.16 US\$)

#### (1) Fuel and Oil Costs

Annual fuel cost is expressed as;

$$\begin{aligned} & \text{(Fuel consumption rate, liter/truck · day)} \\ & \times \text{(Number of operating trucks)(Annual operating days)} \\ & \times \text{(Unit price of fuel, birr/liter)} \end{aligned}$$

From the data above, the Diesel fuel consumption rate per truck · day is calculated as 34.5 liters. Similarly 0.8 liter per truck · day is calculated for oil. These values are applied to the vehicles of this plan including a jet cleaner, because their sizes are comparable to the existing ones. Assuming that a pickup is driven 50 km a day with a gas mileage of 8 km/liter, the fuel consumption rate is calculated as 6.3 liter/truck · day. Referring to Table 3-3, 52 large trucks and 4.8 pickups are operating. The annual operating days on a 6 days a week basis is  $365 \times 6/7 = 313$  days.

Table 3-3 Operating Vehicles in 1977

Category		Number	Operating Efficiency	Number of Operating Vehicle
Large Trucks	93 World Bank	28	0.6	16.8
	96 World Bank	5	0.8	4.0
	This Plan	39	0.8	31.2
Pickups	96 World Bank	2	0.8	1.6
	This Plan	4	0.8	3.2

In the absence of field data, it is assumed that each of the existing 320 HP bulldozer and the new 230

HP bulldozer of this plan are operated 1,000 hours per year. The standard fuel consumption rate of a bulldozer is 0.133 liter/hour/HP. Then the total fuel consumption rate of bulldozers is

$$(320+230)/2 \times 0.133 = 36.6 \text{ liter/hour.}$$

The estimated total annual fuel consumption is calculated as shown in Table 3-4.

Table 3-4 Rough Estimate of Annual Rate of Fuel Consumption

Vehicles	Fuel consumption rate	Number of operating vehicles	Number of Operating days	Unit cost of fuel	Sum	Total
Large Trucks	34.5 l/day	52.0	313 day	1.5 Birr/l	842,283 Birr	911,380 Birr
Pickups	6 l/day	4.8	313 day	1.5 Birr/l	14,198 Birr	
Bulldozer	36.6 l/day	1.0	1,000 hr.	1.5 Birr/l	54,900 Birr	

Only oil is calculated for the lubricant cost. The cost of oil for large trucks is calculated on the basis of 0.8 liter/truck · day at a unit price of 12.9 Birr/liter.

$$(0.8)(52)(313)(12.9) = 167,968 \text{ Birr}$$

The cost of oil for pickups and bulldozers is calculated on the basis of standard oil change requirements as shown in Table 3-5.

Table 3-5 Cost of Oil for Pickups and Bulldozers

Vehicle	Annual Total distance or operating hours	Oil change frequency	Number of oil change	Oil tank capacity	Total oil consumption	Unit price of oil	Amount
Pickups	(4.8 units) (50km) × (313 days) = 75,120 km	Every 5,000 km	15.0 times	5 liters	75 liters	12.9 Birr	968 Birr
Bulldozer	1,000 hr.	Every 200 hr.	5.0 times	20 liters	10 liters	12.9 Birr	1,290 Birr

Thus the cost of oil is 170,226 Birr, making a total of 1,081,606 Birr for fuel and oil. This corresponds to 1.7 times the 1994 data.

## (2) Maintenance Service

The cost of maintenance consists mainly of spare parts, tires, other consumables, and the labor. From the previous data, the cost of maintenance is 78.95 Birr/truck · day. It is assumed that this cost is similarly applied to the new trucks procured by this project, then, maintenance of large trucks requires;

$(78.95)(52)(313)=1,284,990$  Birr.

Generally the cost of maintenance is proportional to the price of vehicle itself. Then the maintenance cost of a pickup and a bulldozer is assumed to be one fifth and four times the large truck cost, accounting for a total of 23,723 Birr and 98,845 Birr, respectively. All of these make a total of 1,407,558 Birr, which corresponds to 2.2 times the 1994 data of 637,214 Birr. During the first few years the actual maintenance cost would be less, owing to the spare parts procured through this project.

