2.2.2 Project Description

The proposed project is the construction of a new landfill site which will receive the urban domestic waste produced in Nairobi City. The new landfill site will consist mainly of the following components:

(1) Fence
(2) Building
(3) Truck scale
(4) Roads
(5) Ramps
(6) Drainage
(7) Gas and leachate treatment system
(8) Wells for groundwater monitoring
(9) Structures for solid waste retention

2.2.3 Present Environmental Condition

(1) Natural Environmental Condition

Sampling points for environmental analysis were selected taking into account existing resources, facilities and representative places of the candidate site as indicated in **Figure I.2-2.**

(a) Water Quality

(i) Surface Water

The only existing river in the area is the Matoine River which is located at about 500 m from the site. Two samplings of this river, up and downstream of the candidate site, were taken in two opportunities and the results of analysis are shown in **Table I.2-1.** In view of the absence of local standards for rivers, Japanese water quality standards were used to assess the water quality of Matoine River.

In the downstream of the proposed site this river is used mainly for watering tree nurseries while the upstream is used for agricultural irrigation. According to some interviewed people, the river is also used in some cases for domestic purposes since the potable water supply in the area is irregular. At the moment of the sampling, the river was of red color, attributable to soil erosion by rainfall.

Table I.2-1 Water Quality Analysis of Matoine River in Ngong Road Forest Area

Parameter	Water Quality Standard (1)*	Unit	Sampling Points			
			R1		R2	
			First Sampling (2)*	Second Sampling (3)*	First Sampling (2)*	Second Sampling (3)*
pH	6.0-8.5		7.4	7.4	7.3	7.3
Temperature		°C	18.5	18.2	19.8	19.5
SS	<100	mg/l	260	270	200	240
Nitrate	-	mg/l	0.12	0.15	1.1	1.3
Nitrite	-	mg/l	0.183	0.189	0.2	0.22
TN	-	mg/l	7.4	9.3	8.1	9.8
NH_3	-	mg/l	0.09	0.12	0.18	0.20
DO	>2	mg/l	5.5	6.0	5.5	5.9
BOD	<8	mg/l	10	10	5	5
COD	-	mg/l	144.2	84.7	76.3	69.0
Total Coliform	-	No./100ml	468	5800	720	21200
Fecal Coliform	-	No./100ml	258	30	306	70
Pesticides	-	ppb	ND	ND	ND	ND

Legend:

(1)* : Except pesticides, Japanese Standard Category D applied for industrial water, Class 2, agricultural water, and uses of Category E. For agricultural water, pH shall be between 6.0-7.5 and D.O. shall not be less than 5 mg/l.

(2)* : Sampling conducted on Nov. 21, 1997

(3)* : Sampling conducted on Nov. 25, 1997

R1 : River sampling upstream

R2 : River sampling downstream

\- : No fixed value

ND : Not detected (<0.01 ppb for all pesticides sought - organochlorine and organophosphate)

According to the result the water was neutral, turbid and well aerated. The water had a high level of both faecal and non-faecal contamination and for drinking purposes proper treatment including disinfection is necessary to meet the WHO guidelines.

(ii) Groundwater

Three (3) wells were selected for sampling. One of them belong to the Ministry of Agriculture (W1), the other one to the private sector (W2) and the last one was constructed by the JICA Study Team (W3). Results of the analysis are presented in **Table I.2-2.**

Table I.2-2 Water Quality Analysis of Groundwater in Ngong Road Forest Area

Parameter	Water Quality Criteria (1)*	Unit	Sampling Points					
			W1		W2		W3	
			First Sampling (2)*	Second Sampling (3)*	First Sampling (2)*	Second Sampling (3)*	First Sampling (4)*	Second Sampling (5)*
Pb	0.05	mg/l	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Cr	<0.05	mg/l	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Cu	0.1	mg/l	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Fe	0.3	mg/l	0.04	0.02	0.03	0.03	0.04	0.035
Mn	0.1	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zn	5	mg/l	0.89	0.583	2.06	2.04	2.15	2.10
Hg	0.001	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
As	0.05	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
pH	6.5-8.5		7.4	7.4	6.1	6.1	7.7	7.7
EC	-	uS/cm	0.393	0.370	0.250	0.266	0.10	0.10
Colour	15	Hazen	>30	>30	>30	>30	1	1
Turbidity	5	JTU	10	22	10	12	156	165
Total Coliform	0	No./100ml	1210	4148	1060	2160	1560	4250
Fecal Coliform	0	No./100ml	0	0	0	0	0	0
Chloride	250	mg/l	41.98	38.99	22.56	21.99	37.87	36.78
Sulphate	400	mg/l	0.00	0.00	0.00	0.00	0.387	0.256
Hardness	500	mg/l	144	136	170	160	120	130
Permanganate	-	mg/l	1.2	2.0	3.3	3.5	10.5	15.7
Nitrate	45	mg/l	7.00	6.40	6.50	5.20	5.12	4.67
Nitrite	0.01	mg/l	0.000	0.000	0.001	0.009	0.015	0.021
NH3	0.5	mg/l	0.0472	0.0584	0.0512	0.0534	0.0210	0.0150
TN	1.0	mg/l	7.9	7.8	9.25	9.6	9.1	10.1
Fluoride	1.5	mg/l	0.60	0.85	0.60	0.60	0.00	0.00

Legend:
(1)* : Criteria developed by NCC for drinking water
(2)* : Sampling conducted on Nov. 20, 1997
(3)* : Sampling conducted on Nov. 25, 1997
(4)* : Sampling conducted on Dec. 5, 1997
(5)* : Sampling conducted on Dec. 10, 1997
W1 : Well owned by Ministry of Agriculture (Bee-keeping area)
W2 : Well owned by private sector (Ngondo Village Area)
W3 : Well drilled for this project by the JICA Study Team

According to the results the groundwater in the area was neutral and turbid with non-faecal coliform contamination and low fluoride content. For drinking purposes water treatment including disinfection is necessary.

(iii) Drinking Water

NCC is in charge of supplying water through pipelines to the population around the candidate site. However in some places, for example in the primary school and forest station, water supply has been stopped for more than 5 years. This fact has brought about the use of Matoine River for domestic purposes including drinking in some cases, according to some interviewed people.

One sample of the distribution system where the supply is more regular was taken in two opportunities. Since the primary school which has about 1,200 children currently use rainwater to alleviate the severe problem that represent the shortage of pipeline water

supply, one water sample was taken from the rain storage tank in order to know the quality of water given to the children.

The results of the analysis are presented in **Table I.2-3** below:

Table I.2-3 Water Quality Analysis of Drinking Water in Ngong Road Forest Area

Parameter	Water Quality Standard (1)*	Unit	Sampling Points		
			D1	D2	
			First Sampling (2)*	First Sampling (2)*	Second Sampling (3)*
Pb	0.05	mg/l	<0.002	<0.002	<0.002
Cr	0.05	mg/l	<0.002	<0.002	<0.002
Cu	0.1	mg/l	<0.002	<0.002	<0.002
Fe	0.3	mg/l	<0.02	0.11	0.60
Mn	0.1	mg/l	<0.05	<0.05	<0.05
Zn	5.0	mg/l	0.00	0.065	0.162
Hg	0.001	mg/l	<0.02	<0.02	<0.02
As	0.05	mg/l	<0.01	<0.01	<0.01
pH	6.5-8.5		7.4	7.4	7.3
Temperature		°C	19.6	20.6	20.0
Colour	15	Hazen	>30	>30	20
Turbidity	5	JTU	1	0	81
Total Coliform	0	No./100ml	1050	610	940
Fecal Coliform	0	No./100ml	0	0	0
Permanganate	-	mg/l	2.8	2.2	5.0
Nitrate as NO_3	45	mg/l	0.15	0.9	0.45
Nitrite as NO_2	0.01	mg/l	0.00	0.00	0.011
NH_3	0.5	mg/l	0.156	0.0783	0.1143
TN exclusive NO_3	1.0	mg/l	0.31	3.8	6.4
Fluoride	1.5	mg/l	0.20	0.50	0.05
Pesticides	ND	mg/l	ND	ND	ND

Legend:
(1)* : Criteria developed by NCC for drinking water
(2)* : Sampling conducted on Nov.20, 1997
(3)* : Sampling conducted on Nov. 25, 1997
- : No fixed value
D1 : Ngong Forest Primary School Tank
D2 : NCC water supply system (Mutego Community Pipe)
ND : Not detected (<0.01 ppb for all pesticides sought - organochlorine and organophosphate)

From the result it was demonstrated the necessity of disinfection of the water to meet WHO guidelines.

(b) Fauna and Flora

The main findings are as described below:

(i) Distribution and Structure of Vegetation Types

In the Ngong study area several diverse vegetation types were identified and they include:

Indigenous Natural Forest

This was found in the vicinity of Ngong Forest Station, along the proposed access road to the candidate site and a small patch in Lenana School. This forest showed the characteristic structure of tropical forests with a dense undergrowth, middle stratum and

upper stratum. This forest is dominated by Croton megalocarpus and Brachylaena hullensis.

Plantation of Indigenous Trees

Exotic and indigenous plantations in Kenya have rapidly gained importance due to increasing demand for wood. The plantations are located along the river, around the station and in other areas. The main species planted are Croton megalocarpus and Brachylaena hullensis. The African Indigenous hardwoods in Kenya employed in joinery furniture and flooring are primarily Octon asambareusus, Brachylaena hullensis, Newtonii buchananii, Juniperus procera, Olea africana and Olea welwitschii.

Riverine Vegetation

Indigenous and exotic trees can be found in the riverine vegetation allocated between Mutoine River and the oil pipeline. Species of Eucaliptus, Crotons, Brachylaena, Jacaranda and a mixed stand of Acacia mearsii and Ligustrum licida exist.

Also in the riverine vegetation the diversity of plant species is high with many indigenous species and macrophytes which act as a good habitat for several species of birds. Along the vegetation the undergrowth is dominated by Lantana camara and Veronia brachycalyx. The latter is an important source of pollen for bees in the area.

Along the pipeline the vegetation was cleared of all woody species and is being frequently used by livestock from the neighbouring Mutuini settlement.

Plantation of Exotic Trees

Eucalyptus saligna mixed with Eucalyptus camaldutensis coppice, were found on the hilltop down to marsh grassland and bordered the indigenous forest. The undergrowth was an almost pure thicket of Lantana camara of about 2 m high. Animals sighted in the plantations were few, mainly birds. Even though Eucalyptus provides an important source of pollen for foraging bees, the trees were not in flower.

Grasslands and Ecotone

The grasslands within the candidate site occupy an area of 7 ha and their occurrence is a result of peculiar soil characteristics. The presence of grassland constitute the main reason of having chosen this site for landfill construction.

Between the grassland and the surrounding Eucalyptus plantation is an ecotone composed of trees and shrubs which are mainly indigenous consisting of Scolopea zeyalanica, Maytenus heterophylla and Rhus natalensis. Many of these species have medicinal value. The area is mainly utilised by antelopes and dik-diks, and birds for browsing and resting.

Settlements

- *Mutuini Area*

The area consists of low income settlement. During the survey it was noted that most of the area was either cultivated or under buildings. A strong tendency to practice agroforestry was observed as nearly all compounds had fruit or timber trees within the farms. Some livestock, mainly sheep and goats, and a small area under crops could be observed.

Regarding wind speed, it was of low level in the area probably due to the sheltering effect of the hill.

- *Kabiria Area*

Most of the farms are kept for pasture since they are generally waterlogged. Eucalyptus plantations were observed in marshy flat grounds. Bee-keeping is also practiced by some farmers.

(ii) Lifeform Spectra

The lifeform spectra consist of trees, shrubs, herbs, grasses and lianas, and according to the survey, in the Indigenous forest site could be found the highest number of species of the lifeform spectra. The second widest lifeform spectra was seen in the riverine community. The grassland on the other hand, due to the soil condition, completely lacks trees but form an important feeding ground for grazers.

The ecotone supports many species of shrubs and the settlements have mainly exotic timber trees, food crops, fruit trees and ornamental plants.

(iii) Density and Cover

Over 250 of plant species were identified in the Ngong vegetation communities [see **Section 9.4 of Data Book (1)**]. The lifeform with the highest number was the trees and among them were protected and overexploited species.

The greatest diversity of indigenous species was found in the Ngong forest station and the lowest was in the settlement.

(iv) Threatened, Rare and Endangered Species

Some of the most important species which are either rare, threatened or over-utilized are: Olea africana (under protection), Warbugia ugandesis and Brachylaena hullensis(overexploited), Elaeodendron buchaunanii (over-harvested) and Vitex keniensis (under Presidential protection).

