

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

**NAIROBI CITY COUNCIL
MINISTRY OF LOCAL AUTHORITIES
THE REPUBLIC OF KENYA**

**THE STUDY ON
SOLID WASTE MANAGEMENT
IN NAIROBI CITY
IN THE REPUBLIC OF KENYA**

FINAL REPORT

VOLUME 2

**MAIN REPORT
(MASTER PLAN STUDY)**

AUGUST 1998

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ENVIRONMENTAL TECHNOLOGY CONSULTANTS CO., LTD.**

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All the Kenyan shilling amounts including the project costs shown in this report are indicated in 1997 price unless otherwise indicated. Those amount are estimated partly based on the foreign prices by applying mean 1997 currency exchange rates; namely, US\$1 = Kshs. 58.8 = 121.76 Japanese Yen.

PREFACE

In response to a request from the Government of the Republic of Kenya, the Government of Japan decided to conduct a development "Study on Solid Waste Management in Nairobi City in the Republic of Kenya" and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Kenya a study team headed by Mr. Takao Yoshida, CTI Engineering Co., Ltd., and composed of staff members of Environmental Technology Consultants Co., Ltd., between March 1997 and August 1998.

The team held discussions with officials concerned of the Government of Kenya, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

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 Republic of Kenya for their close cooperation extended to the team.

August 1998



Kimio Fujita
President

Japan International Cooperation Agency

August 1998

Mr. Kimio Fujita
President
Japan International Cooperation Agency
Tokyo, Japan

LETTER OF TRANSMITTAL

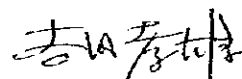
Dear Sir,

We are pleased to submit herewith the Final Report on the Study on Solid Waste Management in Nairobi City in the Republic of Kenya. The report contains the advice and suggestions of the authorities concerned of the Government of Japan and the Japan International Cooperation Agency (JICA), as well as the formulation of the above mentioned project. Also included are comments made by the authorities concerned of the Government of the Republic of Kenya during the technical discussions on the Draft Final Report.

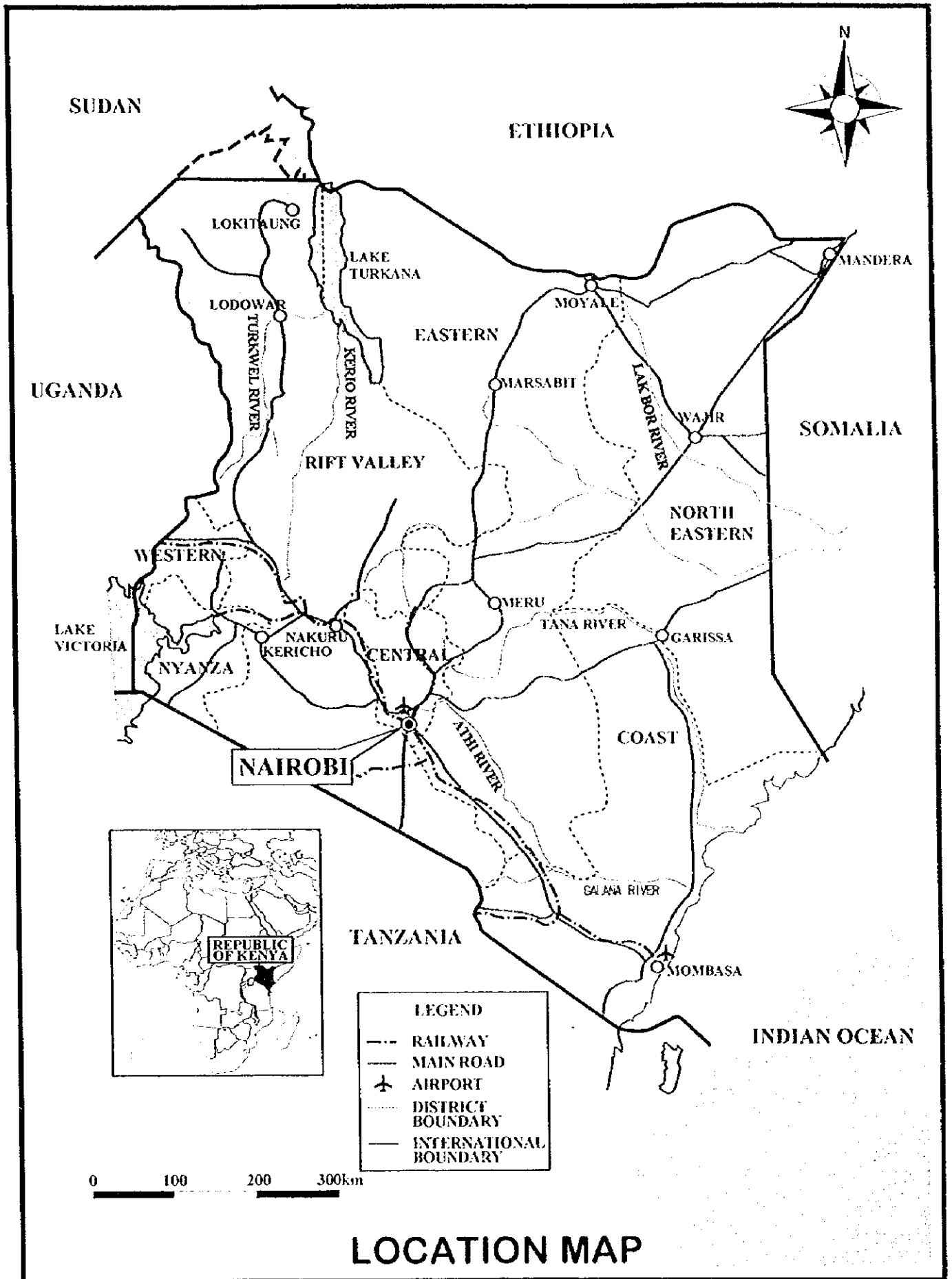
The Final Report presents the Master Plan of the Solid Waste Management in Nairobi City and the Feasibility Study of the priority projects. In view of the urgency and necessity to improve public cleanliness and public health and protect the environment, the priority projects were selected and technical viability and financial affordability were identified. We recommend that the Government of the Republic of Kenya and the Nairobi City Council who is an executing agency of the projects should promote all priority projects to the next stage of project implementation at the earliest possible time.

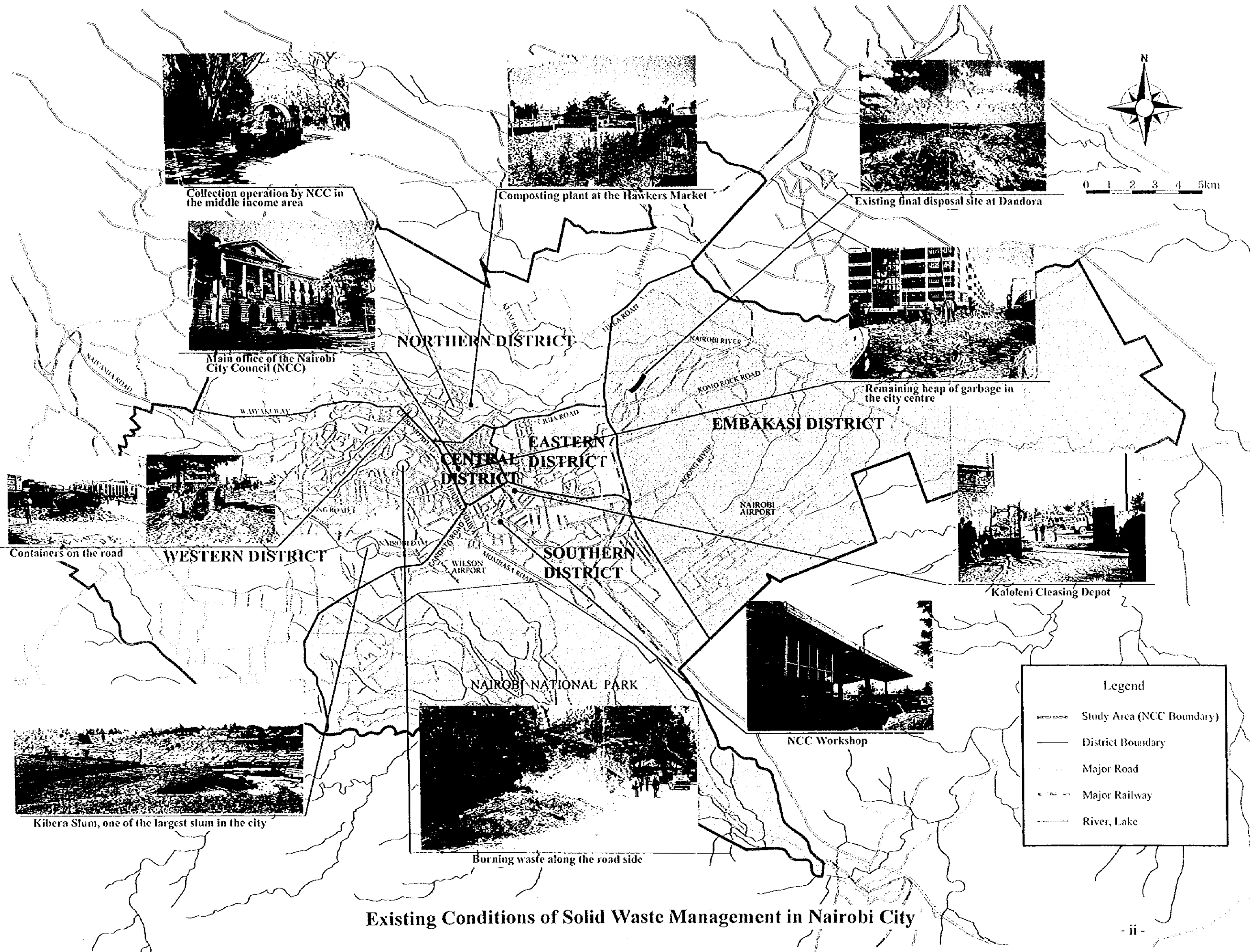
Finally, we wish to take this opportunity to express our sincere gratitude to the Government of Japan, particularly, JICA, the Ministry of Foreign Affairs, the Ministry of Health and Welfare, Osaka City Government and other offices concerned. We also wish to express our deep appreciation to the Ministry of Local Authorities, the Nairobi City Council and other authorities concerned of the Government of the Republic of Kenya for the close cooperation and assistance extended to the JICA Study Team during the study.

Very truly yours,



Takao Yoshida
Team Leader
JICA Study Team





Existing Conditions of Solid Waste Management in Nairobi City

COMPOSITION OF FINAL REPORT

Volume 1:	Executive Summary
Volume 2:	Main Report (Master Plan Study)
Volume 3:	Main Report (Feasibility Study)
Volume 4:	Supporting Report
Section A:	Waste Generation and Composition Analysis
Section B:	Institutional and Organisational Study
Section C:	Legal Study
Section D:	Private Sector Involvement in Solid Waste Management
Section E:	Collection and Transportation Study
Section F:	Environmental Considerations
Section G:	Waste Reduction, Recycling and Intermediate Treatment
Section H:	Final Disposal
Section I:	Environmental Impact Assessment
Section J:	Economic and Financial Aspect
Section K:	Public Education and Social Considerations
Volume 5:	Data Book (1)
Volume 6:	Data Book (2)
Volume 7:	Drawings



**THE STUDY ON SOLID WASTE MANAGEMENT
IN NAIROBI CITY
IN THE REPUBLIC OF KENYA**

FINAL REPORT

MAIN REPORT (MASTER PLAN STUDY)

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ABBREVIATIONS AND ACRONYMS

ASG	Apparent Specific Gravity
BOD	Biochemical Oxygen Demand
BOOT	Build, Own, Operate and Transfer
CBAP	Capacity Building Assistance Program
CBD	Central Business District
CBO	Community-Based (Voluntary) Organisation
CBP	Capacity Building Program
CDP	Communal Disposal Point
CDS	Community Development Section
CED	City Engineer's Department
CGT	Clean and Green Towns
CI	City Inspectorate
CME	Chief Mechanical Engineer
CMS	Contract Management Section
COD	Chemical Oxygen Demand
DI	District Inspectors
DoE	Department of Environment
DoPH	Department of Public Health
DSO	Deputy Superintendent Operations
EIA	Environmental Impact Assessment
EPM	Environmental Planning and Management Division
FIDIC	Federation Internationale Des Ingeneurs Counsels
FIRR	Financial Internal Rate of Return
FSDA	Foundation of Sustainable Development in Africa
GDP	Gross Domestic Product
GEMS	Global Environmental Monitoring System
GOK	Government of Kenya
GPT	Graduated Personal Tax
GTZ	Deutsche Gesellschaft Technische Zusammenarbeit
HCDP	Horticultural Crops Development Authority
HIS	Health Inspectorate Section
HRMU	Human Resource Management Unit
HRP	Human Resource Plan
IEE	Initial Environmental Examination
IPC	Investment Promotion Centre
IRP	Institutional Restructuring Plan
JICA	Japan International Cooperation Agency
KBS	Kenya Broadcasting System
KCPC	Kenya Certificate of Primary Education
KIM	Kenya Institute of Management
LRP	Legal Restructuring Plan
MENR	Ministry of Environment and Natural Resources
MIS	Management Information System
MOH	Ministry of Health
MOIC	Ministry of Industry and Commerce
MOLG	Ministry of Local Government

MOWD	Ministry of Water Development
MSW	Municipal Solid Waste
MYSA	Mathare Youth Sports Organisation
NCC	Nairobi City Council
NEAP	National Environmental Action Plan
NES	National Environmental Secretariat
NGO	Non-Governmental Organisation
NICs	Newly Industrialized Countries
NYS	National Youth Service
PHO	Public Health Officer
PHT	Public Health Technician
Pis	Performance Indicators
PRS	Public Relations Section
PSC	Public Service Commission
PSI	Private Sector Involvement
PSIA	Programme Support Implementation Arrangement
RDF	Refuse Derived Fuel
SAL	Social Affordable Limit
SDO	Social Development Officer
SPEK	Society for Protection of the Environment in Kenya
SPHO	Senior Public Health Officer
SPHT	Senior Public Health Technician
SPM	Suspended Particular Matter
SWM	Solid Waste Management
TA	Technical Assistance
TO	Transport Officer
TOR	Terms of Reference
UAP	Urban Agriculture Project
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UWASM	Urban Water and Sanitation Management
VAT	Value Added Tax
VFM	Value for Money
WHO	World Health Organisation
WSD	Water and Sewerage Department

CHAPTER 1
INTRODUCTION



CHAPTER 1

INTRODUCTION

1.1 Background of the Study

The City of Nairobi is the capital of the Republic of Kenya and the largest administrative, commercial and industrial center of the country. Nairobi City is experiencing a rapid population growth largely due to rural-urban migration and natural rate of increase. The present population of Nairobi City is estimated at 2.2 million and is growing at the rate of 4 to 5% per annum.