### (3) Labor Cost

Drivers and assistants have to be employed. One each driver for each vehicle including pickups has to be provided, making a total of 57 drivers. One each assistant for each multi loader, cesspool emptier and jet cleaner, and two each assistant for each side loader and compactor type loader will have to be provided, making a total of 76 assistants. Considering the absenteeism of 15 % in 1994, at least 67 drivers and 89 assistant, a total of 156 personnel, have to be employed. This number is below the number of 237 personnel planned to be employed by the Health Bureau. No new additional operators are required for the bulldozers.

Based on the average monthly salary of 328 Birr inclusive of various compensations and insurance, the annual cost of labor is calculated as;

$(328)(156)(12)=614,016$  Birr

The present number of drivers and assistant is 138 men. The difference of 18 men is 70,848 Birr.

The differences of cost between the foregoing expenses and the 1994 data are, 441,021 Birr for the fuel, 770,344 Birr for the maintenance, 70,848 Birr for the labor, and 1,282,213 Birr as a total. Assuming that other expenses remain the same, the total required budget of Health Bureau is 8,231,461 Birr, which is lower than the estimated lower bound of budget in 1995.

### (4) Organization for Maintenance

Maintenance of the vehicles owned by the Health Bureau is done at the Equipment Service of Region 14. At present the Equipment Service has about 60 mechanics, seven of which are qualified for the highest rank of senior mechanic. Deterioration of the facilities can not be denied, but the skill of

maintenance is satisfactory. Spare parts for the repair have to be supplied by the Health Bureau, and nominal amount of fee is charged to the Health Bureau.

Some of the workshops run by agents of major manufacturers are better equipped and manned than the Equipment Service of Region 14. Generally, the stockpile of spare parts is not so large. However, it is possible to receive the overseas supply in less than three months. Unless too minor manufactures are chosen, maintenance can be done without much trouble. The outfit manufactures do not have local agents. The agents for the vehicles are to be responsible for repairing the outfit, whereby some troubles may arise. This has to be reaffirmed during detail design and before concluding a contract.



## CHAPTER 4 PROJECT EVALUATION AND RECOMMENDATION

### 4-1. Project Effect

#### (1) Increased Capacity of Solid Waste Collection

Waste collection capacity of each vehicle is expressed by;

$$\begin{aligned} & (\text{Number of vehicles})(\text{Operational efficiency}) \\ & \times (\text{Loading capacity})(\text{Volumetric efficiency})(\text{Number of trips}) \end{aligned}$$

The waste collection capacities at the time of project implementation are summarized in Table 4-1. The values of operational efficiencies, volumetric efficiencies, daily number of trips given in Section 2-2 are used.

Table 4-1 Collection Capacity of Each Type of Vehicle

Vehicle	World Bank Phase 1 & 2		This Plan		Total number of oper. vehicles	Loading capacity (m <sup>3</sup> )	Vol. efficiency	Number of trips per day	Collect. capacity (m <sup>3</sup> /day)
	Number of vehicles	Number of oper. vehicles	Number of vehicles	Number of oper. vehicles					
Multi loader	28	16.8	10	8	24.8	8	0.9	4.4	785.7
Side loader	0	0	16	12.8	12.8	9	0.9	2.8	290.3
Rotary loader	5	4	0	0	4.0	12	0.9	2.6	112.3
Packer	0	0	8	6.4	6.4	12	1.5	2.6	299.5
Total	33	20.8	34	27.2	48.0	-	-	-	1,487.80

As six days a week operation has been assumed, the average collection rate is;  
 $(1,487.8)(6/7)=1,275.3 \text{ m}^3/\text{day}$ .

The daily rate of solid waste generation in Addis Ababa in 1997 is assumed as 1,794.8 m<sup>3</sup>. Implementation of this project enables collection of 71 % of solid wastes. If it is operated on a seven days a week basis, the percentage of collection would be raised to 83 %.