(v) Common Uses of Plant Species

The main uses are for medicinal purposes, timber, ornamental, carving, spices, etc. The grassland plant species and the forest graminoids, herbs and shrubs at Ngong Station supporting many ungulates and livestock were observed.

(vi) Animal Distribution and Habitat at Ngong

The indigenous forests and riverine vegetation are supporting the greatest diversity of animals. Antelopes grazing in the grassland were observed and animals in the forests included baboons, monkeys, wild pigs, antelopes, birds, squirrels, frogs, chameleons, worms and bees. However, it was not possible to observe all of the animals due to time limitations.

An apiary at the edge of the Ngong forest which belong to the Ministry of Agriculture and Livestock was observed. Bees require a high diversity of plants to get pollen all year round and due to this fact bees mainly forage in the flora of the Ngong forest given that the surrounding areas are cultivated. The dam and seasonal river play the role of water resources for antelopes, birds and primates. The Consultant did not identify any rare or endangered species of animals in the area.

In terms of bird diversity, it is assumed that the 60 species of birds frequently found in the vicinity of the place (Nairobi National Park) can well migrate to the Ngong forest. [See **Section 9.5 of Data Book (1).**]

(c) Landscape

(i) Topography

Topographic survey was undertaken through visual observation by walking around the entire study area.

The topography of Ngong Study Area is relatively high at the western boundary reaching the elevation of 1,880 meters above mean sea level and falling to the east and southeast to the elevation of 1,820 meters near the main Nairobi-Ngong Road Bridge over Mutoine River.

The drainage of the area is composed mainly by Mutoine River and the southern tributary of Kerichawa Kubwa. These rivers flow from west to east and dissect the landscape forming deep valleys.

The land slopes steeply near Mutoine valley but it is flat at the middle of the spur and internally drained elongated basins are formed. These poorly drained basins are grasslands which form part of the site for landfill construction.

(ii) Geology

The geology of the project area is dominated by volcanic rocks associated with volcanic activities of the eastern escarpment of the Great Rift Valley. Weathering of these rocks have produced the dark brown loam soils in the well drained areas which are overgrown with forest and have crop cultivation. In the poorly drained flat lands, depressions and river valleys, rock weathering has resulted in the formation of dark grayish clay soils which are covered by grass. Below the dark gray clay soils at depths of 0.5 m to 1.0 m are the ferricrete overlying the weathered tuffs, agglomerates and trachytes. Permeability of the three dominant soils of the area are high for ferricrete, low for loam and poor for moist clay.

(iii) Land Use

The following major land uses were identified in Ngong Road Forest Study Area:

- Indigenous forest and plantation forest used for biodiversity habitat, commercial exploitation of wood, and for fuel and medicine.
- Bee-keeping which is dependent on the flowering of the plants in the forests and the surrounding settled areas.
- Residence areas
- Agricultural production of food crops in the settled areas including maize, beans, bananas and livestock fodder crops.
- Open grassland (glade) and adjoining ecotone which are important grazing, browsing, breeding and refuge areas for many animals and birds.
- Livestock production including cattle, sheep, goats and horses.
- Water storage by the two dams on Mutoine River, used for tree nursery at the forest station and irrigation and livestock watering during drought.

(d) Climate

Monthly mean rainfall, temperature and evaporation at Dagorreti Meteorological Station, which is 6 km from Ngong Road Forest Site Area, are summarised in **Table I.2-4.**

Table I.2-4 Climatic Condition of Ngong Road Forest Project Area (1955-1980)

Month	Mean Rainfall	Mean Temperature	Mean Evaporation	Dominant Wind Direction *
January	73	20.4	187	NE
February	60	21.2	178	NE
March	93	21.0	191	NE
April	211	20.0	149	SE
May	195	18.9	124	SE
June	37	17.6	98	S
July	19	16.6	89	S
August	25	17.0	100	S
September	35	18.8	138	S
October	52	20.0	167	SE
November	157	19.2	140	NE
December	92	19.8	160	NE

Sources: Climatological Statistics for Kenya by Kenya Meteorological Department, 1984.
The National Water Master Plan - Ministry of Water Development and JICA, 1992.

(e) Noise

For two days and for the period of 12 hours/day from 6 a.m. to 6 p.m. at Ngong Road and at the access road to the candidate site as indicated in **Figure I.2-2,** survey on noise and traffic were carried out simultaneously. The vehicles counted in both directions were categorised into small, medium and large sizes. **Tables I.2-5** and **I.2-6** show the results.

Table I.2-5 Noise and Traffic Survey on Ngong Road

Traffic Time	Small Vehicles		Medium Vehicles		Large Vehicles		Average Noise dB (A)	
	Date		Date		Date		Date	
	Dec. 02	Dec. 06	Dec. 02	Dec. 06	Dec. 02	Dec. 06	Dec. 02	Dec. 06
6:00-7:00	215	72	138	76	14	8	58	56.8
7:00-8:00	600	218	364	168	52	31	66.7	64.7
8:00-9:00	1081	476	372	241	52	31	66.5	63.4
9:00-10:00	531	674	321	194	86	68	60.2	66.0
10:00-11:00	337	761	243	280	12	57	64.2	65.6
11:00-12:00	479	750	278	351	60	55	62.6	65.7
12:00-13:00	326	635	167	178	31	55	63.9	68.9
13:00-14:00	450	651	225	199	65	54	63.1	64.7
14:00-15:00	395	596	287	282	47	43	71.5	60.6
15:00-16:00	339	628	270	286	36	46	75.5	63.4
16:00-17:00	599	628	348	246	73	32	78.5	62.9
17:00-18:00	739	825	359	260	36	33	77.4	62.9
Total	6091	6914	3372	2761	564	513		

Remarks: Heavy rains pounded the Ngong area during the survey period on Dec. 2, 1997. There were intermittent rains and windy conditions especially in the morning and drizzles in the early afternoon on Dec. 6, 1997.

Table I.2-6 Noise and Traffic Survey on Access Road

Traffic Time	Small Vehicles Date		Medium Vehicles Date		Large Vehicles Date		Average Noise dB(A) Date	
	Dec. 02	Dec. 06	Dec. 02	Dec. 06	Dec. 02	Dec. 06	Dec. 02	Dec. 06
6:00-7:00	6	0	3	2	0	0	51	47.4
7:00-8:00	22	5	8	1	3	0	53.2	51.4
8:00-9.00	24	19	8	5	3	1	55.1	51.2
9:00-10:00	45	41	9	15	5	1	57.6	55.4
10:00-11:00	30	35	23	13	2	2	54.6	53.7
11:00-12:00	27	34	17	10	2	2	55.8	56.1
12:00-13:00	29	43	21	18	3	8	54.7	58.1
13:00-14:00	34	21	6	5	3	3	57.1	54.8
14:00-15:00	38	31	3	8	2	1	55.2	54.5
15:00-16:00	25	36	2	8	0	2	63.8	53.5
16:00-17:00	48	21	5	13	0	1	64.2	53.8
17:00-18:00	27	30	10	8	2	1	57.9	53.9
Total	355	316	115	106	25	22		

2.3 Candidate B (Ruai Area)

2.3.1 Brief Description of the Site

The site is located on flat land adjacent to the Nairobi River at about 30 km east of Nairobi City, as presented in **Figure I.2-1.** The area available for the disposal site is composed mainly of grassland of about 20 ha., next to the actual Dandora Estate Sewage Treatment Works. The area is owned by NCC and its main entrance is fenced.

2.3.2 Project Description

The proposed project is the construction of a new landfill site which will receive the urban domestic waste produced in Nairobi City. The new landfill site will consist mainly of the following components:

(a) Fence
(b) Building
(c) Truck scale
(d) Roads
(e) Ramps
(f) Drainage
(g) Gas and leachate treatment system
(h) Wells for ground water monitoring
(i) Structures for solid waste retention

2.3.3 Present Environmental Condition

(1) Natural Environmental Condition

Sampling points for environmental analysis were selected taking into account existing resources, facilities and representative places of the candidate site as indicated in **Figure I.2-3.**

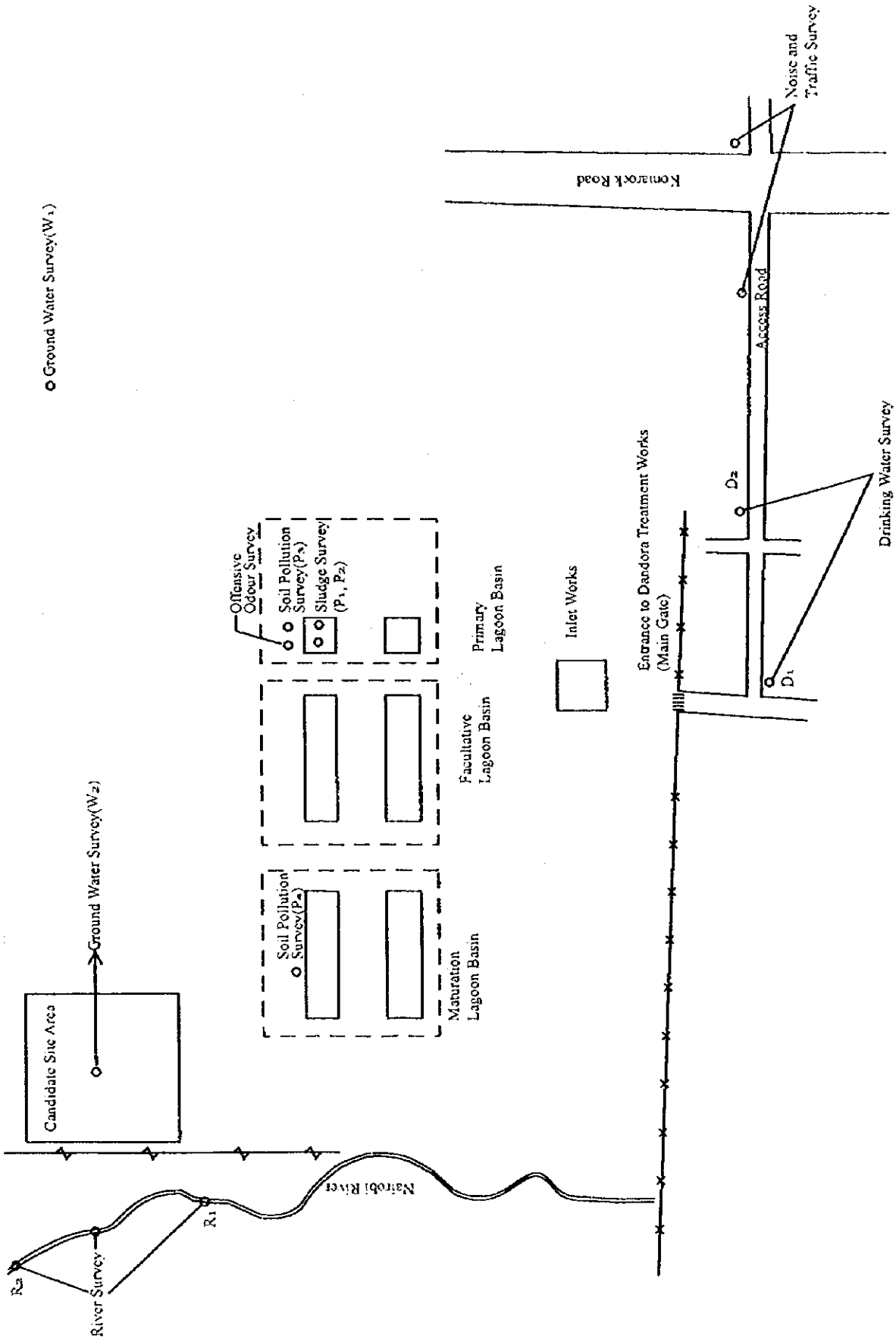

Fig.I.2-3 Location of Sampling Points for Environmental Survey in Ruai Area

(a) Water Quality

(i) Surface Water

The only existing river in the area is the Nairobi River which is located next to the site. Two samplings of Nairobi River, up and downstream of the candidate site as indicated in the **Figure I.2-3,** were taken in two opportunities and the results of analysis are shown in **Table I.2-7.** The water level of the Nairobi River has been higher than the usual level registered for the same period as a consequence of the early rainy period which was characterised with rains of short interval.