As a result of population increase, the generation rate of solid waste which is now about 1,500 ton/day, is concurrently increasing. The present capacity of refuse collection and disposal cannot cope with this situation, resulting in a large volume of waste uncollected, or dumped along streets, side ditches and other areas inside the city.

The condition is creating hygienic, environmental, as well as aesthetic problems. Since the final disposal site is an open dumping type landfill at approximately 8 km southeast of the city center, it also has a detrimental effect on the surrounding environment, due not only to the generation of offensive odour and gases but also to the associated problem of insects and animal pests.

To improve the City's environmental and sanitary conditions, the Nairobi City Council (the authority concerned in the City of Nairobi, hereinafter referred to as "NCC") has recognised the necessity of a solid waste management master plan, including institutional and administrative strengthening strategies. The Government of Kenya (hereinafter referred to as "GOK"), therefore, requested the Government of Japan (hereinafter referred to as "GOJ"), in 1993, to provide technical assistance for the Study on Solid Waste Management in Nairobi City in the Republic of Kenya (hereinafter referred to as "the Study").

In response to the request of the GOK, the GOJ decided to conduct the Study in accordance with the relevant laws and regulations of Japan. The Japan International Cooperation Agency (hereinafter referred to as "JICA"), the agency responsible for the implementation of technical cooperation programs of the GOJ, made a preparatory survey, and the implementing arrangement for the technical assistance was agreed upon among the Ministry of Finance of GOK, Ministry of Local Government of GOK, NCC of GOK, and JICA of GOJ in October, 1996.

1.2 Objectives of the Study

The objectives of the Study are as follows:

- (1) To formulate a master plan of improvement of solid waste management (SWM) in Nairobi City with emphasis on operational, institutional and administrative aspects, with the target year 2008;
- (2) To conduct a feasibility study on the priority project(s) to be selected from the master plan; and

- (3) To effect transfer of technology on solid waste management to Kenyan counterpart personnel in the course of the Study.

1.3 Scope of the Study

1.3.1 Study Area

The Study Area covers the whole jurisdictional area of the Nairobi City Council (NCC). In case the proposed landfill site is outside of Nairobi City, the site will also be included as part of the study area.

1.3.2 Types of Solid Waste

The types of solid waste to be studied are limited to household waste, market waste, commercial waste, street sweeping waste and office waste. The study on industrial and medical wastes are limited only to policy suggestions and recommendations in the Master Plan.

1.3.3 Study Scope

The Study covers the following items.

Phase I: Master Plan

- (1) Collection and analysis of existing data and information on Nairobi City
 - (a) Data and information on physical conditions such as climatic, topographic, meteorological, hydrological, soil, geological and geographical conditions;
 - (b) Social and economic situations;
 - (c) City planning, urban development plans and land use plans related to the Study;
 - (d) Legislations and regulations concerning environment/sanitation;
 - (e) Financial situations;
 - (f) Policy concerning environment/sanitation; and,
 - (g) Other relevant plans.
- (2) Understanding of present conditions in Nairobi City, such as:
 - (a) Implementation of SWM;
 - (b) Operation and maintenance of equipment for SWM;
 - (c) Recycling and reuse of solid waste;
 - (d) Health and hygiene of residents;
 - (e) Institutional and administrative capacity;
 - (f) Human resource development plan;

- (g) Environmental pollution caused by solid wastes; and,
 - (h) Activities of non- governmental organisation (NGO), private companies and scavengers.
- (3) Field survey
- (a) Amount of solid waste and its composition;
 - (b) Time and motion; and,
 - (c) Public awareness on SWM.
- (4) Evaluation of present condition of SWM and identification of problems and issues with emphasis on:
- (a) Relevant plans;
 - (b) Environmental and hygienic aspects;
 - (c) Financial aspects;
 - (d) Operational and institutional aspects;
 - (e) Legal aspects;
 - (f) Socioeconomic aspects; and,
 - (g) Administrative aspects.
- (5) Establishment of basic policies and frameworks and forecasting through projection on:
- (a) Population growth and urbanisation;
 - (b) Economic growth and changes in living condition;
 - (c) Changes in quality and quantity of solid waste;
 - (d) Operational and institutional aspects; and,
 - (e) Administrative aspects.
- (6) Establishment of basic plan, including:
- (a) Treatment and collection of solid waste;
 - (b) Operation and institution strengthening;
 - (c) Financial planning; and,
 - (d) Legislation and regulation.
- (7) Institutional and organisation plans, including:
- (a) Human resource development plan; and
 - (b) Administration development plan.
- (8) Facilities plan, including:
- (a) Preliminary design of facilities; and,
 - (b) Preliminary equipment plan.
- (9) Preliminary cost estimate

(10) Comprehensive master plan evaluation, including:

- (a) Environmental and hygienic aspects;
- (b) Financial aspects;
- (c) Operational and institutional aspects;
- (d) Legal aspects;
- (e) Socioeconomic aspects; and,
- (f) Administrative aspects.

(11) Staged implementation plan

(12) Selection of priority projects(s)

(13) Selection of pilot study(ies)

Phase II: Feasibility Study

(1) Collection and review of existing supplementary data and information on Nairobi City

(2) In-depth understanding of the present conditions in Nairobi City

(3) In-depth field survey

(4) Implementation of selected pilot study(ies)

(5) Establishment of feasible specifications

(6) Organisation, institution and human resource development plans, including:

- (a) Organisational structure;
- (b) Staffing and manpower development;
- (c) Private sector promotion;
- (d) Recycling systems;
- (e) Environmental education; and,
- (f) Residents participation.

(7) Feasible facilities plan, including:

- (a) Equipment plan;
- (b) Construction plan; and
- (c) Operation and maintenance plan.

(8) Financial plans, including:

- (a) Tariff policy;
- (b) Expected financial sources for investment; and,
- (c) Expected financial sources for operation, maintenance and depreciation.

- (9) Cost estimate, including:
 - (a) Human resource development cost;
 - (b) Public education cost;
 - (c) Construction and equipment cost; and,
 - (d) Operation and maintenance cost.
- (10) Conduct of Environmental Impact Assessment (EIA)
- (11) Comprehensive project evaluation, including:
 - (a) Technical aspects (appropriate technology);
 - (b) Financial aspects;
 - (c) Environmental aspects; and,
 - (d) Socioeconomic aspects.
- (12) Implementation plan

1.4 Schedule and Staffing of the Study

The Study was, in principle, to be carried out through field studies in Kenya and home office studies in Japan from March 1997 to June 1998, as shown in **Annex 1**. The total duration of the Study was approximately 15 months. Reports were to be presented at times shown in the same annex. Workshops for technology transfer were to be held (three times during the second field study in Kenya).

The organisational structure for the Study is also presented in **Annex 1**. The function of the JICA Advisory Committee is to give necessary advice on the Study to JICA. The members of the Kenyan counterpart personnel, the Advisory Committee and the Study Team are also presented in the same annex.

The minutes of meetings conducted during the study period are attached in **Annex 2**.

CHAPTER 2
DESCRIPTION AND EVALUATION
OF CURRENT CONDITIONS

CHAPTER 2

DESCRIPTION AND EVALUATION OF CURRENT CONDITIONS

2.1 Introduction

Through the first field work from 25 March 1997 to 21 June 1997 and the second field work from 23 October 1997 to 19 January 1998, the JICA Study Team collected relevant data and information, investigated candidate disposal sites and conducted waste generation/composition analysis, public awareness survey and so on. The results were used as basic data for the Master Plan formulation. This chapter presents the current conditions of solid waste management (SWM) in Nairobi, as well as the evaluation, mainly in terms of institutional, financial and technical aspects.

First of all, the present generated waste amount and composition in the city are presented in **Section 2.2**, based on the result of the field survey. From the institutional point of view, the analysis and evaluation of the present arrangements not only for institutional but also organisational and human resource management aspects were carried out as described in **Section 2.3**. A legal approach was made to reinforce the institutional and human resource management programme, as presented in **Section 2.4**. Private sector involvement which is an integral part of SWM in Nairobi is also addressed in **Section 2.5**.

Based on technical approaches, collection and transportation, waste reduction, recycling and intermediate treatment, and final disposal studies were conducted as described in **Sections 2.6, 2.7 and 2.8**, respectively. **Section 2.9** covers environmental observations and evaluation for the existing waste collection points and explains the result of the initial environmental examination for the selection of candidate disposal sites.

Finally, as the other important components for implementation of the SWM programme, the City's economic and financial conditions are analysed in **Section 2.10**, and public education and social aspects for SWM, considering the results of public awareness survey and field investigation, are presented in **Section 2.11**. The current conditions of hospital and industrial waste are additionally described in **Section 2.12** and general recommendations for improvement of handling these kinds of wastes are made.

All data and analyses relevant to each section are compiled in **Volume 4, Supporting Report; Volume 5, Data Book (1); and Volume 6, Data Book (2)**.

2.2 Waste Generation and Composition Analysis

2.2.1 Survey Methodology

The objective of the survey was to grasp the present and projected future conditions of solid waste amounts and characteristics classified by generation source. Knowing the waste amount to be generated is essential for the formulation of the collection and

transportation plan and the final disposal plan. In particular, the required number of collection vehicles will depend on the condition of waste generation, and the area required for the final disposal site is to be estimated by using the total waste amount to be generated. Further, feasibility of the plans will be studied based on the waste generation and composition derived from the survey.

The survey was conducted two times, in May and November 1997, by a local consultant under the supervision of the JICA Study Team. The sampling for waste generation and composition was conducted in a residential area, residential/commercial mixed area, markets and roads to get a true and representative picture of waste generation in Nairobi City. Taking into account housing types and different socioeconomic groups living in the city, the residential area was further subdivided into high income, middle income (high/low), low income (high/low) and surrounding areas, including slums and squatter settlements. Besides, a compost sample was taken for chemical analysis to evaluate the quality of compost. The number of samples and the survey chart are summarised in Table 2.2-1 and Figure 2.2-1, and the detailed survey methodology and instructions are presented in Supporting Report Section A.

2.2.2 Solid Waste Generation Rate from Each Generation Source

The solid waste generation rate was assessed by weighing the wastes generated from each generation source. Waste generation rate per capita was calculated by dividing the total household waste by the number of household members in residential area. The waste generated by the daytime population was estimated in consideration of the waste generated from offices, restaurants and shops in "Mixed" area. In markets, the waste was assessed in terms of quantity only. The waste generation of each generation source is shown in Table 2.2-2. The waste generation rate per capita in residential area is shown in Figure 2.2-2.

Table 2.2-1 Sample Number of Waste Generation and Composition Survey

Generation sources		Number			Waste Characteristics	
		Samples per day	Survey days	Total samples	Physical Composition	Chemical Composition*
Mixed	restaurant others**	36	7	252	252	1&3
		18	7	126	126	1&3
High income		30	7	210	210	1&3
Middle income	high	48	7	336	336	1&3
	low	48	7	336	336	
Low income	high	36	7	252	252	1&3
	low	36	7	252	252	
Surrounding area		18	7	126	126	1&3
Markets		3	7	21	21	1&3
Roads		7	7	49	49	0
Compost		0	0	0	0	1&3
Total		280		1,960	1,960	8&24

* One sample in the first survey and 3 samples in the second survey

** Others include waste from offices and shops.

Table 2.2-2 Waste Generation of Each Generation Source

Income Class	Unit	Value (kg/day)
Mixed (restaurant)	shop	6.79
Mixed (others)	shop	1.39
High income	household	3.84
Middle income	household	3.34
Low income	household	2.72
Surrounding area	household	3.07
Markets	market	2,425
Roads	1 km	48.3

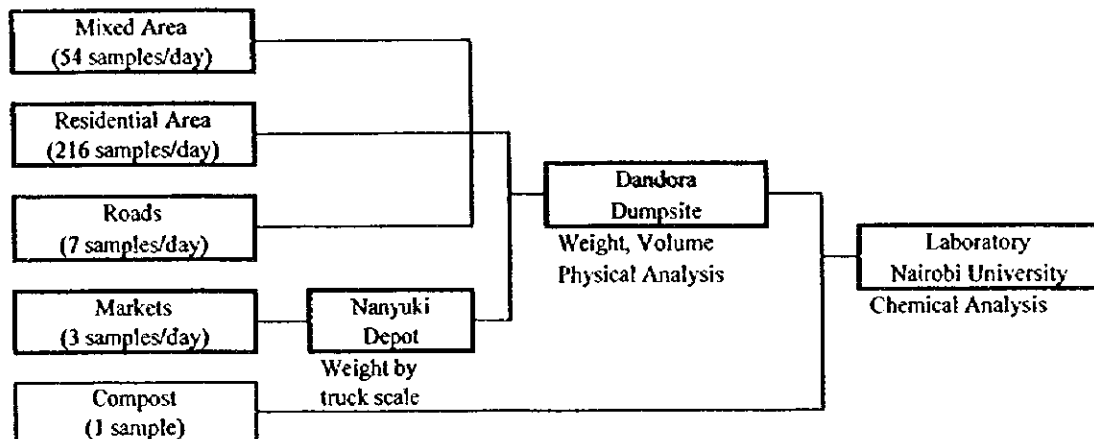


Figure 2.2-1 Survey Chart of Waste Generation and Composition

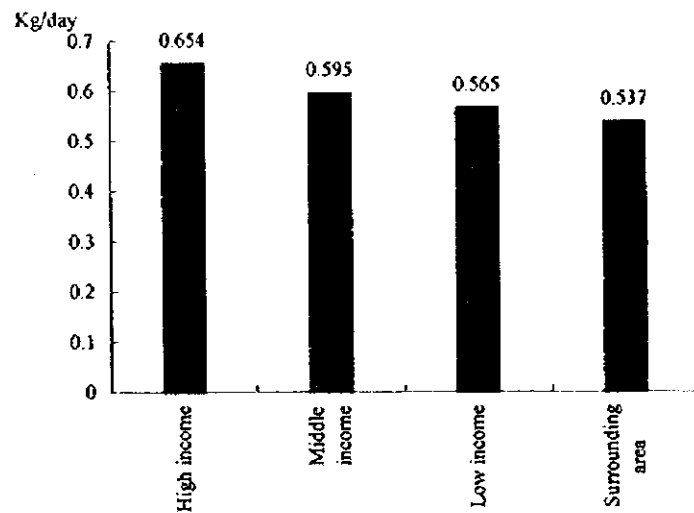


Figure 2.2-2 Waste Generation per Capita in Residential Area

The results are as follows:

- (1) In mixed area, waste generation of restaurants is 6.79 kg/day and this value is more than 4 times as that of others.

- (2) In residential areas, the generation rate of high, middle, low and surrounding area is 0.654, 0.595, 0.565 and 0.537kg/capita/day, respectively, and this value is in proportion to the level of income.
- (3) The waste generation of markets and roads is about 2,400 kg/market/day and 50 kg/km/day, respectively.

2.2.3 Total Amount of Solid Waste

The assumption for calculating the total waste amount generated in Nairobi City is as follows. The data for assumption such as population, number of shops, etc., were provided by the Nairobi City Council (NCC).