While at present, the rate of solid waste collection is 753.3 m<sup>3</sup>/day or only 46 % of the total of 1,639.1 m<sup>3</sup>/day in 1995. Without implementation of this project, the rate of collection would drop to 602.6 m<sup>3</sup>/day due to loss of efficiency of the vehicles. Adding the collection capacity of rotary type loaders supplied by the World Bank,  $(112.3\text{m}^3)(6/7)=96.3 \text{ m}^3/\text{day}$ , the rate of collection becomes 745.4 m<sup>3</sup>/day, which is still at the low level of 39.8 %.

## (2) Enlarged Collection Areas and Increased Frequency of Collection

Addis Ababa is divided into 6 Zones, 28 Waredas, and 328 Kebeles. Each Kebele has a population ranging from 5,000 to 10,000. Current data of collection frequency indicate that 120 or 37 % of Kebeles are not subject to collection by containers. 112 or 34 % of Kebeles are serviced for container collection for less than once a week. Even more number of Kebeles are not serviced by door to door collection. No door to door collection is done in 207 or 63 % of Kebeles. The door to door collection is done for less than once a week in 99 or 30 % of Kebeles. Implementation of this project will not only improve such situations but also eliminate littering of wastes or foul odors arising from infrequent collection of less than once a week.

## (3) Improvement in Night Soil Collection

All of the existing cesspool emptiers are not expected to be used for a long time. Assuming that only four cesspool empties supplied by this project are available, their collection capacity is calculated as follows like in the case of solid waste collection by using the same parameters;

$$(4)(0.8)(8,000)(0.9)(2.9) = 66,816 \text{ (liter/day)}$$

Currently the vehicles are operated on a seven days a week basis, so that this rate is the daily collection rate as it is. The average daily collection rate for the past one year from June 1994 to May 1995 is 25,597 liters. Therefore the collection capacity will be improved to 2.4 times the current capacity by implementation of this project.

In 1997, the number of beneficiaries will be 179,003 men/women, combining the number of daily users of public toilets, 103,449, and the number of people covered by free collection service, 75,554. As discussed in Chapter 2, the number of vehicles was limited to four, implementation of this project will achieve 57 % collection rate of daily generation of 116,352 liters. If the vehicles are concentrated on public toilets only, 99 % collection rate is achieved.

At present, the rate of collection is as low as 45 % of the daily generation of 61,458 liters, based on 94,550 public toilet users with a unit rate of 0.65 liter/day/man.

Some of the inaccessible toilets are discharging the effluent to the river. Introduction of cesspool emptiers, however, does not necessarily mean that all public toilets are serviced for collection. Therefore it is possible to divert the excess capabilities to the free collection of the poor. If it is assumed that only those public toilets which are now serviced for collection are to be serviced by the new vehicles. The excess capacity is calculated as 36,557 liters, considering the quantity of collection,  $(67,242)(45 \%)=30,259$  liters. This will cover 74 % of the generation by the affected

poor or  $(75,554)(0.65)=49,110$  liters.

(4) Others

Extensive improvement of urban health and environmental conditions is expected as a direct effect of factors stated in (1) through (3). In addition to improvement of street scenes and benefiting the residents due to expansion of waste collection services, contribution toward suppressing the infectious diseases, regarded highly by the Health Bureau, International Organs and NGO, is a remarkable effect of this project.

4-1-2 Adequacy of Execution of Grant Aid

The adequacy of execution of this grant aid by the Government of Japan was proved as shown in Table 4-2.