Table I.2-7 Water Quality Analysis of Nairobi River in Ruai Area

Parameter	Water Quality Standard (1)*	Unit	Sampling Points			
			R1		R2	
			First Sampling (2)*	Second Sampling (3)*	First Sampling (2)*	Second Sampling (3)*
pH	6.0-8.5		7.7	7.7	7.9	7.7
Temperature		°C	22.2	22.1	23.1	22.2
SS	(4)*	mg/l	400	430	310	340
Pb	<0.1	mg/l	< 0.002	< 0.002	< 0.002	< 0.002
Cr^{+6}	<0.05	mg/l	< 0.002	< 0.002	< 0.002	< 0.002
Cu	-	mg/l	< 0.002	< 0.002	< 0.002	< 0.002
Fe	-	mg/l	2.8	8.5	2.35	8.85
Mn	-	mg/l	0.1	0.1	0.1	0.1
Zn	-	mg/l	0.061	0.061	0.03	0.06
Hg	No detectable	mg/l	<0.02	<0.02	<0.02	<0.02
As	<0.05	mg/l	<0.01	<0.01	<0.01	<0.01
DO	>2	mg/l	7.2	6.5	7.1	6.5
BOD	<10	mg/l	25	37	23	21
COD	-	mg/l	186.5	152.6	186.5	152.6
TN	-	mg/l				
Total Coliform	-	No./100ml	18420	16830	32420	24350
Feacal coliform	-	No./100ml	960	1560	315	50
Pesticides	-	ppb	ND	ND	ND	ND

Legend:
(1)* : Except pesticides, Japanese Standard Category E applied for environmental conservation and industrial use of rivers
(2)* : Sampling conducted on Nov. 20, 1997
(3)* : Sampling conducted on Nov. 25, 1997
(4)* : Floating matter not observed
R1 : River sampling upstream
R2 : River sampling downstream
- : No fixed value
ND : Not detected (<0.01 ppb for all pesticides sought - organochlorine and organophosphate)

In view of the absence of local standards for rivers, the Japanese water quality standards were used to assess the quality of Nairobi River. From the analysis results the water was heavily contaminated with both faecal and non-faecal coliforms, high suspended solids and organic substances.

(ii) Groundwater

Two wells were selected for the sampling; one of them (W1) is owned by the private sector and is serving as water resource for cattle. The other well (W2) was constructed at the candidate site by the JICA Study Team for the hydro-geological survey (refer to **Figure I.2-3**). Results of the analysis are presented in **Table I.2-2.**

Table I.2-8 Water Quality Analysis of Groundwater in Ruai Area

Parameter	Water Quality Criteria (1)*	Unit	Sampling Points			
			W1		W2	
			First Sampling (2)*	Second Sampling (3)*	First Sampling (4)*	Second Sampling (3)*
Pb	0.05	mg/l	<0.002	<0.002	<0.002	<0.002
Cr	0.05	mg/l	<0.002	<0.002	0.06	0.06
Cu	0.1	mg/l	<0.002	<0.002	0.06	0.06
Fe	0.3	mg/l	<0.002	<0.002	82.80	82.40
Mn	0.1	mg/l	<0.05	<0.05	<0.05	<0.05
Zn	5.0	mg/l	0.44	0.52	0.58	0.58
Hg	0.001	mg/l	<0.02	<0.02	<0.02	<0.02
As	0.05	mg/l	<0.01	<0.01	<0.01	<0.01
pH	6.5-8.5		8.1	8.5	7.7	7.6
EC	-	µS/cm	0.91	0.79	0.12	0.13
Colour	15	Hazen	>30	>30	1.0	1.0
Turbidity	5	JTU	9	10	210	220
Total Coliform	0	No./100ml	6	210	610	1124
Feacal Coliform	0	No./100ml	0	0	0	0
Chloride	250	mg/l	66.98	65.98	60.12	58.27
Sulphate	400	mg/l	0.549	0.524	0.487	0.495
Hardness	500	mg/l	200	200	100	100
Permanganate	-	mg/l	2.1	2.6	15.6	20.7
Nitrate as NO_3	45	mg/l	0.04	0.032	0.010	0.021
Nitrite as NO_2	0.01	mg/l	0.001	0.0	0.241	0.271
NH_3	0.5	mg/l	0.069	0.069	0.051	0.031
TN exclusive (NO_3)	1.0	mg/l	7.3	7.8	8.9	9.2
Fluoride	1.5	mg/l	9.5	9.0	0.0	0.0

Legend:
(1)* : Criteria developed by NCC for drinking water
(2)* : Sampling conducted on Nov. 20, 1997
(3)* : Sampling conducted on Dec. 5, 1997
(4)* : Sampling conducted on Dec. 1, 1997
- : No fixed value
W1 : Private well (Kagia Ranch Embakasi)
W2 : Well drilled for this project by the JICA Study Team

According to the results of the analysis the water of the well W1 is slightly alkaline with high fluoride concentration and presence of non-faecal coliforms. The water of the well W2 was turbid and contains non-faecal coliforms.

(iii) Drinking Water

One well, located near the entrance of the Sewage Treatment Works, is used by NCC to supply water. The system is composed of deep well, reservoir and pipelines for distribution. Samples for this system were taken from pipelines (D1). The people served from the system have complained of brown teeth and salty taste,

assuming that it is due mainly to the presence of high concentration of fluoride in the water.

The other current water supply system owned by the private sector, whose distribution pipelines serve the population located around the Kangundo Road and the access road in the upper site, was also selected for the sampling (D2). Sampling points are indicated in **Figure I.2-3.** Samples were taken at the same day for both systems whose analysis results are presented in **Table I.2-9** below:

Table I.2-9 Water Quality Analysis of Drinking Water in Ruai Area

Parameter	Water Quality Standard (1)*	Unit	Sampling Points			
			D1		D2	
			First Sampling (2)*	Second Sampling (3)*	First Sampling (2)*	Second Sampling (3)*
Pb	0.05	mg/l	<0.002	<0.002	<0.002	<0.002
Cr	0.05	mg/l	<0.002	<0.002	<0.002	<0.002
Cu	0.1	mg/l	<0.002	<0.002	<0.002	<0.002
Fe	0.3	mg/l	<0.02	<0.02	4.6	12.5
Mn	0.1	mg/l	<0.05	<0.05	0.25	0.20
Zn	5.0	mg/l	<0.02	<0.02	0.06	0.07
Hg	0.001	mg/l	<0.02	<0.02	<0.02	<0.02
As	0.05	mg/l	<0.01	<0.01	<0.01	<0.01
pH	6.5-8.5		8.4	8.5	7.6	7.7
Temperature		°C	23.20	25.5	22.7	26.9
Colour	15	Hazen	>30	>30	5	5
Turbidity	5	JTU	5	17	148	134
Total Coliform	0	No./100 ml	25	9605	1050	12540
Feacal Coliform	0	No./100ml	0	0	2	50
Permanganate	-	mg/l	0.7	2.3	20.1	26.5
Nitrate as NO_3	45	mg/l	0.31	0.055	7.6	1.6
Nitrite as NO_2	0.03	mg/l	0.00	0.001	0.079	0.189
Hardness ($CaCO_3$)	500	mg/l	56	48	160	176
NH_3	0.5	mg/l	0.07	0.06	0.11	0.29
TN exclusive NO_3	1.0	mg/l	0.46	0.52	8.4	10.9
Fluoride	1.5	mg/l	6.0	7.5	<0.05	0.20
Pesticides	-	ppb	ND	ND	ND	ND

Legend:
(1)* : Criteria developed by NCC for drinking water
(2)* : Sampling conducted on Nov.20, 1997
(3)* : Sampling conducted on Nov.25, 1997
- : No fixed value
D1 : Sample taken from NCC water supply system
D2 : Sample taken from a private water supply system (Muhuiri)
ND : Not detected (<0.01 ppb for all pesticides sought - organochlorine and organophosphate)

The water analysis of D1 showed high concentration of fluoride and presence of non-faecal coliforms. However, sample D2 showed low concentration of fluoride but heavily contaminated with both feacal and non-feacal coliforms. In both water supply systems, treatment of the water is necessary to meet the WHO guidelines.

(iv) Sediment

Samples were taken from the riverbed just in front of the candidate site in order to detect the contents of heavy metals. Refer to **Figure I.2-3** for the sampling point. Low concentrations of metals

were detected in the analysis excepting iron and zinc. Results of the analysis are shown in **Table I.2-10.**

Table I.2-10 Sediment Analysis of Nairobi River in Ruai Area

Parameter	Unit	First Sampling (1)*	Second Sampling (2)*
Pb	gr/kg	0.006	0.006
Cr^{+6}	gr/kg	<0.002	<0.002
Cu	gr/kg	<0.002	<0.002
Fe	gr/kg	2.5	2.7
Mn	gr/kg	<0.005	<0.005
Zn	gr/kg	4.25	4.20
Hg	gr/kg	0.005	0.005
As	gr/kg	0.002	0.002

Legend:
(1)* : Sampling conducted on Nov. 20, 1997
(2)* : Sampling conducted on Nov.25, 1997

(b) Fauna and Flora

(i) Species Diversity

The diversity of plant species in the Ruai candidate site was small as compared to the Ngong forest candidate site. The riverine community had the highest diversity of plant species and that located on the side of NCC (right bank of Nairobi River) was different comparing with the left bank which belong to a private farm (Sakari Ranch). While all trees had been cleared by charcoal burner and fuel wood collectors on the side of NCC site, large *Acacia kirkii* and *A. xanthopholea* were observed on the Sukari side.

The diversity of animals observed was equally small especially given the fact that land is semi-arid which is the natural habitat of big game animals.

(ii) Density and Cover

Riverine Community

The riverine community (Nairobi River) was found to be the most diverse in the Ruai study area. It consisted of shrubs and herbs along the river to distance ranging from 50 to 150 m. This distance roughly coincides with the flood plain at various points of the Nairobi River.

The herbaceous layer of the riverine community is dominated by *Cynodon dactylon* which form 68% cover. *Panicum maximum* and *Digitaria scalarum* are the common grasses.

Grassland - Sisal Area

The area which formerly could have been a sisal plantation is almost totally devoid of woody vegetation. The low diversity of browse shrubs and trees has serious implications on the use of the area by wildlife and browsers such as goats. It has been noted that once semi-arid areas are cleared of their natural vegetation the process of succession is extremely slow especially if grazing pressure is still maintained.

Grassland

The grassland vegetation type dominates the study area. The densities of the woody species were low probably as a result of firewood harvesting.

Plant species found in Ruai Area are given in **Section 9.6 of Data Book 9.**

(iii) Utilisation and Uses of Plant Species in Ruai Area

The main vegetation found in the largest part of the land were the grass species. Even along the riverbank, there were no trees on the site belonging to NCC. The study site showed a clear indication of the indiscriminate destruction of the environment. This was evidenced by the presence of plant species such as *Lantana camara* which grow on disturbed habitats.

This study showed that there has been two main uses of plant species in Ruai. First of all there is plenty of grass albeit the fact that it is in patches with a coverage of about 50%. Nevertheless this is the place where grazing of livestock by Maasai was taking place. Furthermore, the riverine grass supported wildlife animals such as the Hippos which had made the grasslands their grazing habitats. The second important use of plant species was the harvesting of trees from the riverine vegetation for the purpose of making charcoal.

(iv) Animal Distribution and Habitat

The species of animals observed on the Nairobi City Council side were extremely few. These included Hares, Snakes, Dik-diks, Giraffes, Thomson gazelles, Birds, Hippos and Livestock. Hippos were not observed but their presence was proved by the observed footprints.

Livestock was the main animal activity observed. A few birds were observed especially in the riverine community. The situation was the opposite on Sukari ranch where, across the river, several animals could be observed including antelopes and monkeys.

(c) Landscape

The candidate site is located on flat land adjacent to the Nairobi River (right bank) and no visual changes can be noted by the population living outside of the site.

(i) Topography

The project site is a flat land at an elevation of 1,480 m to 1,485 m above sea level. The changes in elevation takes place over a distance of 575 m in a south to north direction and a slope of 0.009. Former sisal cultivation field drains are ineffective over the site and, therefore, water logging and flooding during rainfall is widespread.

(ii) Geology

Geology of the Ruai site project area comprise surface black cotton soil developed over poorly drained flat surface of the land extending over depths of 0.5 m to 1.5 m. Alluvial soils bordering Nairobi River are also poorly drained and comprise clay loam.

Beneath the soils, the rocks are weathered derivatives of the main volcanic rocks which dominate the area, i.e., tuffs, biachytes and agglomerates as seen at the sewage effluent outflow site on Nairobi River upstream of the project site where the rock outcrops.

(d) Climate

Table I.2-11 shows meteorological data which were taken at the Jomo Kenyatta International Airport located 15 km to the southwest of the project site.