(1) Households

The population in Nairobi City is 2,191,000 as of 1997. The population ratio of high, middle and low income (including surrounding area) is 23.3%, 26.7% and 50.0%, respectively. (Source: *Development Solution for Africa Ltd.: "A Strategic Health Plan for the Nairobi Area", 1992*)

(2) Shops

The number of shops except restaurants is 39,900 and that of restaurants, 5,600. (Source: *Licensing Section, Department of Inspectorate*)

(3) Markets

The number of markets is 34.

(4) Roads

The total length of roads to be swept is around 1,430 km.

On the above assumptions, the total waste amount generated in Nairobi City at present is estimated at 1,530 t/day as shown in Table 2.2-3. The values in this table were the basis of forecasting the future waste amount.

Table 2.2-3 Total Amount of Waste Generation

	weight per unit (kg)			total number			total weight (t)			
	person	shops	1 km	population	shops	length	house	shops	road	total
Mixed (res.)		6.79			5,600			38		38
Mixed (others)		1.39			39,900			56		56
High income	0.654			511,000			334			334
Middle income	0.595			585,000			348			348
Low income*	0.551			1,095,000			603			603
Markets		2,425			34			82		82
Roads			48.3			1,430			69	69
Total				2,191,000			1,285	176	69	1,530

* Low income includes surrounding area, so that the weight per unit in low income area includes that of the surrounding area.

2.2.4 Apparent Specific Gravity

The Apparent Specific Gravity (ASG) of solid waste is an important tool required to assess the total mass and volume of waste. The ASG calculation for each generation source and the average of total waste generated in Nairobi City are as shown in Figure 2.2-3.

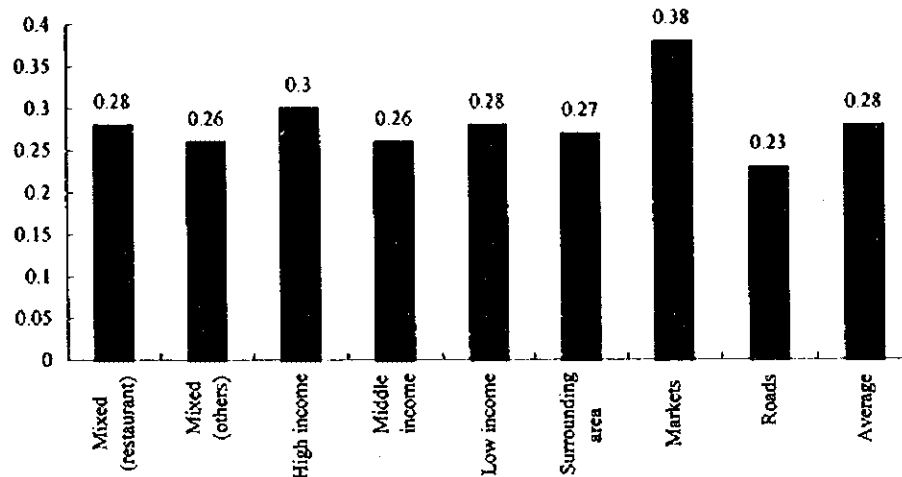


Figure 2.2-3 Apparent Specific Gravity

As shown in the above figure, market wastes have the highest apparent specific gravity and road wastes have the lowest. There is little difference of ASG in mixed and residential areas.

2.2.5 Physical Composition of Solid Waste

Information and data on the physical composition of solid wastes are important in the selection and operation of equipment and facilities, disposal strategy and disposal process. Components that typically constitute municipal solid wastes are as follows:

- (1) Food waste
- (2) Paper (recyclable and others)
- (3) Textile
- (4) Plastic (container and others)
- (5) Grass and wood
- (6) Leather
- (7) Rubber
- (8) Glass (container and others)
- (9) Metal (container and others)
- (10) Others (ceramic and soil, etc.)

On a wet basis, physical separation and determination of percentage composition was adopted in the survey to calculate the physical composition of waste. The results are summarised in Table 2.2-4 and presented in Figure 2.2-4. As described later, the following constituents with highest values were found:

- (1) Food Waste and Paper (others) in mixed (restaurant) area
- (2) Paper (recyclable) in mixed (others) area

- (3) Textile and Glass in high income
- (4) Grass/Wood in Roads
- (5) Plastics, Leather, Rubber, Metals and any other in Market

Table 2.2-4 Waste Composition of Each Generation Source

Generation source		Mixed restaurant	Mixed others	High income	Middle income	Low income	Surrounding area	Markets	Roads
Food Waste		55.92%	36.04%	50.00%	53.52%	57.17%	57.74%	36.55%	24.68%
Paper	Recyclable	13.44%	25.22%	16.81%	11.42%	15.65%	14.64%	10.85%	9.79%
	Others	7.60%	0.69%	0.46%	5.93%	0.55%	0.40%	2.84%	17.11%
	Total	21.04%	25.91%	17.27%	17.35%	16.20%	15.04%	13.68%	26.90%
Textile		4.45%	2.14%	2.82%	2.64%	1.91%	2.13%	3.23%	6.60%
Plastic	Container	1.89%	3.47%	5.51%	5.66%	5.35%	3.54%	2.75%	4.08%
	Others	5.89%	9.59%	8.13%	7.13%	6.98%	5.72%	8.93%	6.63%
	Total	7.78%	13.06%	13.64%	12.79%	12.33%	9.26%	11.68%	10.71%
Grass/Wood		6.11%	2.55%	7.60%	4.72%	2.46%	7.12%	16.98%	20.76%
Leather		1.39%	0.45%	0.81%	0.70%	0.68%	0.72%	3.53%	0.88%
Rubber		0.30%	0.39%	0.62%	1.00%	1.98%	1.24%	6.42%	1.14%
Combustible-subtotal		96.99%	80.54%	92.76%	92.72%	92.73%	93.25%	92.08%	91.67%
Glass	Container	0.84%	6.41%	1.90%	1.66%	1.09%	0.79%	1.36%	0.69%
	Others	0.15%	4.95%	0.46%	0.43%	0.90%	0.80%	0.86%	0.35%
	Total	0.99%	11.36%	2.36%	2.09%	1.99%	1.59%	2.22%	1.04%
Metal	Container	0.87%	4.21%	2.44%	2.02%	1.13%	1.28%	1.15%	1.39%
	Others	0.35%	0.80%	0.82%	0.96%	0.35%	1.82%	0.69%	0.58%
	Total	1.22%	5.01%	3.26%	2.98%	1.48%	3.10%	1.84%	1.97%
Any other		0.81%	3.10%	1.61%	2.21%	3.80%	2.07%	3.87%	5.33%
incombustible-subtotal		3.02%	19.47%	7.23%	7.28%	7.27%	6.76%	7.93%	8.34%
Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

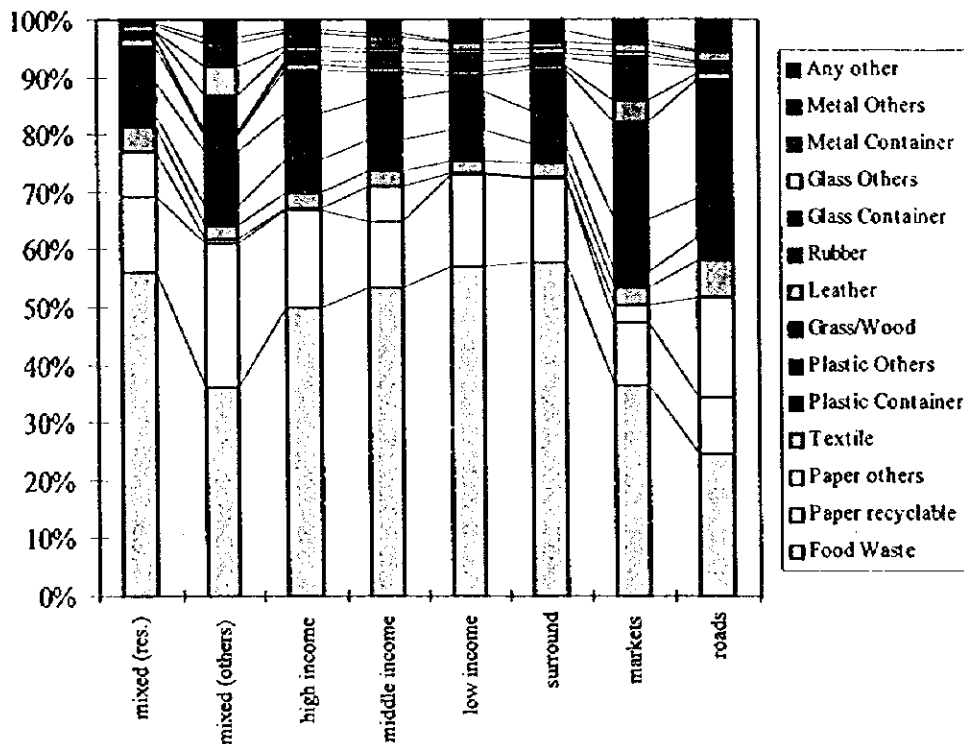


Figure 2.2-4 Physical Composition

The weight and weighted ratio of each constituent of total waste generated in Nairobi City have been calculated, as shown in Table 2.2-5. The characteristics are as follows:

- (1) The rate of food waste is 51.5% and that of paper is 17.3%.
- (2) The rate of recyclable material such as paper, plastic, metal and glass is 22.4%.
- (3) The rate of non-combustible material is 7.6%. This value seems to be extremely low.

Table 2.2-5 Weight and Weighted Ratio of Total Waste

Constituent		Total (t/day)	Weighted ratio (%)
Food Waste		734	51.5
Paper	Recyclable	206	14.5
	Others	41	2.8
	Subtotal	247	17.3
Textile		38	2.7
Plastic	Container	67	4.7
	Others	102	7.1
	Subtotal	169	11.8
Grass/Wood		96	6.7
Leather		13	0.9
Rubber		21	1.5
Combustibles Sub-Total		1,317	92.4
Glass	Container	21	1.5
	Others	11	0.8
	Subtotal	32	2.3
Metal	Container	25	1.7
	Others	13	0.9
	Subtotal	38	2.6
Any other		38	2.7
Non-combustibles Sub-Total		109	7.6
Total*		1,426	100.0

* Total weight of waste is calculated by subtracting self-disposal waste amount from the total waste generation amount, i.e., 1,530 - 104 (self-disposal amount) = 1,426 t/day.

2.2.6 Chemical Analysis

Information on chemical analysis of solid waste is important in evaluating the alternative processing and facilities such as incineration, composting and energy recovery. The important chemical analyses made were the chemical property analysis of three contents (moisture, ash and combustible), ultimate analysis of six elements (Carbon, Hydrogen, Oxygen, Nitrogen, Sulfur, Chlorine), and the low calorific value analysis. The compost sample made from leavings of market waste or food waste was also analysed. Since road waste was not chemically analysed, the average is considered to be the weighted value of total waste generated in Nairobi City.

(1) Three Contents

The results are shown in Table 2.2-6 and Figure 2.2-5. The following contents with highest values were found, as detailed in Table 2.2-6 below:

- (a) Moisture content in the surrounding area
- (b) Ash content in compost
- (c) Combustible content in the mixed area (others)

Table 2.2-6 Three Contents

	Mixed restaurants	Mixed others	High income	Middle income	Low income	Surrounding area	Market	Compost	Average
Moisture	56.88%	35.96%	61.68%	60.16%	71.19%	72.86%	59.01%	23.76%	64.3%
Ash	11.87%	14.38%	6.74%	7.30%	11.17%	9.41%	8.50%	55.08%	8.9%
Combustible	31.25%	49.67%	31.59%	32.54%	17.65%	17.73%	32.49%	21.18%	26.8%

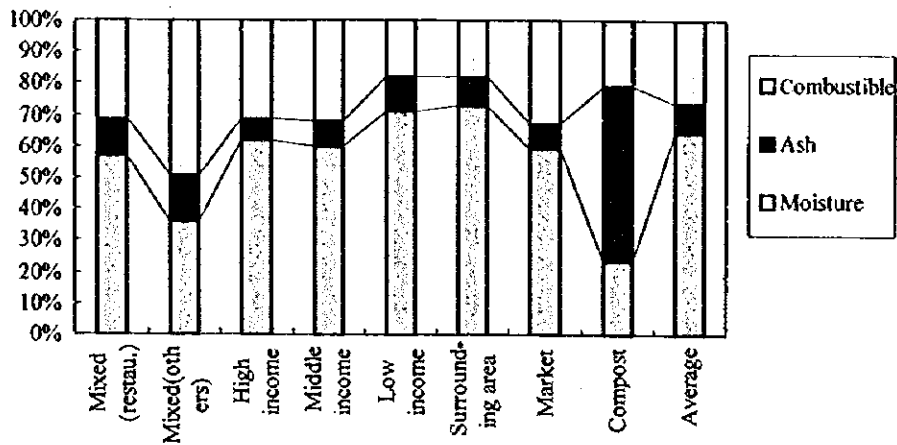


Figure 2.2-5 Three Contents

(2) Ultimate Analysis

The results are shown in Table 2.2-7 and Figure 2.2-6.

There is little difference in generation source except compost. The highest element is carbon, and the next is oxygen. The sum of carbon and oxygen in total waste generated in Nairobi City is more than 90%, followed by hydrogen.

The following elements with the highest values were found, as detailed below:

- (a) Hydrogen and Chlorine in the mixed area (restaurants)
- (b) Carbon in the mixed area (others)
- (c) Oxygen in the middle income area
- (d) Nitrogen in the surrounding area
- (e) Sulfur in markets
- (f) Others in compost

Table 2.2-7 Ultimate Analysis

	Carbon	Hydrogen	Nitrogen	Sulfur	Chlorine	Oxygen
Mixed (restau.)	54.78%	6.64%	1.38%	0.14%	1.08%	36.00%
Mixed (others)	53.63%	5.25%	0.42%	0.17%	0.15%	40.40%
High income	52.74%	5.11%	0.87%	0.14%	0.23%	40.92%
Middle income	46.54%	5.06%	1.21%	0.12%	0.08%	46.99%
Low income	50.41%	6.48%	1.46%	0.14%	0.23%	41.30%
Surround. area	43.96%	5.16%	2.17%	0.10%	0.19%	48.44%
Markets	49.58%	5.25%	0.97%	0.23%	0.35%	43.64%
Compost	36.94%	6.26%	3.72%	0.44%	0.18%	52.52%
Average*	49.33%	5.35%	1.22%	0.14%	0.21%	43.75%

* Average was calculated by excluding road waste.