Table 4-2 Proof of Adequacy of Execution of Grant Aid

	Items to be Proved	Proof of the Item
1	The plan is aimed at the general public including the poor, and a great number of people are affected	2.4 million residents of Addis Ababa are affected, 65 % of which are the poor. Particularly, the poor are affected the night soil collection.
2	The objectives of plan should meet the requirements of BHN, education and human resource programs. Or the plan has to meet the urgent requirement of stabilization of civil administration and improvement of citizen life.	Improvement of health and environmental conditions is the basic requirement of BHN. Replacement of deteriorated old existing vehicles is urgently required..
3	As a principle maintenance and management of the plan should be sustainable by its own money, human resources, and technology of the recipient.	Cost bearing by the Ethiopian Side is confirmed by a document. Estimated cost is within the budget shown by the recipient. Vehicles are manageable because the types are in common with the existing ones.
4	The plan should contribute to achieve objectives of the middle and long term development plan of the recipient.	Status of the plan in the national middle and long term plans is not clear. But the Master Plan of the City gives high priority to this plan.
5	As a principle the plan should not be profit oriented. The plan for a profit oriented project should limit its objective to testing, modeling, or financing of maintenance and replacement.	Almost all of the management expenses are paid by the tax money. Only a limited number of businesses are responding to fee collection. No fee collection is planned after implementation of this plan.
6	No ill effect to the environment. Take necessary measures to remove ill effect to the environment.	Some possible effects to the environment are seen. Improvement of the urban health and environment, will offset this effect. Improvement of disposal methods may be needed in the future.
7	The standard procedures for the grant aid by the Government of Japan is workable for execution of the plan.	It is possible. Considering the type of equipment that require longer delivery period, the key is smooth management toward conclusion of contract with suppliers. Due to recent government reorganization, some difficulties are expected in administrative procedures and execution of obligation by the Ethiopian Side.

## 4-2 Recommendations

### (1) Technical Cooperation

The head of the Health and Environment Department, the virtual counterpart of this project, and persons in charge of waste management are well qualified for implementation of this plan. If proper training or education by a specialist is provided even more effective use of equipment could be expected.

### (2) Improvement of Door to Door Collection Method

Currently, arrival of the door to door collection vehicle is known by blowing the horn. Then every resident rushes to the vehicle with a basket full or bag full of solid waste. This may be good for the resident living along the collection route, but not so for the people back in the alley. It is inefficient when people have to be standing by for the arrival of vehicle. Improvement of this situation has to be tried by initiation of scheduled collection or placing accumulation points in the block.

### (3) Plan for Augmentation of Door to Door Collection

This plan will reinforce the door to door collection vehicles. No definite plan is made yet about collection route and areas as well as distribution of three types of vehicles, i.e., side loaders, compactor type loaders and rotary type loaders supplied by the World Bank. It is desirable to develop a plan that takes characteristics of each type of vehicles and peculiarities of each collection area.

### (4) Collection Plan for Densely Populated Areas

Due to illegal dumping of wastes, the health conditions are not good in the areas where the vehicles are made inaccessible by narrow streets. In such areas a carefully thought out plan for waste collection system has to be developed based on participation of residents.

Steady efforts including sanitary education of the people have to be continued.

### (5) Development of New Landfill Sites and Sanitary Landfill

Equipment to be used for the prospective landfill site have been removed from the request, as a result of preliminary study that it is not quite ready yet for the development of new landfill sites and application of sanitary landfill. At present the city has only one landfill site that forces a long trip for collection in the far side of the city. It is ideal to develop multiple number of landfill sites in the future in order to use collection vehicles more effectively and to increase the collection capabilities. Sanitary landfill is a desirable method, and then efforts should be made for its early application.

**(6) Completion of Waste Disposal Facilities and Garage under the World Bank Credit**

As mentioned before, the suspended works at the existing disposal site have to be resumed as soon as possible. Completion of garage before the implementation of this project is desirable.

**(7) Disposal of Night Soil**

The Addis Ababa Water and Sewerage Authority(AAWASA) of Region 14 is the competent authority for the disposal of night soil. At present the collected night soil is discharged without treatment. It is desirable to develop a facility in the early stage in order to store, decompose and dry the collected night soil.