Table I.2-11 Climatic Conditions of Ruai Site Project Area

MONTH	ATMOSPHERIC PRESSURE (hpa) (1959 -80)		TEMPERATURE (degree Celcius) (1959-90)									RELATIVE HUMIDITY (%)			RAINFALL (MM) (1959-90)				NUMBER OF DAYS OF (1959-90)	
			MEANS		EXTREMES			DRY BULB		DEW POINT										
	0600	1200	MAX	MIN	RANGE	HIGHEST	LOWEST	0600 GMT	1200 GMT	0600 GMT	1200 GMT	0300	0600	1200	MEAN	HIGH	LOW	MAX 24 HR	RAIN	THUNDER
January	840.9	836.6	26.7	12.1	14.6	32.2	4.7	16.4	25.6	13.8	11.2	94	76	42	49	271	0	60.2	4	2
February	840.0	836.3	27.9	12.4	15.4	32.0	6.9	16.7	26.8	13.8	13.2	89	75	37	48	305	0	76.2	4	2
March	840.2	636.6	27.8	15.4	14.4	32.7	6.3	18.8	26.6	15.0	11.5	94	80	40	73	203	1	64.4	8	5
April	841.1	637.1	25.9	14.6	11.9	32.5	6.1	18.3	24.6	15.0	13.0	97	86	53	153	340	1	101.8	13	0
May	842.0	638.0	24.5	13.7	10.9	26.6	6.3	17.6	23.4	15.0	14.1	97	84	55	116	373	9	71.0	8	4
June	842.4	839.5	23.7	11.6	12.1	28.9	4.9	15.3	22.5	13.2	12.4	95	84	53	24	121	0	45.5	3	1
July	842.4	830.8	22.7	10.7	11.9	28.1	4.4	14.0	21.6	12.2	11.4	84	85	53	11	64	0	19.8	1	1
August	842.4	838.9	23.3	10.9	12.3	31.0	4.4	15.1	22.1	12.0	11.2	83	82	51	15	87	0	38.1	3	1
September	842.0	838.9	25.8	11.2	14.6	31.1	4.2	16.4	24.5	12.6	10.7	84	76	49	16	71	0	30.0	3	2
October	841.0	837.4	26.7	12.6	13.9	30.8	5.0	16.1	25.5	13.7	10.8	85	77	41	42	162	1	67.8	5	1
November	841.1	837.2	25.3	13.4	11.9	30.2	5.0	17.0	23.0	15.0	13.0	87	84	52	118	464	15	62.8	12	2
December	840.7	837.0	26.4	12.9	12.5	28.5	7.0	16.2	24.3	14.7	12.5	87	80	49	89	276	6	112.9	7	2
Year	841.3	837.8	25.5	12.5	13.0	26.5	4.2	17.5	24.8	13.9	12.2	84	81	47	749	1285	460	112.9	71	29

MONTH	DAILY SUNSHINE (HOURS) (1960-90)			DAILY RADIATION (1971-90) MJ sq.m MEAN			EVAPORATION (MM) (1968-90) PLAN TYPE - A"			CLOUD AMOUNTS Coetas (1958-90)				DAILY WINDRUN (KM)	WIND SPEED (Knots) (1959-90)		CALKS (m) (1960-90)		VISIBILITY (Days) (1961-90)			
										TOTAL		LOW							FOG		MIST/HAZE	
	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	HIGH	LOW	0600	1200	0600	1200	1968-90	0600	1200	0600	1200	0600	0	0600 1200	
January	9.4	11.3	5.6	21.6	24.1	17.6	222	292	195	4.6	4.6	3.0	8.4	245.6	7	12	3	1	3	0	1	1
February	9.5	11.1	5.2	22.1	24.9	17.6	224	292	111	4.5	4.7	2.9	9.4	262.7	6	12	4	1	2	0	2	1
March	8.5	10.4	5.1	20.7	24.1	15.8	248	457	113	5.7	5.1	4.4	4.1	273.4	6	13	4	1	3	0	1	1
April	8.9	9.8	5.5	17.9	21.7	13.0	177	236	121	6.7	5.0	5.3	6.0	199.8	5	11	6	1	1	0	1	1
May	5.9	8.4	3.6	16.6	20.9	12.3	188	200	114	6.4	6.1	5.2	6.4	150.5	5	8	6	2	2	0	1	1
June	5.2	8.3	2.8	15.0	10.2	10.6	177	241	50	0.1	5.0	4.9	5.2	148.8	5	7	7	2	1	0	2	1
July	4.0	6.8	1.7	14.0	20.4	9.3	177	201	57	6.6	6.2	5.2	5.6	151.9	5	8	7	2	1	0	2	1
August	4.0	6.5	1.6	14.3	20.0	9.3	126	225	89	6.5	6.2	5.5	5.7	166.2	5	7	8	2	1	0	2	1
September	6.1	6.5	3.0	17.8	29.1	12.4	171	295	144	6.0	5.5	5.3	5.0	199.6	4	8	8	1	1	0	1	1
October	7.1	8.5	4.1	19.0	25.0	13.3	210	268	171	6.0	5.6	5.3	5.0	244.1	5	10	5	0	2	0	1	1
November	6.8	9.1	3.3	18.5	29.0	13.4	169	457	129	6.5	5.7	5.0	4.8	256.4	7	11	3	1	3	1	1	1
December	5.5	10.6	4.3	20.2	24.7	14.5	196	274	125	5.2	5.0	4.5	4.1	262.7	6	13	2	0	3	1	1	1
Year	6.8	8.2	3.7	18.1	22.7	13.2	2114	457	50	5.0	5.5	4.8	4.7	213.3	6	10	64	13	24	1	17	8

(e) Soil Pollution

As for the sludge survey, samples were taken from the bottom of the primary pond (inlet and center) currently used for domestic wastewater treatment, while soil samples were taken from around the primary pond and the maturation pond at depths of 50 cm (refer to **Figure I.2-3).** This survey was made to know the influence of the current wastewater treatment plant into the environment of the candidate site. The parameters to be analysed were chosen taking into account that the current sewerage system is collecting industrial wastewater which could contain heavy metals. Results of the analysis are presented in **Table I.2-12** below.

Table I.2-12 Sludge and Soil Analysis in Ruai Area

Parameter	Unit	Sampling Points			
		Sludge		Soil	
		P1	P2	P3	P4
Pb	µg/g	289	226	31	40.3
Cr^{+6}	µg/g	333	278	242	256
Cu	µg/g	123	88.3	<5.0	14.3
Fe	%	4.31	3.97	4.5	5.05
Mn	%	0.29	0.27	0.4	0.27
Zn	µg/g	1370	922	143	184
Hg	µg/g	18.7	18.6	<10.0	<10.0

Legend:
P1 : Sample taken from the bottom of the primary pond (inlet)
P2 : Sample taken from the bottom of the primary pond (center)
P3 : Sample taken from around the primary pond
P4 : Sample taken from around the maturation pond

From the results it was assumed that there is a moderate influence of the sludge into the surrounding soil quality.

(f) Noise and Traffic Survey

For two days and for the period of 12 hours/day from 6 a.m. to 6 p.m. at Kangundo Road and at the access road to the candidate site as indicated in **Figure I.2-3,** noise and traffic survey were carried out simultaneously. The vehicles counted in both directions were categorised into small, medium and large sizes. **Tables I.2-13** and **I.2-14** show the results of the survey for Kangundo Road and the access road, respectively.

Table I.2-13 Noise and Traffic Survey on Kangundo Road

Traffic Time	Small Vehicles		Medium Vehicles		Large Vehicles		Average Noise dB (A)	
	Date		Date		Date		Date	
	Nov. 22	Nov. 25	Nov. 22	Nov. 25	Nov. 22	Nov. 25	Nov. 22	Nov. 25
6:00-7:00	9	15	24	29	18	24	61.7*	57.2
7:00-8:00	23	34	46	29	35	22	56.9	58
8:00-9:00	40	41	53	40	31	25	57.6	55.2
9:00-10:00	33	30	30	38	28	27	58.7	62.9
10:00-11:00	61	32	35	52	36	36	57.7	60
11:00-12:00	79	29	63	44	42	34	57.8	61.9
12:00-13:00	75	24	64	25	29	16	56.5	59.7
13:00-14:00	66	27	63	35	29	29	60.7	61.3
14:00-15:00	66	33	68	42	31	39	56.9	59.8
15:00-16:00	80	26	75	39	39	31	56.3	58.4
16:00-17:00	85	33	61	43	27	21	55.8	56.5
17:00-18:00	87	50	83	50	25	29	56.7	58.1
Total	704	374	665	466	370	333		

* Most of the noise in this period was from rainfall.

Table I.2-14 Noise and Traffic Survey on Access Road

Traffic Time	Small Vehicles		Medium Vehicles		Large Vehicles		Average Noise dB (A)	
	Date		Date		Date		Date	
	Nov. 22	Nov. 29	Nov. 22	Nov. 29	Nov. 22	Nov. 29	Nov. 22	Nov. 29
6:00-7:00	8	1	3	6	6	7	49.4*	54.1**
7:00-8:00	14	7	2	9	5	7	47.5	52.2
8:00-9:00	17	16	4	11	7	4	48.4	55
9:00-10:00	13	17	14	8	12	5	41.7	49.2
10:00-11:00	7	6	12	7	6	4	43.2	46.9
11:00-12:00	12	7	14	6	6	3	41.7	46.9
12:00-13:00	13	7	29	9	7	1	46.5	45.2
13:00-14:00	17	9	17	10	5	6	43.3	45.9
14:00-15:00	11	7	30	17	7	3	43.7	49.6
15:00-16:00	12	5	13	13	6	6	43.8	47.8
16:00-17:00	20	10	16	10	4	4	45.6	48.4
17:00-18:00	21	5	26	15	5	1	45.4	53.1
Total	165	97	180	121	76	51		

* Most of the noise in this period were from donkeys, chicken and birds.

** Noise in this period was mainly from rainfall which was intermittent throughout the day.

(g) Offensive Odour

As for the offensive odour survey, H_2S and NH_3 were checked in-situ. These parameters were chosen since they are considered as the most significant producers of bad odour. Samples were taken from around the primary pond in two opportunities and the survey was made to know the influence of the current wastewater treatment plant to the environment of the candidate site. Results of the analysis are presented in **Table I.2-15** below:

Table I.2-15 Offensive Odour Survey

Parameter	Standard*	Unit	Value	
			Dec.18	Dec.19
H_2S	0.06-0.2 **	ppm	< 0.2	< 0.2
NH_3	1.0-2.0 ***	ppm	< 0.2	< 0.2

Legend:
* Japanese Offensive Odour Control Law
** Value applied for industrial area
*** Value applied on boundary line

In all cases the concentration of both hydrogen sulfide and ammonia were below the standard and, therefore, it is believed that the sewage treatment work currently do not affect the existing air quality of the candidate site.

2.4 Social Environmental Condition

This survey was conducted by questionnaire and direct interview either to people to be affected by the project (Final Disposal Candidate Sites at Ruai and Ngong Road Forest Area) or the would be beneficiaries allocated in different income areas such as High, Middle, Low and Slums. The survey result is summarised as follows:

2.4.1 Analysis of Population Affected by the Projects (Ngong and Ruai Areas)

One hundred households were selected for this survey (50 in Ruai and 50 in Ngong) and the major findings are:

(1) Manner of Subsistence

Employment ratio occupy 75% in Ruai and 76% in Ngong. Most of the residents in the project areas are employed in the public service, mainly as teachers or clerks.

(2) Income Level

In Ngong, 52% have responded to earn less than Kshs.5,000 and 26% between Kshs.5,000 and Kshs.10,000.

In Ruai, 31.4% of the respondents earn less than Kshs.5,000 and 47% between Kshs.5,000 and Kshs.10,000.

(3) Education

In Ngong, 26% of the population have primary level of education while 30% have secondary level of education. In Ruai, these are 23.5 and 37.2%, respectively.

In terms of post secondary level of education, the percentages are 37.3% for Ruai and 34% for Ngong. Thus, the population in the two project sites are fairly well educated and can comprehend the basic advantages of a proper solid waste management. This situation make easier the communication of

various issues of the Project to the beneficiaries in order to create awareness and participation.

(4) Age Structure of the Population and Composition

The age structure is as tabulated in **Table I.2-16** below.

Table I.2-16 Age Structure of the Population in the Ruai and Ngong Areas

Site	Age					
	<20 years	20-29 years	30-39 years	40-49 years	50-59 years	>60 years
Ruai Area	-	27.5%	39.2%	27.5%	5.8%	-
Ngong Area	4.0%	30.0%	38.0%	14.0%	8.0%	6.0%

According to the sample survey, the population is mainly in the 20-49 age group and is composed by 51% Male and 49% Female for Ruai and 36% and 64% for Ngong. The population is largely married and the mean number of children is 2.4 for Ruai and 3.2 for Ngong. Most of the people are Christians and the major ethnic group is Kikuyu.