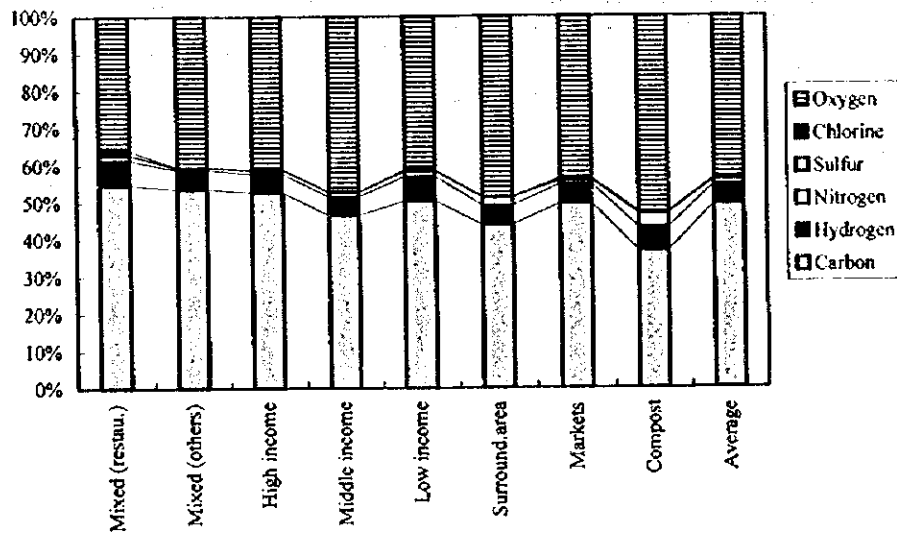


Figure 2.2-6 Ultimate Analysis

(3) Lower Calorific Value

The results are shown in Figure 2.2-7.

The value of mixed (others) is the highest because the rate of paper is the highest and that of compost is extremely low due to decomposition of organic material. The weighted value of total waste generated in Nairobi City is around 1,000 cal/g.

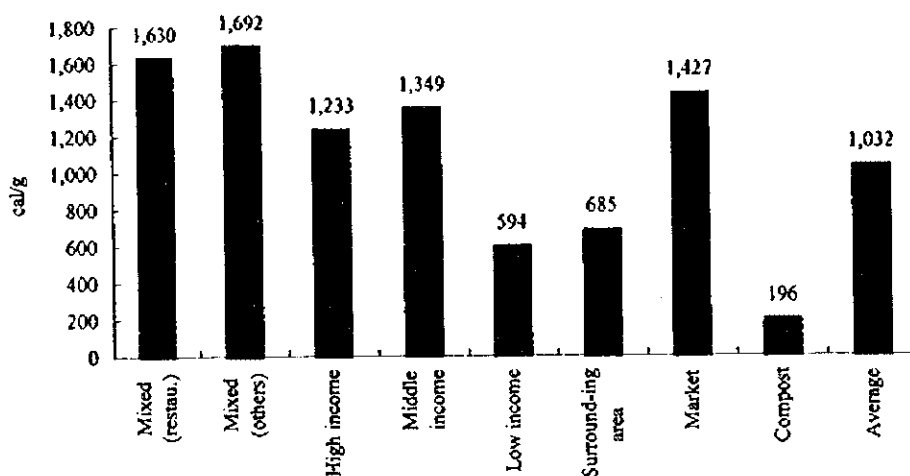


Figure 2.2-7 Lower Calorific Value

2.3 Institutional and Organisational Study

2.3.1 The Ongoing Capacity Building Program (CBP)

There is a clear consensus among senior officials of the Nairobi City Council (NCC), the Ministry of Local Government (MOLG), and the Government of Kenya (GOK) that a workable solution should be found for the current institutional problems at the Nairobi City Council (NCC).

In this connection, the MOLG has implemented a substantial Capacity Building Programme (CBP) for NCC in collaboration with the UNDP under the UNDP Programme Support Implementation Arrangement (PSIA). The PSIA is based on the UNDP's Programme Support Document (PSD) on Enhanced Public Administration and Participatory Development (EPAPD) agreed between the UNDP and the Government of Kenya.

The CBP comprises eight (8) programme components starting in January 1998 until 31 December 1999. The overall objective of the CBP is to develop and strengthen the management capability of NCC focusing on the key areas of organisational governance, organisational restructuring, human resource development, financial management and revenue generation. A key component of the program is the rationalisation of staffing needs and numbers.

2.3.2 Institutional Responsibility on Solid Waste Management (SWM) at the National Level

At the national level the main responsibility on SWM lie with the Ministry of the Environment and Natural Resources (MENR) and the Ministry of Local Government (MOLG). As for Nairobi City, however, the institutional and organisational arrangements at the national level have become deficient due to the remarkable increase of solid waste in the City, and some important SWM responsibilities at the national level seem to necessitate urgent improvement. These responsibilities may be summarised as:

- (a) policy formulation and planning for SWM;
- (b) preparation of a comprehensive national law on SWM;
- (c) formulation of national standards or guidelines on SWM, including policies covering private sector involvement (PSI);
- (d) issuance of permits and licenses to solid waste operators, e.g., permit for landfill sites or waste transportation; and
- (e) monitoring of activities of solid waste generators or operators;

Furthermore, the present coordination and linkages among institutions involved in SWM such as the coordination of policy, planning and legislation through the Inter-ministerial Committee on the Environment chaired by the National Environmental Secretariat (NES) may have to be augmented.

2.3.3 The Nairobi City Council

Figure 2.3-1 presents the organisation chart of the Nairobi City Council (NCC). The Council is headed by the Mayor who is assisted by the Deputy Mayor, and it comprises 73 councilors, 55 of which are popularly elected and 18 are nominated by the Minister of Local Government. Each elected councilor represents one of the City's 55 wards and one of the nominated councilors serve as the Provincial Commissioner of Nairobi. The appointments of the Mayor and the Deputy Mayor are approved by the NCC.

The Council manages its affairs through 12 council committees, some of which have sub-committees (currently there are 5 Sub-Committees). The principal committees are the General Purposes Committee, the Staff Committee and the Finance Committee.

Council committees are composed of councilors one of whom is the nominated chairman. Committees vote by consensus and not by majority, and nine members constitute a quorum.

The Nairobi City Council has the primary duty of care for the provision and regulation of solid waste management (SWM) services to the City of Nairobi. NCC's major objectives towards solid waste management are to:

- (a) improve public cleanliness in order to keep public places aesthetically acceptable,
- (b) improve public health, and
- (c) protect the environment,

by ensuring the proper storage, collection, transportation, safe treatment and disposal of solid waste.

Under the Public Health Act and the Local Government Act and its By-laws, NCC might appear to have, by implication but not expressly, responsibility for all types of solid waste in Nairobi, i.e., municipal, hospital and industrial waste.

NCC's main responsibilities towards SWM are:

- (a) to formulate and implement SWM policies;
- (b) to provide services for the collection, transportation, treatment and disposal of solid waste;
- (c) to regulate and monitor the activities of all generators of solid waste;
- (d) to regulate and monitor private companies engaged in solid waste activities;
- (e) to formulate and enforce laws and regulations relating to SWM; and
- (f) to coordinate with other departments within NCC, donor agencies, NGO's and other government organisations involved in SWM.

2.3.4 The Department of Environment

NCC delivers SWM services through the Department of Environment (DoE) which is one of its administrative departments. The DoE is solely responsible for the delivery of these services through its Cleansing Section. The DoE also manages Nairobi's city parks through its Parks Section.

The organisation chart of the DoE is presented in **Figure 2.3-2**. As a department of NCC, the operations of DoE are regulated by the Local Government Act and its By-laws.

The DoE is divided into the Administration Section and two operational sections, the Cleansing Section and the Parks Section. The DoE is headed by the Director of Environment who is assisted by the Deputy Director.

Directly underneath the Deputy Director are two Assistant Directors (both positions are currently vacant) one of whom is responsible for the Cleansing Section and one is for the Parks Section. Directly under the Assistant Director for Cleansing is the Cleansing Superintendent who is supported by two Deputy Cleansing Superintendents.

The main responsibilities of the DoE towards solid waste management are:

- (a) to implement NCC's SWM policies formulated by the Council's Environmental Committee;
- (b) to maintain public cleanliness, protect public health and the environment, and keep public places aesthetically acceptable by providing services for the collection, transportation, treatment and disposal of solid waste;
- (c) to regulate and monitor the activities of all generators of solid waste;
- (d) to regulate and monitor private companies engaged in solid waste activities;
- (e) to enforce all laws and regulations relating to SWM; and
- (f) to coordinate with other departments within NCC, donor agencies, NGOs, the private sector, and other government organisations involved in SWM.

The Cleansing Section is divided into six (6) districts for operational purposes. Each District provides both collection and transportation and street cleansing (including street sweeping and gully cleaning) services.

The Districts are grouped into two (2) Divisions, and each Division has three (3) Districts. One Division also manages a Transportation Unit. The Administration Section reports directly to the Director of Environment.

Each of the two Deputy Cleansing Superintendents is responsible for one Division and is in turn directly supported by one Assistant Cleansing Superintendent. The Deputy Cleansing Superintendent (Operations) manages the Transportation Unit and the Southern, Embakasi and Eastern districts. He also has overall responsibility for all operations of the Districts. The other Deputy Cleansing Superintendent manages the other three (3) districts, the Northern, Central and Western districts.

Each District is headed by a District Inspector and provides both collection and transportation and street cleansing services to a designated area of the city. Each District has its own assigned staff, equipment (excluding vehicles) and operating base, i.e., an office and depot.

The size of a District ranges considerably from Embakasi with 202 staff to Central with 5 staff. Twenty-two percent (22%) of the Cleansing Section's staff work in collection and disposal and 78% work in street cleansing. Each District is divided into:

- (a) Subdistricts, headed by a Senior Foreman
- (b) Locations, headed by a Foreman (there are few locations)
- (c) Beats: Collection and street cleansing, headed by a Senior Headman

The Senior Headman supervises headmen who are assigned to either street cleansing or collection. On the average a Senior Headman supervises 6.4 headmen.

Headmen directly supervise groups of manual workers in the field, i.e., loaders or sweepers. Typically a headman supervises one driver and four loaders or about 15 sweepers.

The functions of the Cleansing Section are:

- (a) Waste collection and transportation;
- (b) Medical wastes collection from hospitals, maternity homes, medical and veterinary clinics;
- (c) Street cleansing;
- (d) Cleaning and recovery of solid wastes from road gullies;
- (e) Road side and estates drain cleaning;
- (f) Night soil collection;
- (g) Dead animal collection;
- (h) Refuse disposal;

- (i) Supplying households with refuse bins;
- (j) Grass cutting along roadsides; and
- (k) Destruction of condemned foods and other goods, and issuance of destruction certificates.