**(8) Improvement of Public Toilets**

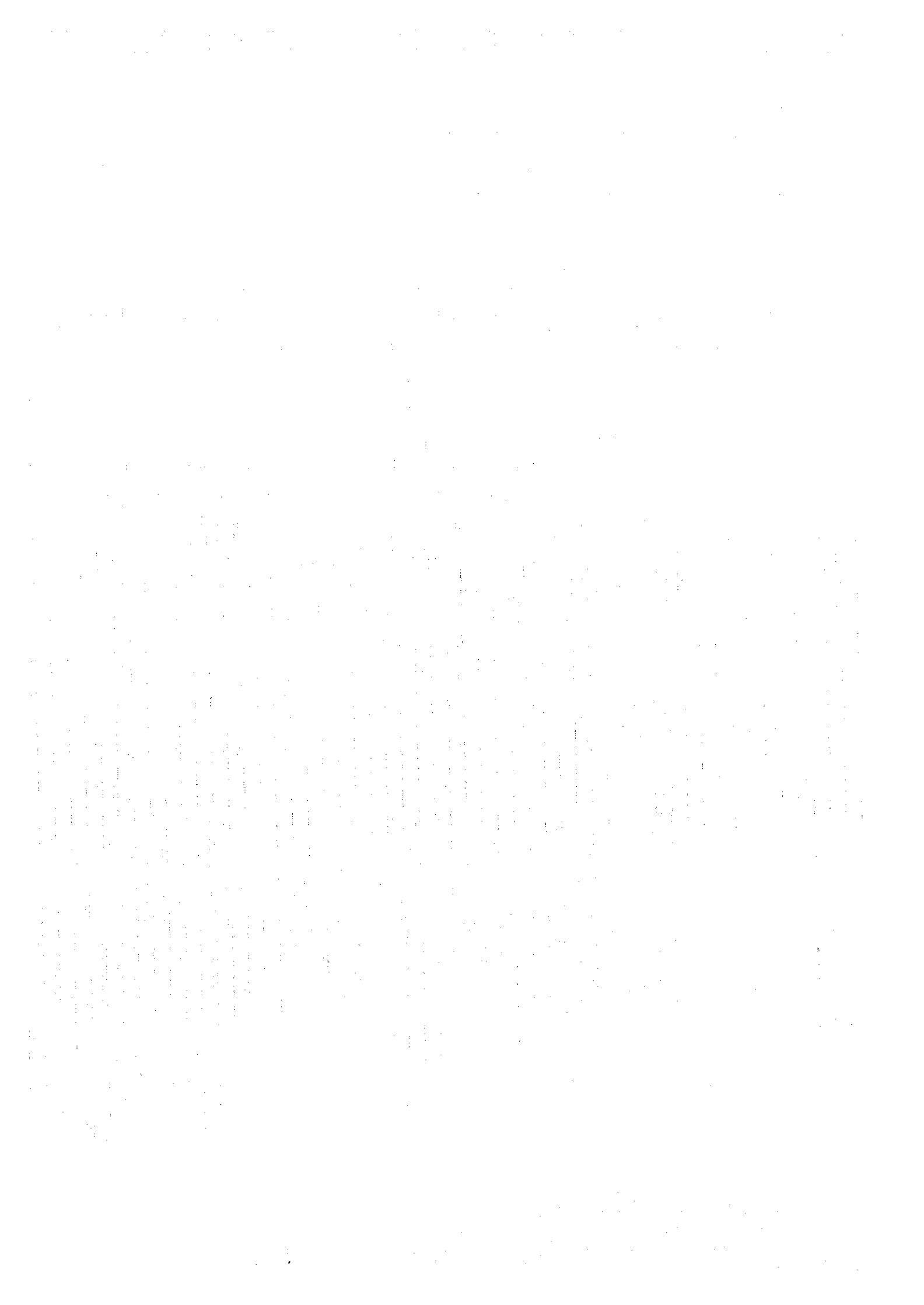
Some of the public toilets are directly discharging their effluent to the streams. Some of the damaged pits are not repaired. These public toilets have to be improved in order to achieve 100 % collection rate.

**(9) Organizational Buildup**

Sudden increase in the number of fleet by this plan will substantially raise the burden of maintenance. Especially from the period of three to five years after implementation of this project, mechanical troubles are expected to become frequent. Then the management capability buildup is compelling in order to ensure budgeting for the maintenance cost and to improve the work efficiencies lest the collection capability should decline.

**(10) Fee Collection and Privatization**

Presently waste collection fee is not collected except for some business enterprises. Under the forecasted increase in the financial burden, studies have to be made for increasing the income, as for instance by collection of fee from businesses and residents in the wealthy districts.











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