(5) Housing

The housing ownership and permanent structure are as shown in **Table I.2-17** below.

Table I.2-17 Housing Ownership and Permanent Structure in the Ruai and Ngong Areas

Site	Housing Condition	
	Ownership	Permanent Structure
Ruai Area	52.9%	66.7%
Ngong Area	32.0%	62.0%

People who own the houses they live in and those who live in houses built of permanent structure are likely to be more concerned about the dumping of garbage near their sites. For both sites and specially for Ruai, the location of houses are far away from the site chosen for the garbage disposal and no objection could arise from the people for the project implementation.

(6) Health Condition

According to the survey, the types of illness in the project areas range from malaria, diarrhea, colds to typhoid fever. In Ruai most children suffer from malaria (25.5%) and colds (29.4%) while in Ngong the figures are 28% and 6%.

(7) Sanitation

The percentage of respondents according to the sanitation condition or practices in the Ruai and Ngong area are summarised below.

(a) Water Sources

In the Ngong area, 52% of the respondents get their water from tap and many people also get water from other sources such as wells/boreholes, dams and rivers located next to the candidate site. In the Ruai area the existing wells/boreholes are located far away from the place chosen for dumping site. (Refer to **Table 1.2-18.**)

Table I.2-18 Sources of Water in the Ruai and Ngong Areas

Water Sources	Ruai	Ngong
Household Tap	41.2%	22.0%
Public Tap	0.0%	30.0%
River	5.8%	2.0%
Dam	0.0%	2.0%
Wells/Boreholes	51.0%	44.0%
Others	2.0%	0.0%

(b) Sewage Disposal Methods

The sewage disposal methods are as given in **Table I.1-19** below.

Table I.2-19 Sewage Disposal Methods in the Ruai and Ngong Areas

Disposal Method	Ruai	Ngong
NCC Sewer	21.6%	20.0%
Septic Tank	3.9%	14.0%
Pit Latrine	72.5%	64.0%
Open Ground	2.0%	2.0%

(c) Garbage Disposal Methods

High percentages of the respondents dispose their garbage by burning. Others make compost while others dump the garbage on open ground. The implementation of the SWM project will contribute to the improvement of the environmental condition of the two project sites. (Refer to **Table. I.2-20.**)

Table I.2-20 Waste Disposal Methods in the Ruai and Ngong Areas

Disposal Method	Ruai	Ngong
NCC Collection	19.6%	8.o%
Burning	56.9%	42.0%
Recycling	2.0%	0.0%
Composting	13.7%	28.0%
Dumping	7.8%	22.0%

(d) Knowledge of Garbage Disposal Sites

Most of the respondents in Ruai (56.9%) knew of the Dandora disposal site while this figure was only 26.0% in Ngong. A significant number of

respondents in both project sites (92.2% in Ruai and 88.0% in Ngong) felt that the project sites should be delineated for disposal site.

(8) Types of Pollution

According to the survey, air pollution was considered most significant by respondents in Ruai (35.3%) and water pollution was considered most significant by respondents in Ngong (56.0%). The other type of pollution indicated by the respondents is noise. (Refer to **Table I.2-21** below.)

Table I.2-21 Types of Pollution in Ruai and Ngong Areas

Type of Pollution	Ruai (%)	Ngong (%)
Air	35.3	8.0
Water	27.5	56.0
Noise	19.6	12.0
Other	11.8	0.0
None	5.8	24.0

2.4.2 Public Awareness

This analysis was done through a questionnaire administered to heads of households in various areas of Nairobi. The major findings are summarised below:

(1) Necessity of New Disposal Sites

According to the survey, the people of Nairobi consider that a garbage disposal site is very important. The total number of samples was 381 distributed as follows: 42 samples in the high income area, 89 in the middle, 90 in the low, 59 in the slums, 51 in Ruai and 50 in Ngong. Out of a total of 381 respondents, 247 respondents said that a garbage disposal site is very important. Thus, Nairobi residents would want a garbage disposal site delineated and would accept the SWM project.

The highest percentages of respondents reporting "very important" came from the middle income group (79.8%), and high income group (73.8%). The figure was 66.7% in Ruai, and it was 60% in Ngong and 40.7% in the slums.

(2) Environmental Degradation in Nairobi

The extent of environmental degradation in Nairobi were asked from the same respondents as above and 80.3% said it was very much and only 2% said it was very little. The implication of this for the SWM project is that the project will get a lot of support from the residents as they are already aware of the high degree of environmental degradation as a result of poor garbage management.

(3) Importance of Sanitary Improvement

The survey also reveals that there is need for sanitary improvement in the city not only because of the extent of environmental degradation but also due to the presence of diseases mainly associated with poor sanitary conditions. The

survey was conducted on 361 respondents and distributed as follows: 41 respondents in the high income area, 83 in the middle, 85 in the low, 55 in the slums, 48 in Ruai and 49 in Ngong. Respondents were asked to specify some types of health hazards associated with poor sanitation and the majority mentioned cholera (33.5%), malaria (21.6%), typhoid fever (15.5%) and dysentery (9.1%).

(4) Willingness to Participate in the SWM Improvement for Nairobi City

Nairobi residents are willing to participate in SWM improvement even to the extent of paying for improved service. The total number of samples was 380, distributed as follows: 42 samples in the high income area, 89 in the middle, 90 in the low, 59 in the slums, 50 in Ruai and 50 in Ngong. A majority of respondents in the survey are willing to pay; i.e., 52.4% in the high income, 61.8% in the middle income, 66.7% in the low income, 50.8% in the slums, 66.0% in Ruai and 46.0% in Ngong.

2.5 Predictable Impacts, Assessment and Mitigation Measures

Impact prediction is based on all activities relating to the project implementation. Considering that the solid waste management in Nairobi City will be improved, it will contribute in a positive way to the improvement of the environment and the public health of Nairobi's residents. Nevertheless some adverse impacts can also be predicted and proper mitigation measures should be taken to protect or minimise negative effects accordingly. In the EIA study, potential impacts were predicted and their significance were also assessed during the four phases of the project; i.e., Construction Phase, Operation Phase, Closure Phase, and Post-closure Phase.

The significance of environmental impacts determined on the basis of non-negligible environmental changes induced by the project implementation are shown in three levels; namely, high impact, moderate impact and low impact.

The environmental impact results are assessed by comparing them with values specified in standards used as assessment targets. The standards used in this study, which are presented in **Section 9.3 of Data Book (1)**, include the following:

(1) WHO Guidelines for Drinking Water Quality
(2) NCC Drinking Water Quality Criteria
(3) Japanese Water Quality Standards
(4) Japanese Offensive Odour Control Law
(5) WHO Noise Specification
(6) Japanese Standards for Discharge into Public Water Courses
(7) Road Design Standards and Classification in Nairobi District

2.5.1 Candidate A - Ngong Road Forest Area

(1) Predictable Negative Impacts on Natural Environment, Assessment and Mitigation Measures

The most affected by project implementation is the flora and fauna of the site. The following negative impacts were identified:

(a) The major impacts during construction of the disposal site will be the destruction of approximately 0.8 ha of indigenous forest, 25.4 ha of Eucalyptus plantations and 7.0 ha of grassland. Besides, the physical removal of a section of the indigenous forest measuring approximately 0.5 km and 12 m for the access road construction is considered of high impact. This section contains about of 4,600 individual trees and shrubs in various ages and heights. These impacts are assessed as impact with high significance and the mitigation measures include the plantation of 1.4 ha of mixed indigenous species with emplasis on the protected species; i.e., *Brachylaena huillensis* and *Warburgia ugandesis.*

(b) Destruction of grassland and ecotone which have a total of 61 species of which 32 only occur there. These will be destroyed, and since there are no other glades and ecotones in the Ngong system they will be completely lost. Also animals and birds dependent on them will be disturbed. The impact is of high significance and can be mitigated with the plantation of a belt of mixed indigenous species around the candidate site reflective of the ecotone of approximately 15 ha.

(c) The Bee-keeping Division of the Ministry of Agriculture, Livestock and Marketing is located in the Forest. The bee-keeping activities which are dependent on the flowering of the plants in the forest and the surrounding settled areas will be adversely affected. This impact is also of high significance and it can be mitigated by means of maintaining the diversity of plants in the indigenous forest.

(d) Potential fire risks and squatting in the gazetted forest which are considered as high impact during operation of the project. The mitigation measures include intensified patrols of the forest and the prohibition of scavenging activities inside and outside of the landfill.

(e) Poaching of trees and tree parts for medicinal purposes and other uses will have a high impact on protected and over-exploited species. This will lower the biodiversity on both the indigenous forest and plantations. Fencing off the indigenous and riverine communities, inspection of vehicles entering and leaving the site, intensified patrols of the forest, expansion of the nursery to produce more seedlings and of a wider variety, plantation of a fuel wood buffer zone along the perimeter of the indigenous forest to cater for local requirements for wood and medicinal uses and the increase of areas with plantations of indigenous species are proposed mitigation measures. Regarding the plantation of indigenous species, the trees require over 50 years to mature; thus, a high rate of poaching cannot be solved in this way.

As for groundwater pollution, low impact is predicted on the existing wells (W1 and W2) allocated in adjacent areas considering the geological properties of the soils of the site. The implementation of a leachate collection and treatment will mitigate this impact.

The generation of offensive odour and harmful insects are predictable impacts of high significance at the site especially when the disposal site is not well operated. These impacts shall be mitigated by daily soil covering of the

disposed garbage, the installation of a gas control system and a regular medical checkup for workers.

Water pollution of Mutoine River which is used for irrigation of forest tree nurseries, watering livestock and alternative source of domestic water supply to the surrounding areas poor communities during drought is assessed as negative impact during the construction, operation, closure and post closure stages. A high significance of the impact is assessed taking into account the current water use and water quality condition. The adverse impact shall be controllable with the proper management of construction, provision of drains with sediment traps, provision of water supply system for the surrounding communities as well as the proper operation of the proposed leachate collection/treatment.

As regard smoke, low impact is predicted when sanitary landfill method is implemented in which daily soil covering of the disposed garbage is practiced and the installation of gas control system is provided. However, dust and exhaust fumes from vehicles and equipment are predicted impacts of moderate significance on the workers at the site and the community. Exhaust fumes from vehicles shall be controlled with the proper maintenance of trucks and equipment. For the dust control, a control on the number or speed of vehicles/ equipment shall be implemented and watering may be required for access road and operational places during the construction, operation and closure stages, especially in the dry season. During operation a medical checkup program shall be established. During the construction, operation and closure stages it is also important to cover soil materials transported to the disposal site.

Soil pollution is considered to be of low significance, due to the nature of solid waste to be disposed of at the landfill site. The pollution shall be minimised by the prohibition of entering of toxic waste to the disposal site.

Noise generation is expected during construction, operation and closure stages of the project. During operation, assuming that only 45 % of the vehicles will be deployed to the Ngong site, the resulting increase in noise on the Ngong Road and access road will not have a significant influence on the current noise levels and no community complaints are expected. On the other hand, during construction of the landfill, impact of moderate significance is likely to affect the workers. In order to mitigate these impacts, a control on the number or speed of vehicles/ equipment shall be implemented and the work schedule should be informed to the public and operation of heavy equipment limited to the day time only. Also, adequate maintenance of equipment and trucks which must have exhaust mufflers shall be implemented and the occupational exposures to noise should be kept to below 90 dB(A) during construction of roads and landfill.

Gas migration has low impact due to absence of buildings in the surrounding area and this condition should be kept to minimise this impact.

Due to the location of the disposal site, visual changes on the landscape may not be noted by residents living around the place.

Regarding land use, the long term plan as stipulated in the Kenya Forestry Master Plan, 1994, which has been adopted by the Government is to introduce ecotourism in the Ngong Road Forest and to enhance the use of the forest for forestry research and education. Therefore, construction and operation of a sanitary landfill on the site will adversely affect the current and planned uses of the Ngong Road Forest. For this impact, no mitigation measures can be proposed.

On the other hand the petroleum pipeline passing through the landfill site at Ngong Road Forest Site is likely to be affected by the project. Mitigation measures include the proper management of construction and operation of the landfill.

(2) Predictable impacts on the Social Environment, Assessment and Mitigation Measures

(a) Negative Impacts

Migration of scavengers to the new disposal site is highly predictable and the destruction of the forest by them is also highly predictable because they will build their houses inside the forest and, probably, they will cut the trees for selling as a secondary activity to the recycling. For these reasons no scavengers should be permitted at the site but this decision is not practicable in Nairobi City unless NCC or the Government can accommodate these people to work in other businesses.