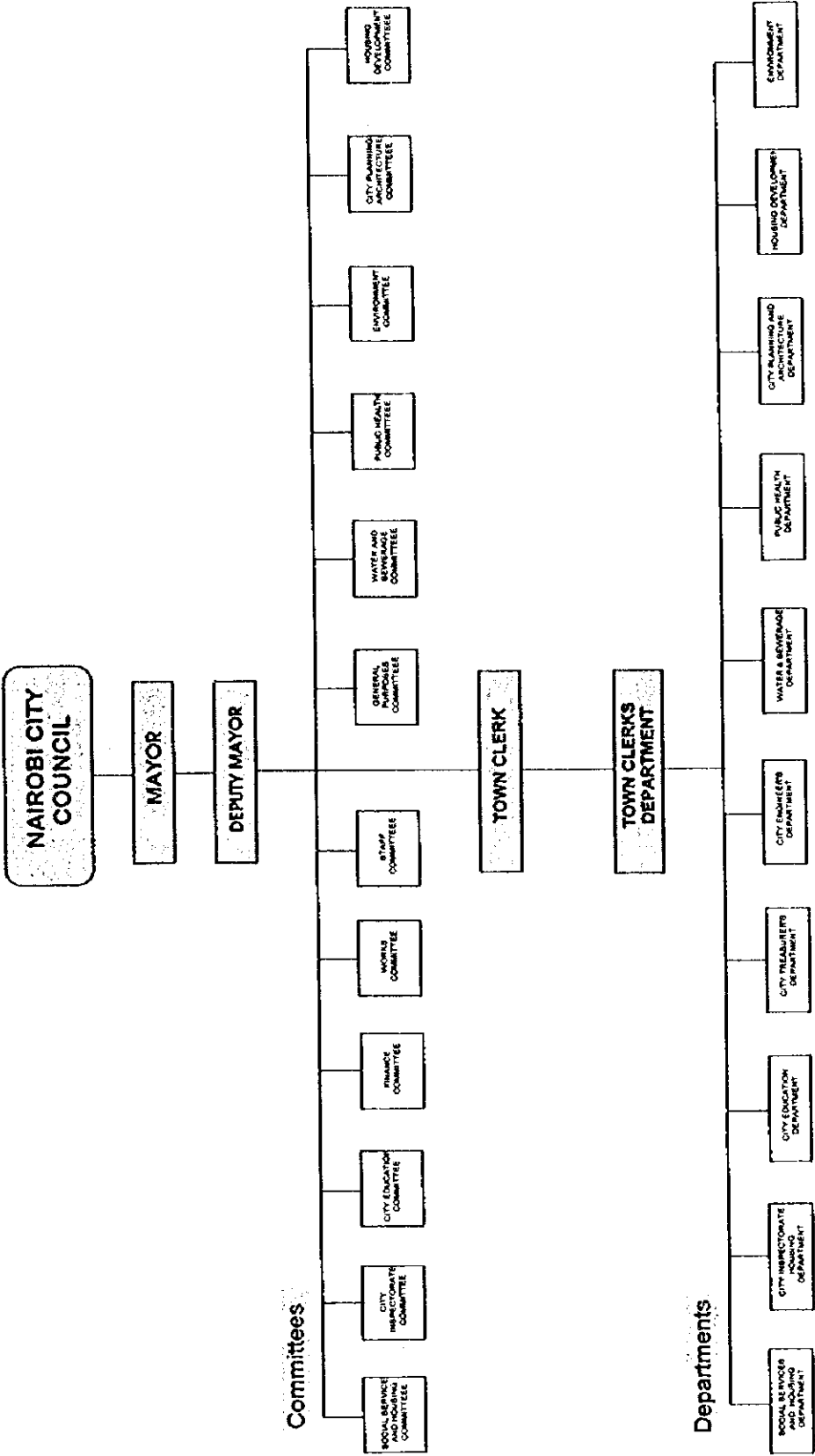


Figure 2.3-1 Organisation Chart of NCC

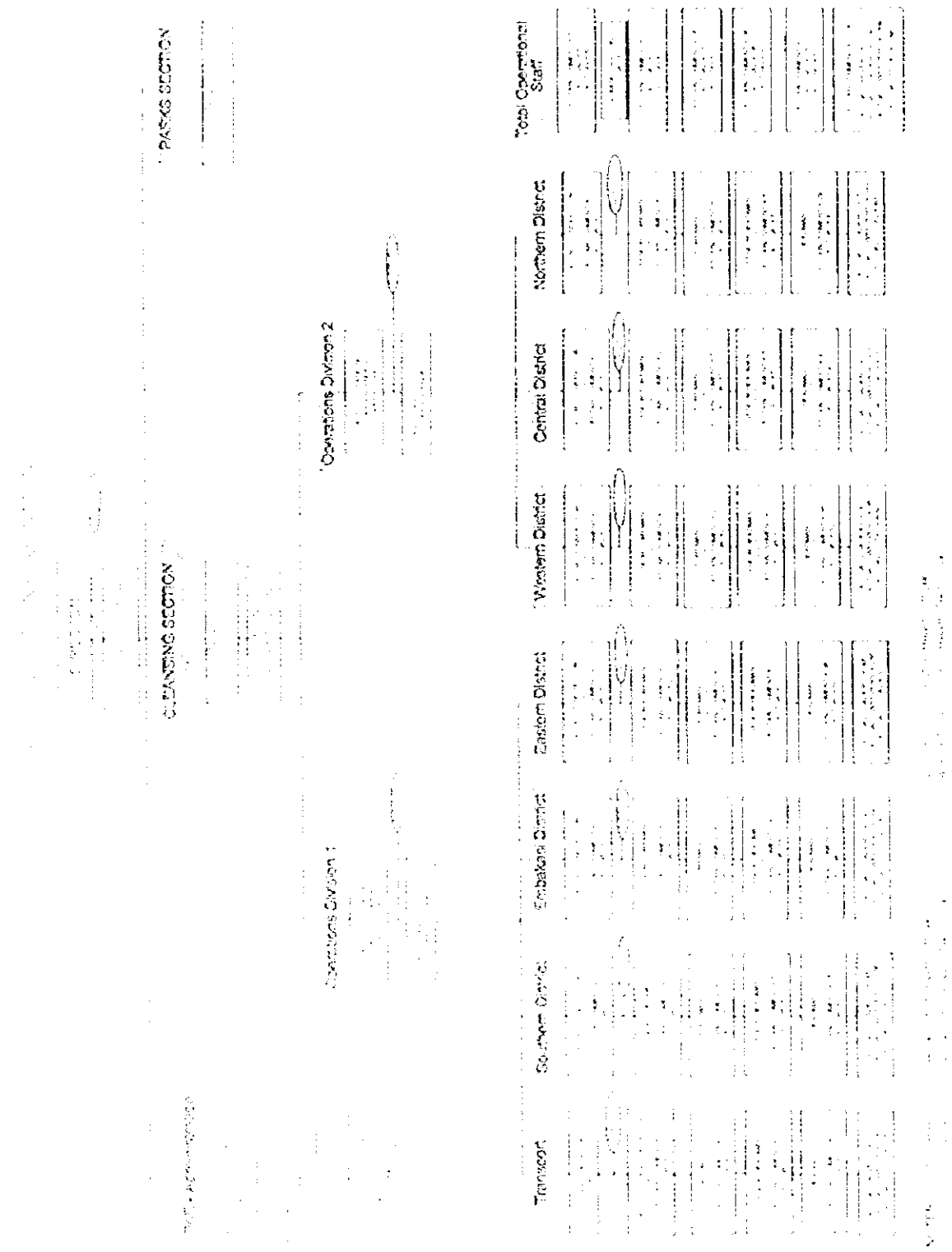


Figure 2.3.2 - Organisation Chart of the Department of Environment

2.3.5 Evaluation of Organisation and Management of SWM Services in NCC

The DoE is making utmost efforts to manage and finance its SWM functions. It cannot however sustain its SWM services because of chronic under-funding, too few vehicles, poor equipment, inadequate maintenance and insufficient human resources. The overriding constraint is insufficient funds.

Its primary organisational and management deficiencies may be summarised as:

- (a) duplication and vague responsibilities of the organisation and staff;
- (b) inadequate planning of SWM services;
- (c) unclear procedures to set and monitor objectives from the strategic level down to middle managers and supervisors;
- (d) inefficient management information and monitoring systems (information is presently prepared on a "day to day" management of operations);
- (e) insufficient monitoring of individual staff performance;
- (f) inefficient human resource management (recruitment, promotion, discipline);
- (g) inadequate coordination and communication between the DoE and other departments (Managers rarely communicate with one another because of insufficient authority and inter-departmental issues are typically handled between Department Heads.); and
- (h) over-staffing at the junior scales (16,17 and 18).

In addition, the DoE's organisational capacity is insufficient on certain points such as:

- (a) environmental regulation and monitoring of SWM activities of waste generators and waste operators;
- (b) human resource management such as development policies or programs, periodic appraisal of staff, and recruitment, promotion and training of personnel;
- (c) financial management including financial planning and budgetary systems;
- (d) managing and monitoring private sector contracts;
- (e) facilitation of self-help community based services in the informal settlements; and
- (f) public awareness and education.

2.4 Legal Study

2.4.1 National Overview

The existing body of legislation concerning SWM is very incomplete at the national level. At present a comprehensive law regarding SWM, including control of hospital,

industrial or hazardous wastes, has yet to be enacted. The existing legislations provide a workable but very limited basis for SWM. With regard to the environment, the Ministry of Environment and Natural Resources (MENR) had formulated the Environmental Management and Coordination Bill with general provisions covering waste management, disposal site licensing, control of hazardous, industrial and hospital waste and environmental impact assessment.

2.4.2 Existing Legislation which Directly Relates to SWM

At the moment the Public Health Act, Cap 242 and Local Government Act, Cap 265 are the only laws in Kenya which expressly cover the responsibilities of local authorities towards solid waste. The contents of each Act are described in **Supporting Report Section C**. NCC provides and regulates its SWM services under these laws. Other legislation which refers to solid waste are scattered with very little substance through a number of national laws.

The Public Health Act places a duty on all local authorities to provide SWM services. The Local Government Act (LGA) gives power to local authorities to establish and maintain SWM services. NCC has also enacted several By-laws under the LGA through which it regulates SWM activities. The By-laws provisions cover the prohibition of illegally depositing waste, general duties of the generators of waste on the storage and collection and NCC's right to impose charges on citizens.

2.4.3 Evaluation of the Legislation which Directly Relates to SWM

The responsibilities of local authorities towards solid waste under the Public Health Act and the Local Government Act are covered in a very general way and therefore these Acts provide a very limited basis for the proper regulation of SWM. In particular:

(1) The Legislation is not comprehensive

Generally, the Acts are deficient to some extent in setting standards and conditions covering the key aspects of SWM, particularly operational aspects. For example, the Acts do not define standards for collecting, treating and transporting solid wastes or for the proper management of sanitary landfills and they do not refer to waste reduction or recycling.

(2) Solid wastes are not classified

There is no classification of waste in either the Public Health Act or the Local Government Act or in any other legislation. It seems that both Acts were intended to cover municipal waste only, without categorically stipulating so.

NCC and MOLG also assume that the two Acts imply that NCC is responsible for the collection and disposal of hospital, industrial and hazardous wastes, in the absence of any law expressly assigning responsibility for these wastes. All wastes are simply lumped together.

(3) NCC's By-laws

NCC's By-laws exhibit many limitations of the Acts. It deals with minor aspects of SWM, focusing mainly on prohibition of generators to illegally dispose of waste and on general provisions for generators to store and prepare their wastes for collection.

2.4.4 Analysis of the Local Government Act (Cap 265) Draft "Disposal of Refuse By-laws"

The "Draft Disposal of Refuse By-laws" was jointly prepared in November 1993 by the Ministry of Local Government (MOLG) and GTZ (Deutsche Gesellschaft Technische Zusammenarbeit) under the UWASM programme and was made available to Kenyan local authorities as a basis to enact a local SWM By-law. A large number of local authorities including Eldoret, Kiricho and Thika have already adopted it.

However, the By-laws deal only with arrangements for collection of refuse. It needs to cover the entire waste management cycle, from generation through collection, treatment (including separation), to transport and final disposal. All of these aspects are important.

2.4.5 Enforcement

Enforcement mechanisms and penalties are contained in NCC's By-laws. However, enforcement seems to be weak because the By-laws fail to define the standards of solid waste, penalties are low and do not deter violators, and it may be difficult to restrain waste generators from illegal acts.

2.4.6 Legal Basis for Private Sector Involvement Study in SWM

The legal basis of private sector involvement for local authorities is established and governed by the powers contained in the Local Government Act, Cap 265 of the Laws of Kenya.

Section 160 of the Act gives local authorities, NCC included, power to provide SWM services. Section 143 states that "a local authority may enter into contracts necessary for the discharge of any of its functions." This indicates that NCC is free to contract out SWM services to private sector companies. Local authorities are not proscribed from legally doing so.

Section 148 empowers the local authority to impose fees or charges for any service or facility provided or goods supplied by it in pursuance of or in connection with the discharge of any duty or power of the local authority. Further, all fees or charges imposed by the local authority shall be regulated by By-laws, or if not regulated by By-laws, may be imposed by resolution of the local authority with the consent of the Minister.

Currently, SWM charges are regulated by the City of Nairobi (Conservancy) By-laws 1961 L.N. No. 659 of 1961.

2.5 Private Sector Involvement in SWM

2.5.1 Current Situation of Private Collection Services Delivered under Open Competition

Currently, there is a significant amount of private sector provision of collection services to predominantly middle to high income households and businesses in Nairobi. However, there is no private sector provision of either street cleansing apart from the Central Business District or disposal services both of which are exclusively provided by NCC.

Private collection services are delivered under open and completely unregulated competition, i.e., private companies are free to provide services to whom and to where they like and collect tariffs directly from customers. The tariff ranges from Kshs. 150 to Kshs. 550 for collection services once a week. NCC has no contractual involvement with the private sector and does not regulate it.

NCC estimates that there are about 60 private collection companies operating in Nairobi.

2.5.2 Current Situation of the Contract for Collection and Street Cleansing in Nairobi's Central Business District

NCC has contracted out waste collection and street cleansing services in the Central Business District (CBD) of Nairobi. The Kenya Refuse Handlers Ltd. has been providing the contracted services since September 1997. The contract will run for one year. This is the only involvement that NCC has in contracting out SWM services.

Street cleansing includes street sweeping, gully cleaning and collection of waste from public litter bins as well as transfer to the final disposal site. The collection service in the CBD covers commercial customers, i.e., offices, shops, hotels, restaurants and kiosks, as well as public institutions.

The contract is financed from NCC's "general taxation" revenues because the current waste charges are insufficient to finance it. NCC proposes to levy new waste charges on CBD businesses and households to finance the contract.

NCC plans to present the new waste charges and discuss the new contracting arrangements with the CBD business community, with the objective of getting their support to the new regime and agreement to pay the new waste charges. Once CBD customers are satisfied and confident that NCC can provide a good service through the contract, the new charges will be introduced. NCC will monitor the CBD community to see when it is appropriate to introduce the new arrangements.

2.5.3 Performance of the CBD Contract

The contractor, Kenya Refuse Handlers Ltd., initially performed very well and there was a very substantial and very noticeable improvement in collection and cleansing services in the CBD. However, NCC has been unable to finance the contract and to make payments to the contractor. As a result, the Kenya Refuse Handlers Ltd. has to

reduce the level of its services. NCC's current financial situation makes the future viability of the contract very uncertain.

2.5.4 National Arrangements for the Regulation of Private Sector Involvement in SWM

There is no formal policy for Private Sector Involvement in SWM at the central government level. There are no national laws which cover private sector involvement in SWM, nor is there any responsibility assigned at the central government to give guidance to local governments on how to regulate the private sector.

The Ministry of Local Government (MOLG) should take the lead to formulate a policy and to issue guidelines to local governments on how to regulate and manage PSI in their services.

In addition, the Ministry should monitor local governments' involvement of private sectors, e.g., to ensure that they comply with and meet certain standards of tendering, awarding and monitoring contracts.

Policy should be coordinated with the Ministry of Environment and Natural Resources (MENR). It should be noted that the MENR endorses PSI in SWM.

2.5.5 Evaluation of NCC's Capacity to Regulate the Private Sector

Pre-contract award arrangements, i.e., from the initial identification of the contract requirement to the award of the contract, need to be strengthened, e.g., by improving contract strategy, contract documentation and contract management.

Likewise, monitoring and enforcement of contracts after they are awarded are not so effective at present. The physical monitoring arrangements being implemented for the CBD contract are sufficient but seem to need further development.

As it is the Council's policy to contract out collection services means that a contract management capability needs to be developed in advance of any contracting. At the appropriate time the DoE needs to establish a separate Contract Management Section headed by a Contract Manager who has contracting expertise. The Contract Manager should have strong coordination with the Town Clerks Department.

2.6 Collection and Transportation Study

2.6.1 Present Conditions of Collection and Transportation System for SWM

(1) Collection Method

Collection methods in Nairobi are primarily classified into the following two categories: station type collection and door-to-door type collection.

The results of the time and motion study show that distribution of the station type is 91% for NCC and 48% for private collectors, while distribution of the

door-to-door type is 9% for NCC and 52% for privates. This clearly shows that NCC depends mainly on the station type collection.

In addition, NCC provides the station type collection services mainly for commercial and middle and low income residential areas in Nairobi. Due to lack of collection vehicles, it is much easier and more efficient to collect discharged or dumped waste on the edge of alleys and in open derelict spaces rather than the collectors dropping in each household. The station type, according to site observation, is used by private companies for waste collection from the commercial area and flats or housing complex where a large amount of wastes are generated.

On the other hand, the door-to-door type collection is widely used by private collectors especially in high income residential areas, because almost all high income residents are living in separate houses where it is more convenient for them to be visited for waste collection. Also, by the door-to-door type, private companies can easily collect charges from each household on a contract basis.

(2) Collected Solid Waste

(a) Amount of Solid Waste Collected

The solid waste amount survey shows that the average amount of solid waste carried by collection vehicles is 195 tons per day. Some 40% of the total amount, i.e., about 80 tons are collected daily by NCC and the remaining 60%, i.e., 115 tons are collected by private companies. The same survey shows that a collection vehicle of either the NCC or a private company can carry approximately 4 tons of solid waste per trip on the average.

(b) Amount of Solid Waste Collected from the CBD Area

According to the data submitted by a private collector, Kenya Refuse Handlers Ltd. (KRH), to the Cleansing Section of DoE, the amount of solid waste collected from the Central Business District (CBD) area is estimated at 557 tons per day. However, this figure is actually unrealistic because the tonnage carried per trip is 9.4 tons on average despite the average weight of carried waste is generally 2 to 3 tons per trip according to the waste amount survey. Also, it was observed that KRH either does not have any weigh-bridge or try to weigh in somewhere. In addition, KRH refused to be surveyed by the waste amount and time and motion study, so that there is no data in terms of its daily operation. Thus, the data presented for KRH is revised on the assumption that the recorded tonnage is the volume of carried waste, not the weight. The average carried waste is estimated at 167 tons per day. This estimate is almost double of the waste amount collected by the NCC.

(c) Total Amount of Solid Waste Collected

By combining the above two estimates, the average amount of solid waste carried by collection vehicles is approximately 360 tons per day, or about 25% of the total amount of waste generated in the city. In the first field survey, the carried waste amount is estimated at 200 tons per day. This result shows a considerable increase of waste amount carried in the city after starting a contract for waste collection in the CBD area.

NCC collected 22% of the total amount, and private collectors collected 32%. The contract in the CBD has the largest part of the waste amount collected in the city, i.e., 46%.

(3) Kind of Solid Waste Collected

On the average about 61% of the solid waste collected come from residential areas, while 21% are from industrial areas and 6% from roads. Household waste seems to be the single largest source of solid waste carried by collection vehicles in the city. Site observations show that waste from residential areas include hospital waste and wastes from industrial areas are mixed with residential waste. This observation shows one tendency of solid waste composition in the city.

(4) Kind of Collectors

A wide variety of some 54 to 55 organisations of waste collectors carrying solid waste to the Dandora dumpsite were observed during the solid waste amount surveys.

NCC and private collectors are the two major collectors in the city. About 70% of all visitors to Dandora are occupied by both of them.

(5) Collection and Transportation Operation

(a) Operation Time

Collection and transportation work mostly starts from 7 to 8 o'clock in the morning and finishes around 5 to 6 in the afternoon for both NCC and private collectors. The total operation time of NCC is almost the same as that of private collectors; i.e., 330 to 416 minutes for NCC and 376 to 402 minutes for private collectors on the average, which is approximately 6 to 7 hours. However, three major private companies, i.e., Bins (Nairobi) Services Ltd., City Bins and Domestic Refuse (K) Disposal Ltd. (usually called "DRDS"), work longer than NCC. Their average operation time is calculated at 468 minutes (approximately 8 hours). NCC spends much longer for transport than collection, although the private collectors mostly take a longer time for collection.

(b) Operation Distance

In terms of average distance for daily collection and transportation operation, the study results show that NCC has the longest transportation distance among the major waste collectors in Nairobi. As to operating distance per trip, the private collectors, on the contrary, has a longer operating distance than the NCC; in other words, approximately 35 km per trip for NCC, and 50 km per trip for the private collectors.

(c) Number of Trips

The two different surveys, i.e., the solid waste amount survey and the time and motion study, bring nearly the same results; that is, the average number of trips per day for each collection vehicle is 1.7 to 2.0 trips for NCC while private collectors make only 1.2 to 1.4 trips. The larger number of trips for NCC results from the different types of collection method between NCC and private collectors as previously mentioned.

(d) Number of Crew

The average number of crew for each NCC collection vehicle is 4.8 while the private average is 4.0 from the time and motion study. The results of the waste amount survey also show the same tendency. This crew includes one driver so that the number of workers for loading waste may be 3 to 4 people. This is slightly larger than that of private collectors but it is not a large number.

(e) Collection Area

Although the collection area varied from survey to survey, the collection services by both NCC and privates on the average seem to cover all the districts in the city. NCC collects the waste almost equally from each district, and the proportion of each district is between 14% and 23% of the total. On the other hand, the private collectors mostly pick up the waste from the Western District where many high income residents live.

(6) Maintenance of NCC Vehicles

(a) Availability of NCC Vehicles

The availability of vehicles is calculated based on the daily records of NCC's collection vehicles at the Kaloleni Cleansing Depot. The average number of workable trucks for collection is approximately 15, and the average number gradually decreased from nearly 20 trucks in August and September 1996 to 13 trucks in May 1997.

Also, government trucks have been provided specifically by the National Youth Service (NYS) since June 1996 and the maximum number of trucks from NYS was recorded at about 18 in July 1996. The number of the NYS trucks, however, has remarkably decreased since November

1996. No support from NYS was given to NCC between October 1997 and January 1998.

(b) Causes of Failure

According to the average records regarding NCC vehicle operations from May 1996 to May 1997, the causes of failure of NCC trucks and the number of days used for repairs have been counted and accumulated for each cause. As a result of this analysis, the 'Service' and 'Financial' items represent trucks which are under service or with financial problems. Although these items are not related to mechanical failure, they contribute to the increase of non-working vehicles.

Major failures resulted from 'Accident' which occupy about 20% of all failures. Other causes of failure are mechanical problems, specifically coming from 'Engine,' 'Gear' and 'Brake' troubles. The proportion of these failures ranges between 15 and 20%.

2.6.3 Evaluation of the Current Collection and Transportation System for SWM by NCC

(1) Collection Method and Service Level

The NCC collection method depends primarily on the station type of collection which seems to be unable to cover the entire city due to extremely insufficient number of collection vehicles. The collection coverage ratio, i.e., the proportion of amount of waste collected to the total amount of waste generated, is consequently very low at about 25% at present. This poor collection service has resulted in the environmental deterioration over the residential area, causing fear of deterioration of public health.

In view of time spent for collection and transportation activities and the number of trips, the station type system has worked relatively well under "crisis management" circumstances, i.e., scheduling of collection and street cleansing is no longer necessary and the service is operated on a day by day basis. In addition, since there are many flats and housing complexes dominantly in middle and low-income residential areas of the city, the station type of collection is more efficient than the door-to-door type to pick up waste from households. Nevertheless, urgent actions for the improvement of the collection and transportation services are required.

(2) Vehicle Operation

While it may be suitable to conduct the station type of collection under the limited number of vehicles, daily operation is not necessarily efficient due to totally depending on manual loading of waste except for the time when a wheel loader is used together with a collection truck. The time and motion study shows that the average loading time by NCC is 54 minutes for one trip and 21 minutes for one collection point. Based on this result, the required time

for loading may be reduced considerably if a mechanical loading system, specifically containerization, is introduced.

(3) Collection Area

The analysis of the field survey result clearly illustrates that some locations in the city have no collection service. The NCC services concentrate only on the downtown and west-northern area of the city such as Starehe and Parklands, while the eastern edge of the city such as Karen/Langata, Mutuini and Waithaka have no collection service. Even though these eastern edge areas naturally do not generate a large amount of waste, the collection service should be equally provided for all residents as one of the public services of NCC.

(4) Vehicle Maintenance

The review of daily operation and maintenance records show that inappropriate vehicle maintenance, in particular, causes a extremely low level of vehicle availability. In addition, the main causes of failure such as brake, wheel and gear require a long duration at the workshop due not only to lack of spare parts but also long procedures for procurement of the spare parts.

All the required spare parts, tools or equipment have to be purchased through the City Treasurer's Department. The Department of Environment (DoE) cannot deal autonomously with the procurement of spare parts and other required physical materials. This bureaucratic system actually interrupts immediate supply for replacement and repair in most cases. A new workshop which will be fully managed by the DoE should be constructed to cover preventive maintenance of the collection vehicles on a daily basis.

2.7 Waste Reduction, Recycling and Intermediate Treatment

2.7.1 Current Activities on Community Based SWM Projects

Due to the decline of solid waste collection services by NCC, community based solid waste management was initiated in 1992, particularly in the informal settlements, to clean the neighbouring area and to setup self-help income generation projects for the community.

Currently there are 15 groups involved in composting and other waste management activities, mainly concentrated in low income areas. Eleven (11) of these groups are supported by the Foundation of Sustainable Development in Africa (FSDA), and 10 groups produce solid waste derived compost. The total number of members is approximately 10,300 people.

The amount of final products of compost of each group is estimated to be 200 to 2,500 kg a month. Total production amount reaches 8,300 kg a month which is equivalent to raw material input of 20 to 30 tons a month or 0.7 to 1 ton a day. In other words, the community groups collect and treat municipal solid waste of about 1

ton everyday. The compost is sold at 5 Kshs. per kg and the groups earn 41,500 Kshs. a month.

Composting by the groups has a potential of generating income; however, the groups are facing a number of constraints to maintain their activities. The most significant of these is procurement of land on which to carry out their activities.

2.7.2 Resource Recovery by Scavengers

A questionnaire survey was conducted with the scavengers at the Dandora Dumpsite who recover recyclable materials from municipal solid waste. Some 513 people responded to the questionnaire.

According to the survey, materials recovered by scavengers are more than 30 types. The major materials recovered are ferrous metals (tin and cans), plastics, bottles, bones, paper, textile, non-ferrous metals (aluminum and copper) and so on. On the average, each scavenger recovers 46 kg. and earns 105 Kshs. per day. Average selling price is calculated at 2.4 Kshs per kg. Unit price for each type of recovery material ranges from 1.8 to 3.5 Kshs. per kg. for ferrous metals and non-ferrous metals, respectively. Among the major recovery materials, the cheapest selling price was 1.8 Kshs. per kg. for ferrous metals and paper.

On the other hand, an interview survey with recycling companies shows that the purchase price ranges 3 to 5 Kshs. per kg. for plastics and ferrous metals. Judging from the difference of unit prices between the questionnaire survey and the interview survey from recycling companies, the recovery amount per scavenger is estimated at about 30 kg. per day, more or less.

2.7.3 Activities of the Solid Waste Recycling Industry

The solid waste recycling industry has not developed well in Nairobi, but some recycling companies are playing a key role in resource recovery through purchasing recovered materials from scavengers and manufacturing process wastes. Some 26 companies in 7 types of industries relevant to recycling activities were identified in this study. Twenty (20) companies out of the 26 companies are known to have been purchasing recycled materials from the groups operating at the Dandora Dumpsite.

Among the 26 companies, questionnaire survey was conducted with six (6) companies. These companies are one community based group for composting, one company for production of steel bars, two companies for production of plastic goods and two companies for production of paper.

The size of these recycling companies ranges from 16 to 300 in terms of number of employees. The two plastic factories produce 1 and 4 tons plastic goods per day using processing leftovers from other plastic manufacturers. Two paper factories produce 10 and 15 tons of paper goods per day using wastepaper. A steel company produces 40 to 80 tons of steel bars per day but use of waste steel is nil. A compost production group produces about 0.4 tons of compost per day using organic waste from markets.

2.7.4 Community Based Organisations (CBOs)

Considering public participation in solid waste management, the involvement of community based organisations (CBOs) will be a key issue on how to make use of their functions for implementation and establishment of efficient and effective solid waste reduction and/or resource recovery activities. Survey was made with Non-Governmental Organisations (NGOs) and church groups in Nairobi.

A directory of Non-Governmental Organisations (NGOs) No. 2/96 issued in September 1996 was obtained. The directory shows all the NGOs registered at the Non-Governmental Organisations Coordination Board, Office of the President. The directory shows the fields of activity, area of operation, contacting address and others. The total number of the NGOs registered are 672 groups all over the country. Out of this number, three hundred fourteen (314) NGOs have registered their operation areas as Nairobi and/or countrywide. The names of NGOs, postal address, telephone number, sector of operation and area of operation are tabulated in **Section 7.1 of Data Book (1)**.

In addition to the NGOs, school and church groups have a great possibility to participate in the programmes. The total number of primary schools in Nairobi is 232, accounting for 186 primary schools belonging to NCC and 46 primary schools belonging to private entities.

On the other hand, church groups also have a high possibility to get involved. Churches and relevant bodies number about 390 in Nairobi. The names of churches and relevant organisations or associations are tabulated in **Section 7.2 of Data Book (1)**.

The activities of these CBOs extend to various fields including water, religion, health, environment, population, relief, informal sector, social services, welfare, child rights, education, etc., and the fields of activity are closely related to daily life. The establishment of links between these CBOs and the NCC is needed to encourage them to participate in public services.

2.7.5 Evaluation of the Current Status of Solid Waste Recycling and Resource Recovery

Solid waste recycling is being carried out by the community based self-help groups and several recycling industries only as a small scale activity. The self-help activities of the Mukuru project earned 1.55 million Kshs. in 1996 from the materials recovery of 1,018 tons per year operated by about 60 members, but the income was not sufficient for their living and the cost for improving efficiency of the activities. The major problem of the Mukuru project is to secure a stable sales route for the recovered materials, especially for wastepaper and compost, with the assistance of the NCC.

Due to the unstable supply and quality of materials recovered by community based self-help groups or the scavengers, it is not convenient for the recycling industries to use the recyclable materials. Recycling industries (e.g., steel, paper, plastics) expect the NCC to launch a public educational campaign to promote the use of recycled goods, the separation and resource recovery at generation sources, distribution of

recyclable materials and financial support, so that the recycling industries can use more of the recyclable materials from municipal solid waste.

Composting activities of the community base self-help groups forming the Nairobi Compost Co-ordinating Group are not effective in terms of the amount of waste treatment. The major constraints of their activities exist in procurement of land and equipment, storage of compost, transportation and securing stable marketing places. In the other words, the solid waste treatment amount through community based composting will not increase unless income generation meets the labour requirement and the cost with or without the support of the NCC.

Currently, the NCC is not involved in the resource recovery activities of community based groups and the recycling industries, nor is it involved in intermediate treatment of municipal solid waste. Nowadays, the growing social awareness of environmental conservation in solid waste management has promoted waste reduction, recycling and proper treatment of solid waste before disposal for the purpose of reducing pollution load to the environment. For the establishment of an integrated solid waste management in Nairobi, it will be required to carry out the waste reduction, recycling and intermediate treatment plan of the NCC, taking into consideration the world-wide tendencies and the local constraints in consistency with the planning for collection, transportation and collection systems.

2.8 Final Disposal

2.8.1 Present Condition of the Existing Dandora Dumpsite

The Nairobi City Council has been using 7 landfill sites for disposal of solid waste since 1968. Detailed information is in **Supporting Report Section H**.

In Nairobi, there is, at present, only one landfill site, which is located at Dandora. With an area of about 26.5 ha, the site is located 7.5 km southeast of the centre of Nairobi. It is filled with approximately 1.3 million m³ waste at present. The site map is given in **Figure 2.8-1**.

The Dandora disposal site has been owned by the NCC but recently the land was acquired by a private developer. The site can be used for several years more, if waste is loaded up a few meters higher; however, the NCC has decided to stop the dumping of waste and turnover the site to the private developer. Therefore, a temporary landfill site is required for piling up wastes until a new landfill site is ready for operation; otherwise, the Dandora site is to be used during the transition period.

The construction of a new sanitary landfill site, at any rate, is an urgent matter for NCC's solid waste management. The present condition of the existing dumpsite is as described below.