During the construction, operation and closure phases of the landfill site, traffic congestion should be avoided in order not to increase the current traffic jam in Nairobi City. Ngong Road was designed for an average daily traffic of 3685 small/ medium vehicles and 365 heavy vehicles.

For Case A, which applies 60% of collection rate for 1998 and 100% for 2008, the project will introduce 257 vehicles by 1998 and 714 vehicles by 2008 on Ngong road bringing the total traffic to 10,366 and 10,823, respectively. For Case B, which applies 40% of collection rate for 1998 and 60% for 2008, introduction of 171 and 428 vehicles are expected by 1998 and 2008.

Since the current level of traffic on Ngong Road is about 2.5 times of the road capacity design, it is sensitive to any increase in the number of vehicles; therefore, impact of high significance is predicted on this road for the two cases of collection rates. To ensure smooth flow of the traffic on this road it should be upgraded to a dual carriage way. This upgrading will adequately take the extra volume, load and improve the control of traffic on this road.

On the other hand, the access road will be loaded with the same number of trucks and considering its current civil structure condition impact of high significance is predicted on it. To mitigate this impact a new access road of Class C should be constructed to take the heavy trucks from Ngong Road to the site. For more details on traffic assessment, see **Section 9.9 of Data Book (1).**

(b) Positive Impacts

The positive impacts may be as follows:

(i) The project will improve the health condition in the city.

(ii) The project will create several jobs directly in various aspects of construction, transportation and operation of the SWM system.

Predictable negative impacts, assessment and mitigation measures for Ngong Forest Area are summarised in **Table I.2-22.**

Table I-2-22 Predictable Negative Impacts, Assessment and Mitigation Measures for Ngong Area

Predictable Impacts	Impact Stage	Significance	Mitigation Measure
Flora & Fauna	C	High	• Plantation of 1.4 ha of indigenous species • Expansion of the nursery to produce more tree seedlings • Plantation of 15 ha of mixed indigenous species around the candidate site
	O	High	• Plantation of a fuelwood buffering zone • Inspection of vehicles and patrols of the forest • Expansion of the nursery • Increase of areas with plantation of indigenous forest of various species to maintain the diversity of plants. However a high rate poaching can not be solved in this way. • Fencing off the indigenous and riverine communities • Activities of scavengers should be eliminated. However, this measure is not practicable in Nairobi City
	CL	Moderate	• Inspection of vehicles and patrols of the forest
Groundwater	O, PCL	Low	• Collection and leachate treatment
Offensive odour	O	High	• Daily soil covering of the disposed garbage • Implement medical check-up program • Installation of a gas control system
Harmful insect generation	O	High	• Daily soil covering of the disposed garbage • Implement medical check-up program
Water Pollution of Mutoine River	C, CL	Moderate	• Provision of drains with sediment traps • Proper management of the construction
	O	High	• Maintain a ring-drain outside the landfill site enclosing dike • Provision of leachate treatment facilities • Water supply system for the surrounding communities
	PCL	High	• Maintain the ring-drain in operation after the closure stage • Continue using the leachate treatment facilities for long time depending on the production/quality of the leachate
Smoke from garbage	O	Low	• Daily soil covering of the disposed garbage, install gas control system
Dust, exhaust fumes from vehicles and equipment	C, O, CL	Moderate	• Control on the number or speed of vehicles/ equipment • Watering of access road and operational places. Soil materials should be covered with sheet • Proper maintenance of vehicle
Soil pollution	O, PCL	Low	• The landfill site should receive solid domestic waste only
Noise	C, O,CL	Low	• Trucks shall use exhaust mufflers to maintain the current noise levels • Work schedule should be informed to the public and operation of heavy equipment should be limited to the day time only • Control of number or speed of vehicles/ equipment • Adequate maintenance of equipment and trucks which must have exhaust mufflers
Gas Migration	O, PCL	Low	• Land use regulation should be enforced for surrounding area avoiding building construction
Traffic	C, O, CL	High (Access road)	• Construction of access road of Class C
		High (Ngong road)	• The road should be upgraded to a dual carriage way
Landscape	C	Low	• The project should be implemented in an aesthetic development scene with landscape harmonisation
Interference with petroleum pipeline	C,O,CL,PCL	High	• Proper management of the construction and operation of the landfill site
Interference with Kenya Forestry Master Plan	C,O,CL,PCL	High	• No mitigation measures can be proposed
Scavengers	O	High	• NCC or the Government should provide alternative sources of jobs

Legend: C: Construction Phase; O: Operation Phase; CL: Closure Phase; PCL: Post-closure Phase

(3) Conclusion

In consideration of the results of the EIA Study, the JICA Study Team considers that the construction of the disposal site in the Ngong Road Forest Area is not suitable because it is not compatible with the Kenya Forestry Master Plan which will introduce ecotourism in the area and will use the forest for forestry research and education.

The other constraint is related to the current level of traffic of Ngong Road which is about 2.5 times of the road design capacity and this condition makes it sensitive to any increase in the number of vehicles. To take the extra volume of vehicles of the project, upgrading of the road becomes necessary but this is beyond of the scope of this project.

On the other hand, scavengers are likely to move to the new landfill site after closing of the existing one at Dandora. This fact will contribute to the total destruction of the forest allocated around the candidate site.

2.5.2 Candidate B - Ruai Area

Since the Ngong Road Forest Candidate Site is not suitable for construction of the landfill site, it is assumed that all the solid waste of Nairobi City shall be taken to the Ruai Candidate Site using a transfer station whose location has not still been decided by the Kenyan authorities concerned. On the basis of the above assumption, the study on predictable impacts and assessment was conducted as well as the identification of mitigation measures which finally are reflected in the environmental management plan and environmental monitoring plan.

(1) Predictable Negative Impacts on Natural Environment, Assessment and Mitigation Measures

As for groundwater pollution, the nearest existing well to the candidate site is 5 km to the south east and no impact is predicted on this well. Other existing wells used for domestic water supply are the NCC well and Muhuri well located 11 km and 17 km to the south west of Ruai Site respectively. These wells are located on higher ground with respect to the site and no impact are predicted on them due to the hydraulic characteristics of the area. Impacts of low significance are predicted on the groundwater quality of adjacent areas especially downstream of the candidate site considering the geological properties of the soils of the site. The implementation of a lecheate collection and treatment will be applied as a mitigation measure.

A poor operation of the disposal site can adversely impact the environment such as the breeding of harmful insects and the generation of offensive odour which could affect the health of workers and the neighborhood of the landfill site. These impacts considered to be of high significance shall be minimised by means of daily soil covering of the disposed waste, the installation of a gas control system and a regular medical checkup for workers.

The survey on water quality of Nairobi River was conducted during a heavy rainfall period associated with El Niño phenomenon and, therefore, the pollutant concentrations had been significantly diluted. Water pollution of Nairobi River is assessed as negative impact although it is determined to be low in significance, because according to secondary data the water quality is already too degraded. The adverse impact shall be controllable with a proper management of the construction and the provision of drains with sediment traps as well as the proper operation of the proposed leachate collection and treatment.

As regard smoke, dust, exhaust fumes, soil pollution, gas migration and landscape, these are impacts of similar significance when compared to the Ngong site; therefore, the same conditions of mitigation measures are applicable.

Noise will be generated in the construction, operational and closure stages of the disposal site. On the main road the current levels are already above the recommended 55 dB(A) by WHO for communities exposures and the additional number of vehicles will generate an impact of low significance either on the main road as well as on the access road; however, proper measure should be taken to avoid any inconvenience to the residents. Public consensus is absolutely necessary about the project prior to the construction, and for the noise control, work schedule should be prepared in such a way that the operation of heavy equipment is limited to the daytime only. On the other hand for the workers involved in the construction and operation the impact will be of moderate significance due to the high noise levels emitted by the equipment. In this last regard, the level of 90 dB(A)-8hr should not be exceeded in the working place.

(2) Predictable Impacts on the Social Environment, Assessment and Mitigation Measures

(a) Negative Impacts

Migration of scavengers to the new disposal site is highly predictable. If NCC decides to allow them to work into the facility, the provision of specific working rules should be enacted to control their activities without disturbing the smooth operation of the site.

During the construction, operation and closure phases of the landfill site, traffic congestion should be avoided. Kangundo Road was designed for an average daily traffic of 1,330 small/medium vehicles and 570 heavy vehicles.

For Case A, which applies 60% of collection rate for 1998 and 100% for 2008, the project will introduce 311 vehicles by 1998 and 967 vehicles by 2008 on Kangundo Road, bringing the total traffic to 1,768 and 2,424. Consequently, the impact will be low on this road at the beginning of the project and moderate at the final stage, taking into account the road design capacity. On the other hand, the access road will be loaded with

near double to the current level by 1998 and considering its civil structure condition, impact of high significance is predicted on it.

For Case B, which applies 40% of collection rate for 1998 and 60% for 2008, the impact is predicted to be low on Kangundo Road and high on the access road for the same reasons given for Case A.

Mitigation measures for Kangundo Road include the proper maintenance of the road, adequate routing and collection hours, as well as the selection of the nearest source for necessary materials. To mitigate the high impact on the existing access road, its upgrading to Class C is recommended to meet the additional number of collection vehicles. For more details on traffic assessment, see **Section 9.9 of Data Book (1)**.

(b) Positive Impacts

The following are the positive impacts:

(i) The project will improve the health condition in the city.

(ii) The project will create several jobs directly in various aspects of construction, transportation and operation of the SWM system.

Predictable negative impacts, assessment and mitigation measures for Ruai Area are summarised in **Table I.2-23**.

Table I.2-23 Predictable Negative Impacts, Assessment and Mitigation Measures for Ruai Area

Predictable Impacts	Impact Stage	Significance	Mitigation Measures
Groundwater	O, PCL	Low	• Collection and leachate treatment
Offensive Odour	O	High	• Daily soil covering of disposed garbage • Implementation of medical checkup program • Installation of gas control system
Harmful Insects Generation	O	High	• Daily soil covering of disposed garbage • Implementation of medical checkup program
Water Pollution of Nairobi River	C, CL	Low	• Provision of drains with sediment traps • Proper management of the construction
	O	Low	• Maintenance of ring-drain outside the landfill site enclosing dike • Provision of leachate treatment facilities
	PCL	Low	• Maintenance of ring-drain operation after closure stage • Continued use of leachate treatment facilities for a long time depending on production/quality of leachate
Smoke from Garbage	O	Low	• Daily soil covering of disposed garbage • Installation of gas control system
Dust, Exhaust Fumes from Vehicles and Equipment	C, O, CL	Moderate	• Watering of access road and operational places. Soil materials should be covered with sheet • Proper maintenance of vehicles • Control on the number or speed of vehicles/equipment
Soil Pollution	O, PCL	Low	• Landfill site should receive solid domestic waste only
Noise	C, O, CL	Low	• Public Information on work schedule • Limitation of operation of heavy equipment to daytime only • Adequate maintenance of equipment and trucks which must have exhaust mufflers
Gas Migration	O, PCL	Low	• Land use regulation to surrounding area, avoiding building construction

Table I.2-23 Predictable Negative Impacts, Assessment and Mitigation Measures for Ruai Area (Cont'd.)

Predictable Impacts	Impact Stage	Significance	Mitigation Measures
Traffic	C, CL	Low	• Adequate working hours to minimize traffic congestion • Selection of nearest source for necessary materials
	O	High (in access road)	• Upgrading of access road to Class C to accept the additional number of vehicles
		Low (Kangundo road)	• Adequate routing and collection hours to avoid traffic congestion • Selection of the nearest source for necessary materials • Proper maintenance of the road
Landscape	C	Low	• Project implementation in an aesthetic development scene with landscape harmonisation
Scavengers	O	High	• Enactment of specific working rules for scavengers if allowed to work in the landfill site

Legend: C: Construction Phase; O: Operation Phase; CL: Closure Phase; PCL: Post-closure Phase

2.6 Environmental Management Plan for Ruai Area

Predictable impacts and mitigation measures as mentioned in the previous section must be considered for the preparation of an environmental management plan. Managing item is specified in each phase of the project implementation describing impact source, measuring standard, management approach and management location. The post construction phase is composed of operation, closure and post-closure stages. The environmental management plan is shown in **Table I.2-24**.

2.6.1 Construction and Closure of the Landfill

Noise, dust and traffic congestion are controllable to some extent by adjusting working hours and the number or speed of mobilised vehicles. Besides, the Nairobi River can be protected from adverse effects by means of proper construction management in an effort not to worsen its present condition.