(1) Environmental Condition of the Dandora Dumpsite

Adjacent to the Dandora dumpsite is the Dandora Housing Estate. However, there are no facilities provided to prevent secondary pollution. There is a high

risk of environmental pollution which may affect the health of residents in the following ways:

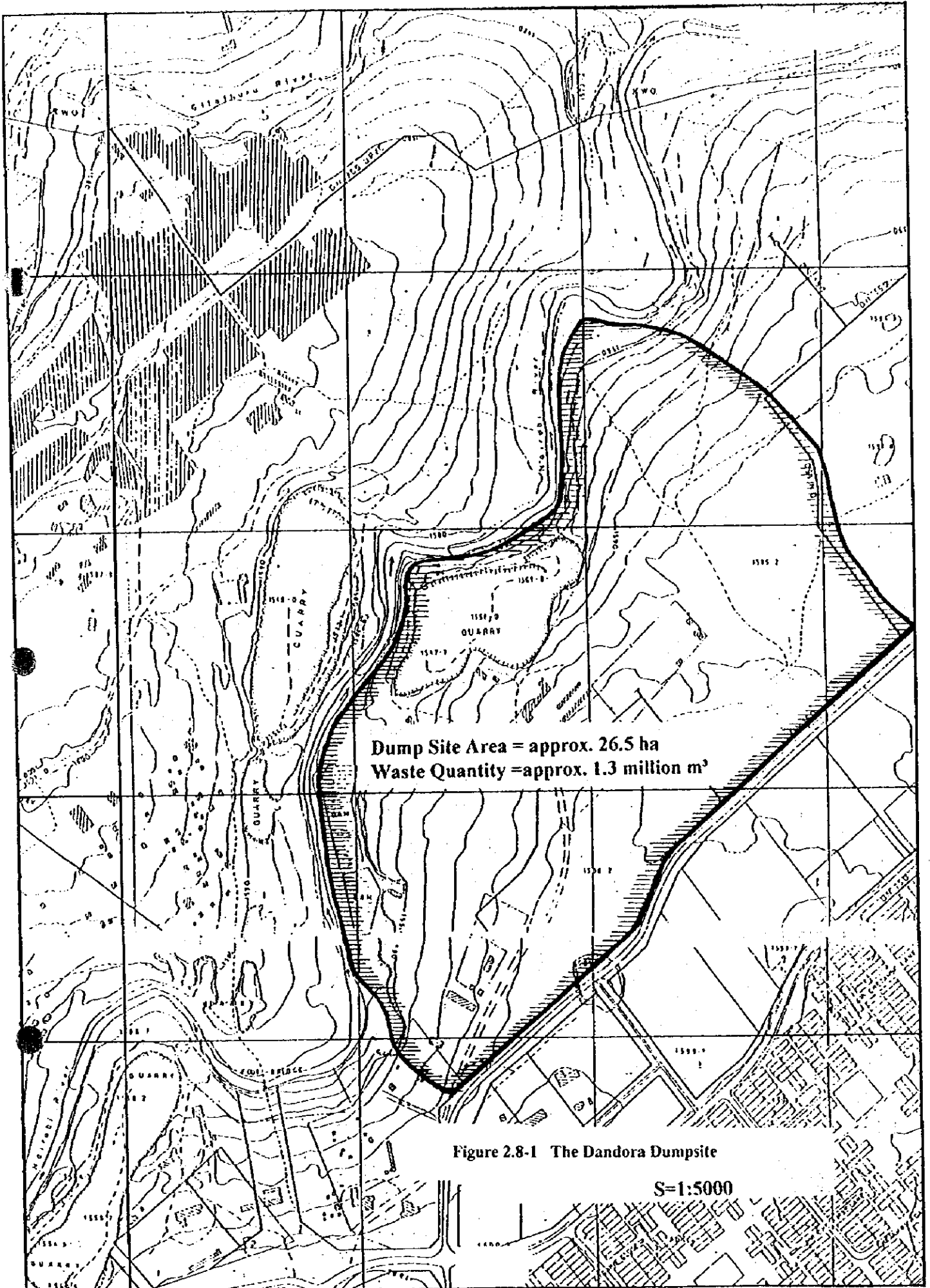
- (a) Smoke, odour and rodents break out and these will affect the health of people living near the site. The problem may become more serious because the dumping operation area is moving towards the housing area.
- (b) There is a high risk that leachate generated from the waste deposits will contaminate surface and groundwater on the Nairobi riverside.

(2) Management Condition of Dandora Dumpsite

- (a) Controls being undertaken to prevent toxic and hazardous wastes into the site are not so effective.
- (b) A systematic operation of the landfill is sometimes difficult to achieve; tipping method and area are often decided by the drivers of dumping vehicles.
- (c) The site office is so far from the dumping area; therefore, truck drivers often disregard the instructions of site controllers as to the correct waste dumping place.
- (d) There is a need for heavy equipment to manage the daily land-filling work and to cope with the situation, wastes are first compacted and then removed to a suitable tipping area.

2.8.2 Evaluation of Current Conditions

Environmental and management conditions of the existing Dandora Dumpsite, as well as the final disposal system of NCC, are in a critical situation. It is therefore necessary to improve the existing site conditions and ensure sanitary conditions at the new landfill site.



2.8.3 The Introduction of Sanitary Landfill

(1) The Establishment of Landfill Disposal Concept

The aim of solid waste disposal is to immediately remove solid waste from the urban community and reduce its volume, making it stable and hygienic. In choosing the process of proper treatment and disposal, not only the geographical area but also the financial situation and the level of technology within the organisation responsible for solid waste management should be considered. This management process can usually be divided into three processes: collection/transport, intermediate treatment and final disposal. Basically, the landfill disposal process finally restores solid wastes to nature.

The purpose of landfill disposal is to stabilise the solid waste and to make it hygienic through proper dumping of waste and use of natural metabolic functions. Therefore, it is important to have a practical method of disposal which can be decided upon by regional condition and organisational situation. In making this decision, it is important to take into account the type, form, composition of waste, location of landfill site, regional, hydrological and climatic conditions.

In planning the final disposal system, it is necessary to determine the types and volume of waste for landfill and to formulate an effective master plan for solid waste management based on actual needs of the region. The final disposal plan should also be formulated in such a manner as to be organic with the collection or hauling plan and the intermediate treatment plan.

(2) Adoption of Sanitary Landfill

Although open dumping as currently practiced by NCC is the cheapest method of disposal, it causes environmental pollution and can potentially affect the health of local residents living near disposal sites. Therefore, it is necessary for Nairobi City to adopt the sanitary landfill. Sanitary landfill of the highest environmental standard is still much more economical than other intermediate treatments.

A complete landfill system requires a large amount of capital investment. Taking into consideration the size of NCC's annual budget and NCC's financial situation, various problems are expected with regard to the funding of a complete landfill system.

It is thus unrealistic at the moment to adopt a complete landfill system. It is also important at the same time to consider the need to achieve a balanced urban infrastructure improvement and aspects of urban environmental preservation.

The basic landfill structure shall be planned through the decision of sanitary level for Nairobi City.

(3) Selection and Evaluation of Candidate Final Disposal Sites

(a) Outline of Landfill Site Selection Criteria

In selecting a sanitary landfill site, it is necessary to ensure that the site has a sufficient capacity to accept the planned landfill volume. In addition, the following aspects should also be jointly considered:

- (i) Landfill area is of sufficient size;
- (ii) Efficiency of collection and transport;
- (iii) Surrounding conditions;
- (iv) Topography and geological conditions;
- (v) Safety against disaster;
- (vi) Ultimate land-use plan; and
- (vii) Availability of cover soil.

Details of "The Selection Criteria of Landfill Sites" are given in Section 8.3 of Data Book (1).

(b) Selection and Evaluation of Candidate Final Disposal Sites

The selection and evaluation of the disposal site(s) was carried out based on the nine (9) candidate sites shown in Figure 2.8-2. Every site has been checked as to necessity of Initial Environmental Examination (IEE) and Environmental Impact Assessment (EIA) for screening and scoping. The results suggest that every site need IEE and EIA prior to implementation of the project. The detailed process of evaluation of the nine (9) candidate sites is shown in Volume 4, Supporting Report, Section H in compliance with the selection criteria of landfill sites.

In the selection, the major constraints to exclude candidate sites are as given in Table 2.8-1 below.

Table 2.8-1 Major Constraints to the Selection of Candidate Site

Major Constraint	Candidate Site
(1) Safety against disaster (Fire risk)	Ngong Road Forest Dagoretti Forest Karura Forest
(2) Surrounding condition (Close to Sports facilities)	Kasarani Area
(3) Geological condition (Hard rock is distributed)	Ongata Rongai
(4) Suitable Area for Landfill Site	Ruai Area* Industrial Area* Ruiru Town Athi River Area

* Cover soil is not sufficient at the site.

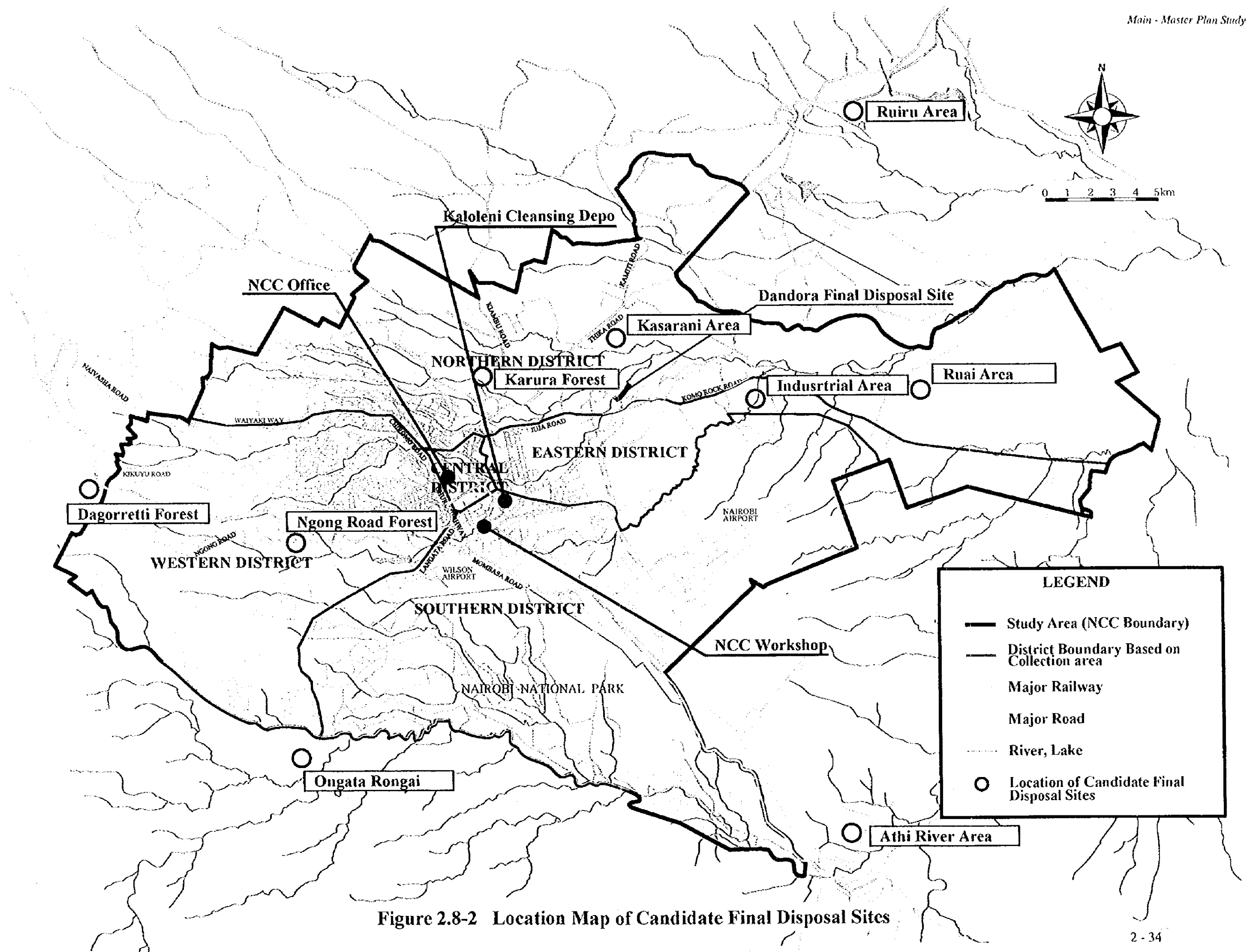


Figure 2.8-2 Location Map of Candidate Final Disposal Sites

The results indicate that four (4) sites have higher feasibility to be developed as landfill site, i.e., Ruai Area, Industrial Area, Ruiru Town, and Athi River Area. Following the first screening on the 9 sites, environmental and technical evaluation of 4 sites was made, as summarised in Table 2.8-2. This table shows that the results of each evaluation give different priorities.

NCC had selected the Ruai Area and the Ngong Road Forest Area for the feasibility study, taking into consideration the possibility of land acquisition. The selection of Ruai Area was given a high evaluation, because ensuring a new landfill site is an urgent matter for NCC's solid waste management. Since the Ruai Area belongs to NCC, NCC will be able to start the construction of a new final disposal site without long land acquisition proceedings.

On the other hand, the Ngong Road Forest Area had not satisfied the conditions of preliminary evaluation; hence, the Kenyan authorities strongly recommended carrying out an Environmental Impact Assessment (EIA) for both sites. The reason why the Ngong Road Forest Area was selected as candidate site is not only the high possibility of land acquisition but also the distance to the centre of the city. The closer distance would reduce the transportation cost compared with the case of only Ruai Area as the final disposal site. Therefore, the necessary investigations required for EIA and the facility plan were carried out at both sites in the second field study stage.

Table 2.8-2 Summary of Evaluation for the Candidate Final Disposal Sites

Site Name	Environmental Approach*		Technical Approach		Priority
	Evaluation (Merits)	Priority	Evaluation (Demerits)	Priority	
Ruai Area	<ul style="list-style-type: none"> • Available large land • No significant socioeconomic activities 	1	<ul style="list-style-type: none"> • Transportation • High construction unit cost 	3	3
Industrial Area Oxygenation Ponds	<ul style="list-style-type: none"> • Mitigation measures of landfill site will improve site conditions 	3	<ul style="list-style-type: none"> • Sewerage sludge should be treated and disposed • Small capacity • High construction unit cost • Private land 	4	4
Area towards Ruiru Town	<ul style="list-style-type: none"> • Limited settlement • Available large land 	2	<ul style="list-style-type: none"> • Out of Nairobi City • Private land 	2	2
Athi River Area	<ul style="list-style-type: none"> • Limited settlement • Available large land 	2	<ul style="list-style-type: none"> • Out of Nairobi City • Private land 	1	1

* Details are described in Section 2.9 below.

2.9 Environmental Considerations

The survey on environmental aspects during the Master Plan Phase was composed of two parts: environmental quality of Nairobi City and the Initial Environmental Examination (IEE) of candidate sites selected for the new landfill.

2.9.1 Environmental Quality of Nairobi City

(1) Water

(a) Surface Water

Field measurements were conducted by the Study Team to know the quality of existing rivers in Nairobi City. In accordance with the results, it is concluded that most of the rivers in Nairobi City are polluted, mainly by organic substances originating from uncollected solid wastes, industrial effluents and domestic wastewater. Besides, analysing previous reports on the subject, it is confirmed that the pollution of rivers crossing Nairobi City is not only organic substances but also heavy metals and chemicals.

(b) Groundwater

The existing data on groundwater quality in Nairobi Province shows an excess in fluoride and iron concentrations with respect to the World Health Organisation (WHO) Guidelines. Data on bacteriological, bio-chemical, nitrogen, pesticides and heavy metals are not available to have a comprehensive water quality data.

(c) Water Supply

Currently the coverage of water supply is about of 95%. The potability of water supplied could not be assessed due to lack of information on bacteriological quality.

(d) Water Pollution Control in Nairobi City

The most important sources polluting watercourses are industrial wastewater, domestic wastewater and solid waste. At present there is no systematic monitoring of the different effluents resulting from various industries.