On the other hand, the project will create job opportunities so that recruitment of local manpower under the guidance of NCC become necessary. Employment generation will allow an increase in the family income and can influence, positively, in the local economy.

2.6.2 Operation of the Landfill

NCC should be responsible for controlling negative impacts appropriately using the environmental management plan and employing competent personnel. Thereby, systematic function can be achieved to satisfy the minimum requirement for the prevention of environmental degradation.

Since the candidate site is fenced, the activities of scavengers can be easily controlled by means of specific regulations to be enforced by NCC. Besides, the working place for scavengers should be decided apart from the current filling place in order to avoid possible accidents or personal injuries.

Table I.2-24 Environmental Management Plan for the Landfill Site at Rual Area

Management Item	Source of Impact	Measuring Standard of Impact	Management Approach	Management Location
Construction Phase				
Water pollution of Nairobi River	• All civil works of project	• No surface runoff and soil erosion from the landfill	• Avoid spill soil into river • Provide ring drain around landfill	• Construction site
Dust, Exhaust fumes from equipment	• Mobilization of equipment and vehicles • Civil works	• People's complaints	• Cover soil materials with sheet • Road watering • Proper maintenance of vehicles and equipment • Control of number or speed of vehicles/ equipment	• Construction site • Access road
Noise	• Operation of heavy equipment and vehicles	• WHO's Noise Standard	• Working hour of heavy equipment limited to daytime only • Control of number or speed of vehicles/ equipment • Proper maintenance of vehicles and equipment which must have exhaust mufflers	• Access & main road • Construction site
Traffic	• Mobilization of vehicles and equipment	• Traffic congestion frequency/ duration	• Effort to minimize traffic jam by selection of nearest source for necessary materials • Adjustment of working time	• Construction site • Access & main road
Landscape	• All civil works of project	• People's perception	• Design of landfill should integrate aesthetic development of area	• Construction site
Post Construction Phase				
Groundwater pollution	• Leachate	• NCC's criteria and WHO guidelines for drinking water	• Control of leachate treatment system	• Landfill site
Offensive Odour	• Decomposition of garbage at landfill site	• Public complaint and reaction	• Daily covering of garbage • Installation of gas control system • Implementation of medical checkup program	• Landfill site
Harmful Insects	• Uncovered garbage	• Public complaint and reaction	• Daily covering of the garbage • Implementation of medical checkup program	• Landfill site
Water pollution of Nairobi River	• Leachate	• Japanese Standard for discharge into Public Water Courses	• Control of leachate treatment plant • Proper maintenance of drains around the landfill	• Landfill site
Smoke from garbage	• Burning of garbage at landfill site	• Public complaint and reaction	• Daily covering of garbage • Installation of gas control system	• Landfill site
Dust, Exhaust fumes from vehicles	• Mobilization of equipment and vehicles	• Public complaint and reaction	• Cover soil materials with sheet • Road watering • Proper maintenance of vehicles and equipment • Implementation of medical checkup program	• Access & internal roads • Landfill site

Table I.2-24 Environmental Management Plan for the Landfill Site at Ruai Area (Cont'd.)

Management Item	Source of Impact	Measuring Standard of Impact	Management Approach	Management Location
Soil Pollution	• Toxic elements in the landfill site	No toxic waste entering the site	• Control of type of waste introduced at landfill site	• Main gate
Noise	• Operation of heavy equipment and vehicles	• WHO's Noise Standard	• Working hour of heavy equipment limited to daytime only • Proper maintenance of equipment/vehicles which must have exhaust mufflers	• Access & main roads • Landfill site
Gas Migration	• Gas generated at landfill site	• Field inspection	• Land use limitation in the surrounding area • Installation of gas control system	• Area surrounding landfill site • Landfill site
Traffic	• Mobilization of equipment/ vehicles	• Traffic congestion frequency/ duration	• Selection of adequate routing and time for waste transportation • Selection of nearest source for necessary materials • Build access road to main road specification (Class C) • Proper maintenance of roads	• Landfill site • Access & main road
Scavengers	• Recycling activities	• Interference with the smooth operation of the landfill	• Provision of rules to control scavengers	• Landfill site

2.7 Environmental Monitoring Plan for Ruai Area

Items that should be monitored during the construction and post-construction phases of the landfill site are based on the identification of natural and social environmental impacts. The main objective of the environmental monitoring plan is to evaluate the efficacy of the mitigation measures. NCC should establish a monitoring system at an early stage possible and be engaged in regular site inspection, field measurement and sample analysis. The monitoring location, frequency and duration should be decided taking into account its significance and effectiveness on each monitoring item. The Matrix of the Environmental Monitoring Plan for Ruai Area is shown in **Table I.2-25.**

Table I.2-25 Environmental Monitoring Plan for the Landfill Site at Ruai Area

Monitoring Items	Location	Monitoring Method	Frequency	Duration
Groundwater	Groundwater monitoring well	Analysis of water for physico-chemical and bacteriological quality	1/year	Operation and post-closure stages
Offensive Odor	Landfill site and surrounding residential area	Public opinion and medical check up	Monthly	Operation stage
Harmful Insects	Landfill site and surrounding residential area	Public opinion, field inspection and medical check up	Monthly	Operation stage
Water Pollution of Nairobi River	• Upstream and downstream of disposal site for water sampling • Inlet and outlet of leachate treatment plant	Analysis of water and leachate for physico-chemical and bacteriological quality	1/year	Operation and post-closure stages
Smoke	• Landfill site • Surrounding residential area	• Field inspection • Public opinion	• Every day • Quarterly	Operation stage
Dust and exhaust fumes	Landfill site and surrounding residential area	Public opinion, field inspection and medical check up	Quarterly	Construction, Operation and closure stages
Soil Pollution	Main gate	Inspection of types of waste	Every day	Operation stage
Noise	Landfill site and main & access roads	Field measurement of noise level	1/year	Construction, Operation and closure stages
Gas Migration	Surrounding area	Field inspection	1/year	Operation and post-closure stages
Traffic	Main & access roads	Field inspection	1/year	Construction, Operation and closure stages
Scavengers	Landfill site	Field inspection	Every day	Operation stage

2.7.1 Natural Environmental Aspects

NCC should assume the responsibility of monitoring surface and ground water. Sampling points for Nairobi River should be the same to those selected for EIA. Monitoring duration is desirable to cover construction, operation and post-closure stages of the disposal site. Sample analysis work should include all parameters employed in EIA.

In establishing the monitoring plan, it is also important to monitor the quality of leachate at the inlet and outlet of the treatment plant, to evaluate effectiveness of the treatment and avoid more degradation of the Nairobi River.

Noise levels should be monitored every year at the landfill site and roads. At the landfill site the level of 90 dB(A)-8hr should not be exceeded to protect the health of the workers.

Gas migration is considered to be of low significance and inspection of the surrounding area should be performed to avoid the construction of buildings.

Although soil pollution is considered to be of low significance, monitoring should be performed to maintain this condition. In this regard, strict control should be provided at the garbage receiving point to monitor the type of incoming waste in order to avoid the introduction of toxic residues in the landfill.

As for dust, smoke and harmful insects, monitoring works shall be performed at the landfill site and surrounding residential area by means of public opinion survey and field inspection. In addition, offensive odour generation shall be monitored by periodically conducting a public opinion survey.

2.7.2 Social Environmental Aspects

NCC should monitor the traffic congestion and noise levels at the same time and monitoring locations should be the same as those employed during the EIA study.

A medical checkup program shall be established for workers of the disposal site and the surrounding affected population.

On the other hand, since the site is fenced, only authorised persons can enter which shall allow appropriate operation of the facility.

3. CONCLUSION AND RECOMMENDATION

From the present study on EIA, conclusions and recommendations are as discussed below.

3.1 Construction of Final Disposal Site at Ngong Road Forest Area

3.1.1 General

The following major potential negative impacts were identified to adversely affect the environment of the area with the project implementation:

(1) The major impacts during construction of the disposal site will be the destruction of approximately 0.8 ha of indigenous forest, 25.4 ha of Eucalyptus plantations and 7.0 ha of grassland. Besides, the physical removal of a section of the indigenous forest measuring approximately 0.5 km and 12 m for the access road construction is considered of high impact. This section contains about of 4,600 individual trees and shrubs in various ages and heights.

(2) Destruction of grassland and ecotone which have a total of 61 species of which 32 only occur there. This will be destroyed and since there are no other glades and ecotones in the Ngong system, this will be completely lost. Also animals and birds dependent on them will be disturbed.

(3) Impact on Mutoine River which is used for irrigation of forest tree nurseries, watering livestock and alternative source of domestic water supply to the surrounding areas poor communities during drought is predicted.

(4) Bee-keeping Division of the Ministry of Agriculture, Livestock and Marketing is located in the Forest. The bee-keeping activities, which are dependent on the flowering of plants in the forest and the surrounding settled areas, will be adversely affected.

(5) The petroleum pipeline passing through the landfill site at Ngong Road Forest Site is likely to be affected by the project.

(6) Illegal cutting of trees, potential fire risks and illegal squatting in the gazetted forest which are considered as high impact during operation of the project.

(7) The diversity of plant species in the Ngong vegetation communities was found to be high especially with the inclusion of the indgenous forest. Over 250 plant species were identified in the various communities. The potential destruction of the forest around the disposal site by scavengers during the operation of the project is highly predictable.

(8) The long term plan as stipulated in the Kenya Forestry Master Plan, 1994, which has been adopted by the Government is to introduce ecotourism in the Ngong Road Forest and to enhance the use of the forest for forestry research and education. Therefore, construction of a sanitary landfill on the site will adversely affect the current and planned uses of the Ngong Road Forest.

(9) Impact of high significance is predicted on Ngong Road traffic level which currently is about 2.5 times of the road design capacity.

3.1.2 Conclusion

Although mitigation measures are workable to minimise the negative impacts on the environment, the JICA Study Team considers that the construction of the disposal site in the Ngong Road Forest Area is not suitable because it is not compatible with the Kenya Forestry Master Plan which will introduce ecotourism in the area and will use the forest for forestry research and education.

The other constraint is related to the current level of traffic of Ngong Road which is about 2.5 times of the road design capacity and this condition will make it sensitive to any increase in the number of vehicles. To take the extra volume of vehicles of the project, upgrading of the road becomes necessary which is beyond of the scope of this project.

On the other hand, scavengers are likely to move to the new landfill site after closing of the existing one at Dandora. This fact will contribute to the total destruction of the forest allocated around the candidate site.

3.2 Construction of Final Disposal Site at Ruai Area

3.2.1 General

Potential negative impacts and mitigation measures are described below.

(1) Contamination of groundwater by leachate can occur under favorable hydraulic conditions, in which the leachate generated from the solid waste pass through the soil to finally reach the acquifer. Groundwater pollution around the disposal site is predicted in low significance taking into account the geological properties of the soils underlying the candidate site. However, no impact is predicted on the existing three wells which are used as sources for water supply and for cattle. The mitigation measure for groundwater pollution consist in the implementation of the leachate collection and treatment system.

(2) Generation of offensive odour created by anaerobic biodegradation of waste is highly predictable. Mitigation measures include the daily covering of the

disposed garbage, the installation of a gas control system and the implementation of a regular medical checkup for workers.

(3) A poor operation of the disposal site can adversely impact the environment such as the breeding of harmful insects which could affect the health of workers and the neighborhood of the landfill site. This impact is considered to be of high significance. The mitigation will be the daily soil covering of the disposed garbage. Frequent medical checkup is recommendable.

(4) Contamination of surface water can occur since lechate is discharged into it, or by surface runoff directly from the disposal site. The water quality of Nairobi River is already too degraded and for this reason the impact shall be of low significance. Mitigation measures include the construction of drains with sediment traps and the provision of leachate treatment facilities.

(5) At the disposal site, smoke can be generated by burning waste and this can occur underground or in the surface. Underground burning mainly emerges due to the high temperature that manage the anaerobic bio-degradation process of the waste. This impact is considered as impact of low significance since the disposal site shall be constructed and operated in a sanitary form. Mitigation measures are the daily soil covering of the disposed waste and the installation of a gas control system.

(6) Dust and exhaust fumes from equipment and vehicles during construction and operation of the disposal site will result. The dust originating from the unloading and spreading operation at the disposal site is of the most concern. Dust can irritate the eyes and may also carry pathogenic microorganisms that might be inhaled. Dust mitigation includes the watering of access and operational places and the covering of soil materials with sheet. As for exhaust fumes, proper maintenance of equipment and vehicles shall be required. Frequent medical checkup and treatment of affected workers is recommendable.