(2) Sewage

The Nairobi City Council through its Sewerage Department has the responsibility of providing services of sewerage in the city. In the field observation, it was confirmed that some parts of the sewers are blocked or damaged, permitting the leakage of sewage directly into the rivers.

(3) Air Quality

There is no systematic air quality monitoring system in Nairobi; therefore, trends in air quality cannot be established. Currently, by simple observation of the city centre, it can be said that air quality has deteriorated mainly due to moving sources.

(4) Solid Waste

The survey was conducted on selected garbage collection points of the city and at the existing final disposal site at Dandora.

(a) Findings on Environmental Pollution by Solid Waste at Selected Garbage Collection Points

(i) High Income Area

Major findings are described below:

- Mainly there are single family houses with extensive grounds and gardens.
- The waste produced is domestic although it is composed also of garden wastes and wastes resulting from the pruning of trees.
- During the survey only in Langata could be seen an open dumping site.
- Presence of scavengers was also noted in Langata and Spring Valley.
- In some areas service is provided every Monday by NCC and in other areas by the private sector. Wastes are put in bins and stored in front of the houses from where they are collected.
- In some areas where no services are provided, the waste is managed by residents individually.
- Although collection services are provided regularly in most parts of the high income areas, the burning of garden waste resulting from pruning of trees is common.
- Environmental sanitation is quite satisfactory in high income areas due to the contribution of a proper solid waste management.

(ii) Middle Income Area

Major findings are described below:

- Open dumping is the usual method of disposal along the roads, next to the buildings, open spaces and even in the places allocated for recreational purposes including school environments.
- Burning of waste, presence of scavengers who deal with recycling and animals which feed on the waste, are the daily panorama of these areas.

- In some areas collection is not provided and the quantity of waste is reduced at the dumping place through burning by NCC employees or the residents.
- In some areas the collection is very irregular while in Nairobi West the collection is provided weekly by NCC and the private sector.
- Leachate generated from the waste and the waste in its solid form pollutes watercourses (mainly Nairobi River and partly Ngong River).
- One communal container could be seen and various refuse cubicles for storage were noted particularly in Madaraka. At the time of survey all of them were full of garbage with presence of flies and bad odour because no regular collection is provided.
- Near Kariokor market could be seen an open dumping site with presence of flies and smell, coexisting with a high number of people.
- Also observed was blockage of drainage channels in many parts of the area.
- Generally, waste in middle income areas is poorly managed.

(iii) Low Income Area

Major findings are described below:

- Open dumping of waste along the roads, burning of waste and presence of scavengers, domestic animals and birds, were common characteristics in these areas. Further, pedestrians crossing over the open dumping site were noted.
- In Makongeni (South) could be noted only one open dumping site with very small quantity of garbage. The place is relatively clean.
- In most of the places surveyed, the waste is clogging the drainage channel.
- No collection is provided in some areas while in other areas it is done occasionally. In some areas tractors and lorries are used in handling the waste.
- In the area of Kawangware, one cubicle managed by a community organised group for the storage of waste was observed.
- Production of compost from market waste is conducted under the auspices of NCC, UNEP, NGOs and residents.

- During the survey, a child trying to dispose of waste into the drainage channel was observed. This should be a consequence of lack of education on waste disposal.
- In Kariobangi North area could be seen a medium scale waste recycling placed on the road. At the time of the survey, smell characteristic of fermentation was noted.
- Sewage flowing over the landscape was observed in some areas.
- Public health risk in these areas due to poor environmental sanitation mainly in the solid waste management sector.

(iv) Slum Areas

Major findings are described below:

- Open dumping of waste along the road sides, burning of waste, presence of birds and domestic animals (chicken, sheep, goats, cattle), pedestrian crossing and sewage constitute the normal panorama of the places.
- Generally, waste is brought from the slums by the residents to the open dumping site located along the roadside. Kibera slum is an example of this practice. Service is not provided and at times tractors are provided to remove the garbage.
- Blockage of drainage channel could also be observed.
- Untreated sewage is discharged into watercourses such as the Nairobi River and Nairobi Dam.
- Community based organisations participation in solid waste management was observed in some slums like Kayaba. This kind of involvement in waste management could facilitate environmental management and sustainability in the area.
- Generally, the waste management in slum areas is unsatisfactory although residents are cooperative in taking the waste to the dumping sites along the roads and open spaces.

(b) Findings on Environmental Pollution by Solid Waste at the Dandora Dumpsite

Major findings are described below.

(i) General Information

The Dandora Dumpsite is the only existing final disposal site in Nairobi City and the place was a quarry site along the Nairobi River. The place is adjacent to a housing area.

Collected solid waste are disposed of by insufficient means permitting serious pollution.

(ii) Air Pollution

The Dandora Dumpsite can be categorised as an open dumping site, where burning waste is usually practiced causing air pollution. Offensive odour and smoke are the major complaints of people living around the place.

(iii) Water Pollution

The only existing river, Nairobi River, near the actual solid waste disposal site, is polluted by leachate and solid waste from the disposal site.

(iv) Health and Sanitation

The site constitutes a breeding ground for different organisms which are carriers of diseases such as malaria, typhoid, dysentery, etc. Cases of respiratory and stomach problems among children and teachers were mentioned by the people interviewed.

(v) Soil Pollution

The Dandora Dumpsite receives domestic, industrial, commercial, hospital and institutional wastes. During the field survey the dumping of tanneries' wastes was noted, meaning that until now toxic wastes are entering the disposal site at Dandora.

(vi) Social Aspect at Dandora Disposal Site

Scavengers

Since the dumpsite is unfenced, a big number of scavengers earn for their living by operating in the site.

Housing

The Dandora Dumpsite is surrounded by a densely populated area, including various schools.

2.9.2 Initial Environmental Examination (IEE)

(1) Candidate A (Ruai Area)

(a) General

The place available for disposal site is a grassland of about 20 ha., next to the actual Dandora Estate Sewage Treatment Works. There are no

trees in the site except the riverine vegetation (forest) on the left bank of the Nairobi River and the place is currently used for pasture of livestock.

(b) Socioeconomic Condition

There is no population living near the site although it is important to mention that the Ruai Area corresponds mainly to the low income area of subsistence cultivators, livestock caretakers and small-scale traders.

(c) Water

The Nairobi River is adjacent to the site and at the moment presents characteristics of pollution. Before entering the site, a population of about 5000 inhabitants is being served by a water supply system owned by NCC.

(d) Air and Noise

During the survey, no air pollution or generation of noise was noted.

(e) Landscape

The place is located on flat land adjacent to the Nairobi River.

(f) Conclusion

The sewage treatment plant can coexist with the proposed solid waste dumping site because of the available large land for a long term demand expansion and some similar characteristics of treatment. In addition, there are no significant socioeconomic activities at the site.

(2) Candidate B (Industrial Area - Kayole)

(a) General

The place is located at about 19.5 km from Nairobi City on a slope area adjacent to the Ngong River. The place for the disposal site of about 20 ha is composed of grassland, agricultural land and four ponds currently used for industrial wastewater treatment.

(b) Socioeconomic Condition

Most of the people living in the slum near the site are using the place for grazing and agricultural purposes. On the other side of the river, there are many quarries which currently are working 24 hours a day.

(c) Water

The existing surface water near the candidate site is the Ngong River which at the moment of the observation was of black colour and smell as

a consequence of high pollution. Regarding drinking water, the service is provided by NCC.

(d) Air and Noise

Production of hard dust and noise was observed from the quarries, affecting the environment of the place.

(e) Landscape

The landscape consists of flat topography which is bordered by two rivers to the West and East. The area has been transformed to a cultural landscape.

(f) Conclusion

The environmental condition of the area is quite unsatisfactory because of the agricultural fields irrigated with sewage, abandoned sewage treatment facilities, unauthorised dumping of solid wastes by private firms in the site and the hard production of noise and dust from the quarries. The proposed site can however be developed for short-term solid waste disposal use. To do this, mitigation measures have to be considered for a number of issues.

(3) Candidate C (Athi River Area)

(a) General

The place is located at about 27 km from Nairobi City on a slope area with respect to the main road. The place for the disposal site of about 20 ha is composed of grassland. The place is unfenced and is a private property. There are no trees in the site and some parts of the place is currently used for soil extraction and pasture for livestock.

(b) Socioeconomic Condition

Near the place can be found some industries such as a whisky factory which has about 90 employees. Currently, in some parts of the proposed site, extraction of soil for use in the cement industry and construction was observed.

(c) Water

The nearest existing surface water to the candidate site is the Athi River which is about 2 km from the site. Regarding groundwater quality, the whisky factory near the site is using groundwater for its production process and the water is quite salty.

(d) Air and Noise

Low level of dust and noise was noted from the excavation place and factories.

(e) Landscape

Some parts of the place are surrounded by hills and have an excellent view from the main road.

(vi) Conclusion

In view of the limited settlements and the availability of land for long term use, the site could serve as dumping site and can also be shared by NCC and Athi River Town.

(4) Candidate D (Ruiru)

(a) General

The place is located in flatland about 22 km from Nairobi City and about 3 km from the Ruiru Urban Center. The place for the disposal site of about 16 ha is grassland and a private property.

(b) Socioeconomic Condition

The area is used largely for cattle ranching. A milk production industry with 400 workers, Nicol Club with 80 staff and the Peponi Secondary School with 200 students are located in the vicinity of the site.

(c) Water

The nearest existing surface water to the candidate site is the Kamiti River which is about 1.0 km from the site. Besides the Kamiti River, there is a dry valley to the North with several dams mainly for watering domestic livestock. Some of the dams are used for irrigation. Groundwater is used for institutional, industrial and domestic consumption in the area. Regarding the quality, the water is quite salty, assuming that this is due mainly to calcium carbonate.

(d) Air and Noise

During the survey, no air pollution or generation of noise was noted in the proposed site area.

(e) Landscape

The place is located on flat land close to the Thika Road, but bordered by two valleys to the South and North.

(f) Conclusion

The site could be used for waste disposal taking into account mitigation measures such as landscaping, and measures against water pollution, noise and air pollution.

2.9.3 Environmental Justification for the Closure of Dandora Dumpsite

(1) Procedure of the Study to Justify the Closure

The study was carried out by a local consultant under the supervision of the JICA Study Team based on the prepared Terms of Reference and taking into account the existing laws and regulations related to environment in Kenya and the international standards.

(2) Negative Impacts of Dandora Dumpsite on the Environment

(a) Negative Impacts on the Natural Environment

(i) Air Pollution

Presently, refuse disposal is by the open dumping method. Strong winds and birds scatter the refuse and strong odour spreads in the neighborhood. From the field survey no offensive gases were detected but this fact does not mean that there is no generation of gases whose concentration level in the environment depends on climatic condition.

Burning of garbage at the dump is usually practiced causing air pollution which can increase respiratory illness in the area.

(ii) Water Pollution

During the survey period there was too much rain due to the El Niño phenomenon causing a considerable dilution of the water of Nairobi River. The water quality data collected by the survey could not be used for environmental assessment because they did not represent the existing condition of the river in the disposal site area. In this regard, more extensive survey is necessary to be made. Definitely, it is assumed that there is pollution of Nairobi River due to leachate.

As regard groundwater pollution, the current water quality of one borehole near the dumpsite seems to be not yet influenced by the dumpsite and this can be attributed to the soil property underlying the site.

(iii) Soil Pollution

From the analysis result it was demonstrated that the soil underlying the site is impacted mainly by chromium and lead.

(b) Negative Impacts on the Social Environment

(i) Housing

The disposal site is surrounded by a densely populated area with various schools. During the survey, a high percentage of respondents in the area have houses of permanent structure, and air pollution was considered as the most significant.

(ii) Public Health

According to the survey, the types of illness in the area range from malaria, cholera, dysentery and respiratory infections to typhoid. The Dump's unsanitary condition constitutes breeding grounds for many vectors of diseases. According to the survey there is a high level of awareness of the people in relation to the health hazards occasioned by a poor solid waste disposal; therefore, they can accept and cooperate with the closure of the dumpsite.

(3) Conclusions and Recommendations

(a) Current Impacts of the Dandora Dumpsite on the Environment

The survey period had coincided with heavy rains attributed to the El Niño phenomenon and some results of the analysis could not be used to reflect the current condition of the site. However, the social environment is the most affected according to the survey. Offensive odour, high frequency of respiratory diseases which are related to smoke, and a lot of flies around the area which are vectors of many diseases were common responses given by many interviewed people.

Finally, from the analysis result it was demonstrated that the soil underlying the site is impacted mainly by chromium and lead.

(b) Closure of the Dandora Dumpsite

Potential negative impacts to be generated during the closure and post-closure stages and mitigation measures are described below:

- (i)** Generation of offensive odour created by the construction of drains and landfill works is highly predictable. Mitigation measures include the proper management of the works for garbage accommodation as well as the provision of air masks to workers.
- (ii)** The water quality of Nairobi River is already too degraded and for this reason the impact will be of low significance during the closure stage and moderate after closure. Mitigation measures include the construction of drains with sediment traps and the proper management of the landfill works.
- (iii)** Dust and exhaust fumes from equipment and vehicles during the closure stage will result. Dust mitigation includes the watering of

access and operational places, the provision of air masks and protective clothing to operators and, finally, the soil materials should be covered with sheet. As for exhaust fumes, proper maintenance of equipment and vehicles shall be required. Frequent medical checkup and treatment of affected workers are recommendable.

- (iv) Moderate increase in the noise levels during the closure stage is expected to affect the workers and the communities located around the site. In this regard, the work schedule should be informed to the public and operation of heavy equipment should be limited to daytime only. Besides, adequate maintenance of equipment and trucks which must have exhaust mufflers is required to minimise this impact. On the other hand, the provision of ear muffs to workers is recommended.
- (v) The gas produced during the anaerobic decomposition process of the garbage in the landfill site can migrate underground and be accumulated in basements of buildings located in the migration way. Landfill gas has a high concentration of methane and for this reason it is potentially explosive. This impact is assessed as having a moderate significance due to the proximity of the dump to the residential area. The installation of a gas control system and the enforcement of land use regulation to avoid building construction in the area surrounding the disposal site are the proposed mitigation measures.
- (vi) During the closure stage, the number of vehicles necessary for transportation of materials to the dumpsite will generate low impact on the current traffic. To avoid more traffic congestion on Nairobi roads, it is important to select the nearest source for necessary materials.
- (vii) Once Dandora is closed, scavengers will be jobless. In this regard, NCC or the government should assist these people and to accommodate them in the new landfill site, or to make them work in other business establishments.

The potential positive impact by the closure is the improvement of health and environmental conditions of the surrounding population.

2.9.4 Project Justification

The Dandora Dumpsite which is categorised as an open dumping type has a detrimental effect on public health and the environment of the surrounding area due not only to air and water pollution but also to the associated problems of insects and animal pest. For this reason the construction of a new landfill site in a sanitary manner is highly recommendable to improve the environmental quality of the city and the level of public health.