(7) The soil existing under the disposal site may be contaminated by pathogenic microorganism, heavy metal, salts and other pollutants contained in the leachate from the solid waste. The introduction of heavy metal in the soil is of major concern and can be introduced through the industrial waste disposal. Since the site is only for domestic waste disposal, the impact on soil is predicted to be of low significance. Strict control of type of solid waste to be introduced at the site should be implemented as a mitigation measure.

(8) Moderate increase in the noise levels during construction, closure and operation stages is expected to affect the workers but low impacts are predicted on the current noise levels of the main and access roads. Public consensus is absolutely necessary about the project prior to the construction, and for the noise control, 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.

(9) The gas produced during the anaerobic decomposition process of the solid waste in the landfill disposal 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 it is potentially explosive. In Ruai area, currently, there is no building that can be affected by the gases and this condition should be maintained through the enforcement of land use regulation avoiding building construction in the area surrounding the disposal site.

(10) During operation stage, the number of vehicles necessary for transportation to the disposal site will generate an impact of low significance on Kangundo Road and high significance on the access road. Mitigation measures for Kangundo Road include the proper maintenance of the road and the implementation of an adequate routing and transportation schedule. However, upgrading of the access road to Class C is necessary to mitigate the high impact predicted on this road.

(11) As for the landscape, the residential area is located far away from the candidate site; therefore, no change in the landscape could be noted by the surrounding communities. At any rate, the project should be implemented in an aesthetic development scene with landscape harmonisation.

(12) Once Dandora is closed, the migration of scavengers to the new site is highly predictable. If they are allowed to work in the landfill site, then, strict control should be paid on them to avoid interference with the smooth operation of the landfill. The provision of specific working rules is highly recommendable.

Potential positive impacts to be generated by the Project are as given below.

(1) Public Health and Environment

The new disposal site for garbage of Nairobi City is proposed to be constructed utilising the method of sanitary landfill which could eliminate or decrease the following components influencing public health and the environment:

(a) Elimination or decrease of disease vectors (e.g., flies, rats, cockroaches), which are popular when garbage is open dumped.

(b) Minimisation of water, soil and air pollution, permitting an increase in the public health level of the population and a better quality of the environment.

(2) Employment

The project will directly create several jobs in the various aspects of construction, transportation and operation of the SWM system.

4. REFERENCES

(1) Terms of Reference for EIA

Technical specifications in the Terms of Reference for EIA were prepared with reference to the findings in the Initial Environmental Examination (IEE) while the administrative procedure was prepared taking into account the following guidelines:

(a) JICA Environmental Guidelines for Infrastructure Projects, VI Solid Waste Management, 1992.

(b) Guidelines of OECF, Waste Disposal Sector, 1996.

(c) Environmental Assessment Source Book, Sectoral Guidelines, World Bank

(d) Guidelines for EIA in the Republic of Kenya, Draft Report, 1996

The standards used in the EIA study are composed of the following:

(a) NCC Drinking Water Quality Criteria
(b) WHO Guidelines for Drinking Water Quality
(c) Japanese Water Quality Standards
(d) Japanese Offensive Odour Control Law
(e) WHO Noise Specification
(f) Japanese Standards for Discharge into Public Water Courses
(g) Road Design Standards and Classification in Nairobi District

(2) References Used by Subcontracted Local Consultant for EIA

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(q) Mbaya JS.K.(1993). Resource and defense behaviours of the African honey bee (Apis mellifera L.) in Kenya.

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(t) African Journal of Range and Forage Science 14 (1)

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(y) Wass, P. (1995); Kenya's indigenous forests, status management and conservation ODA/IUCN Report

SECTION J

ECONOMIC AND FINANCIAL ASPECT

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

FINAL REPORT

SECTION J

ECONOMIC AND FINANCIAL ASPECT

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SECTION J

ECONOMIC AND FINANCIAL ASPECT

1. OVERVIEW AND EVALUATION OF PRESENT CONDITIONS

1.1 Recent Macro Economic Conditions

According to the *Economic Survey, 1997* lately published, the estimated real Gross Domestic Product (GDP) growth in 1995/96 shows 4.6%. This figure is below the projection (5.5%) and revised one of 1994/95 (4.8%). This is mainly due to inadequate rainfall causing slower agricultural performance, increasing prices, high cost of domestic credit, power rationing, and a more competitive trading environment brought about by macro-economic reform measures. In spite of those mentioned above, most economic sectors still recorded steady growth. See **Table J.1-1.**

Table J.1-1 Growth of Real GDP

Unit: Percent

	1992/93	1993/94*	1994/95*	1995/96**
Total Non-Monetary Economy	4.2	2.8	3.4	2.7
Monetary Economy				
Agriculture	-4.1	2.8	4.8	4.4
Forestry	10.3	8.8	5.1	7.0
Fishing	2.9	4.0	4.1	4.0
Mining and Quarrying	2.0	1.6	2.7	2.5
Manufacturing	1.8	1.9	3.9	3.7
Building and Construction	-8.7	1.3	3.8	3.5
Electricity and Water	0.9	2.2	1.6	3.1
Trade, Restaurants and Hotels	0.1	6.1	8.6	8.0
Transport, Storage and Communications	0.8	3.0	4.2	4.0
Finance, Insurance, Real Estate and Business Services	7.2	6.1	6.9	7.1
Other services	0.8	2.6	6.3	6.0
Total Monetary Economy	0.0	3.0	4.9	4.7
Total Non-Monetary and Monetary Economy	0.2	3.0	4.8	4.6

*: Revised **: Provisional
Source: *Economic Survey, 1997*

It may be safely projected that the Kenyan economy continues to grow steadily if there will be no drastic changes in domestic and international circumstances. *Economic Survey, 1997* describes:

Growth in the economy was primarily fueled by higher exports of coffee, tea, and horticulture products, a fairly stable exchange rates, moderate inflation and widening market arising from the establishment of the EAST African Co-operation. In addition, the initial shocks of experienced after liberisation, particularly those of imports and the exchange rate, have largely been absorbed by the economy. (page 16)

On the other hand, Government policy of reducing the budget deficit and concentrating on the provision of essential services caused deceleration of Producers of Government Services from 22.8% nominal growth in 1994/95 to 9.4% in 1995/96. The government aims to allocate more resources to development projects while seeking of depressing recurrent expenditure on wages and salaries.

Further, some negative impact of the growth should be considered. If prices are reviewed closely, it can be found that the inflation rate rose from 1.6% to 9.0% in 1995/96. It is largely due to upward price adjustment of petroleum products, rapid money supply and gradual extension of Value Added Tax (VAT) on consumer goods and services. **See Table J.1-2.**

Table J.1-2 Recent Inflation Rates

	1993	1994	1995	1996
Consumer Price Increase	46.0%	28.8%	1.6%	9.0%

Source: *Economic Survey, 1996 and 1997*

On the movement of interest rates, the upward pressure started in the latter half of 1995 and continued in 1996. The Central Bank of Kenya intervened the money market to maintain high interest rate for attracting deposits which was aimed to finance the budget deficit. Additionally, generally high demand for domestic credit created the upward pressure. See **Table J.1-3.**

Table J.1-3 Recent Interest Rates

	1993	1994	1995	1996
Discount Rate for Treasury Bills	39.3%	17.9%	20.9%	21.6%

Sources: *Economic Survey, 1996 and 1997*

1.2 Overview of Sectoral Economies

1.2.1 Agriculture

The growth rate of this sector is 4.4% in 1996, which is lower than the expected 5.3% due to the following reasons:

(1) inadequate rains during the year
(2) lower prices of some major crops including maize
(3) higher input prices such as fertilizers causing reduced use

In spite of those decline, cash crops such as tea, coffee, sisal rose in 1996. Tea production increased by 16.8% in 1995 and 5.2% in 1996 mainly thanks to high international prices and improvement in crop husbandry. For the first time, Kenya became the world's leading exporter of tea overtaking Sri Lanka and India. See **Table J.1-4.**

Table J.1-4 Agricultural Production and Growth Rate

'000 tonnes

	1993	1994	1995	1996
Maize	241.8	316.0	401.0	295.5
	-25.4%	30.7%	26.9%	-26.3%
Wheat	73.1	105.2	125.5	130.0
	-41.9%	43.9%	19.3%	3.6%
Sugarcane	3,839.4	3,308.1	4,034.9	4,122.0
	5.0%	-13.8%	22.0%	2.2%
Coffee	75.1	79.9	95.4	97.0
	-12.0%	6.4%	19.4%	1.7%
Tea	211.2	209.4	244.5	257.2
	12.3%	-0.8%	16.8%	5.2%

Source: *Economic Survey, 1997*

1.2.2 Manufacturing

It seems that the manufacturing sector is recovering from impact of the market liberalization. Without power shortage resulting from draught, this sector would have shown much better performances than expected. In addition, sluggish household income growth in 1996 due to bad weather, caused reduction in aggregate demand for domestic manufacturing products. Nevertheless, stability of foreign exchange market helped not to make further decline of production. See **Table J.1-5**.

Table J.1-5 Manufacturing Production of Major Items and Growth Rate

	1993	1994	1995	1996
Sifted Maize Meal	168.1	233.2	313.7	266.7
('000 tonnes)	40.6%	38.7%	34.5%	-15.0%
Wheat Flour	143.1	191.4	237.0	227.2
('000 tonnes)	-35.7%	33.8%	23.8%	-4.1%
Spirits	2259.1	1674.0	2261.5	2887.7
('000 liters)	52.6%	-25.9%	35.1%	27.7%
Beer	349.2	302.7	347.4	276.0
(million liters)	-5.3%	-13.3%	14.8%	-20.6%
Mineral Waters	132.3	131.3	122.3	140.3
(million liters)	-0.8%	-0.8%	-6.9%	14.7%
Cigarettes	7,266	7,319	7,931	6,393
(million sticks)	3.3%	0.7%	8.4%	-19.4%
Cement	1,416.2	1,452.3	1,565.6	1,816.0
('000 tonnes)	-6.0%	2.5%	7.8%	16.0%

Source: *Economic Survey, 1997*

1.2.3 Tourism

Because of adverse publicity in the international media, ineffective tourism promotion and stiff competition with similar markets including Southern Africa, Caribbean and South East Asia, total visitor arrivals and departures declined by 20% and 24.2% respectively in 1995. However, they showed increases by 3.9% and 9.8% respectively in 1996. In addition, earnings from tourism increased by 2.4% in 1996 as well as hotel occupancy went up by 2.1%. These relatively good performance in tourism industry

came from lower rates of inflation and stable foreign exchange market. See **Table J.1-6.**

Table J.1-6 Visitor Arrivals and Departures and Growth Rate

'000 visitors

	1993	1994	1995	1996
Arrivals	826.2	863.4	690.5	717.4
	5.7%	4.5%	-20.0%	3.9%
Departures	687.8	865.3	656.0	720.4
	5.8%	25.8%	-24.2%	9.8%

Source: *Economic Survey, 1997*

1.3 Review of National Development Plan

Sessional Paper No. 2 of 1997 on Industrial Transformation to the Year 2020, which is the basis of *The Eighth National Development Plan for the Period 1997 to 2001*, sets out national policies and strategies that will lay the foundation for the structural transformation. Its purpose is to join the league of Newly Industrialized Countries (NICs) by the year 2020.

In the paper, it is expected that for near full employment to be achieved during the period 1997- 2000, employment growth must average 4.3 % annually. It is more than double of 2% in the last decade. In order to catch up with the figure, the economy will have to grow at 8 - 10 %, where industry sector increase its growth rate to 15% by 2020 according to *Sessional Paper No. 2 of 1997*. In addition, *The Eighth National Development Plan* sets a set of development targets as shown in **Table J.1-7**:

Table J.1-7 Projected Growth Rates for GDP and Sectors

Sector	Projected Growth Rate 1997-2000, %
Agriculture	4.4
Industry	7.86
Services in the Private Sector	6.0
Services in the Public Sector	6.2
GDP	5.9

Source: *The Eighth National Development Plan for the Period 1997 to 2000*

1.4 Financial Conditions of NCC

Financial reports of NCC including *Nairobi City Council Statement of Accounts* , *Nairobi City Council Estimates* for last several years and other data as well as interview surveys with related staff in City Treasurers Office illustrates the following financial conditions of NCC, which excludes the Water and Sewerage Department because it has separated account.

Concerning the balance sheet of NCC for last four years, the most noticeable point is the extremely high level of debtors as reported by *City Treasurer's Report* of 1995. It reached at K£129,069,523 as of 30th June, 1995, which is an increase by K£12,725 over the previous year. See **Figure J.1-1.**

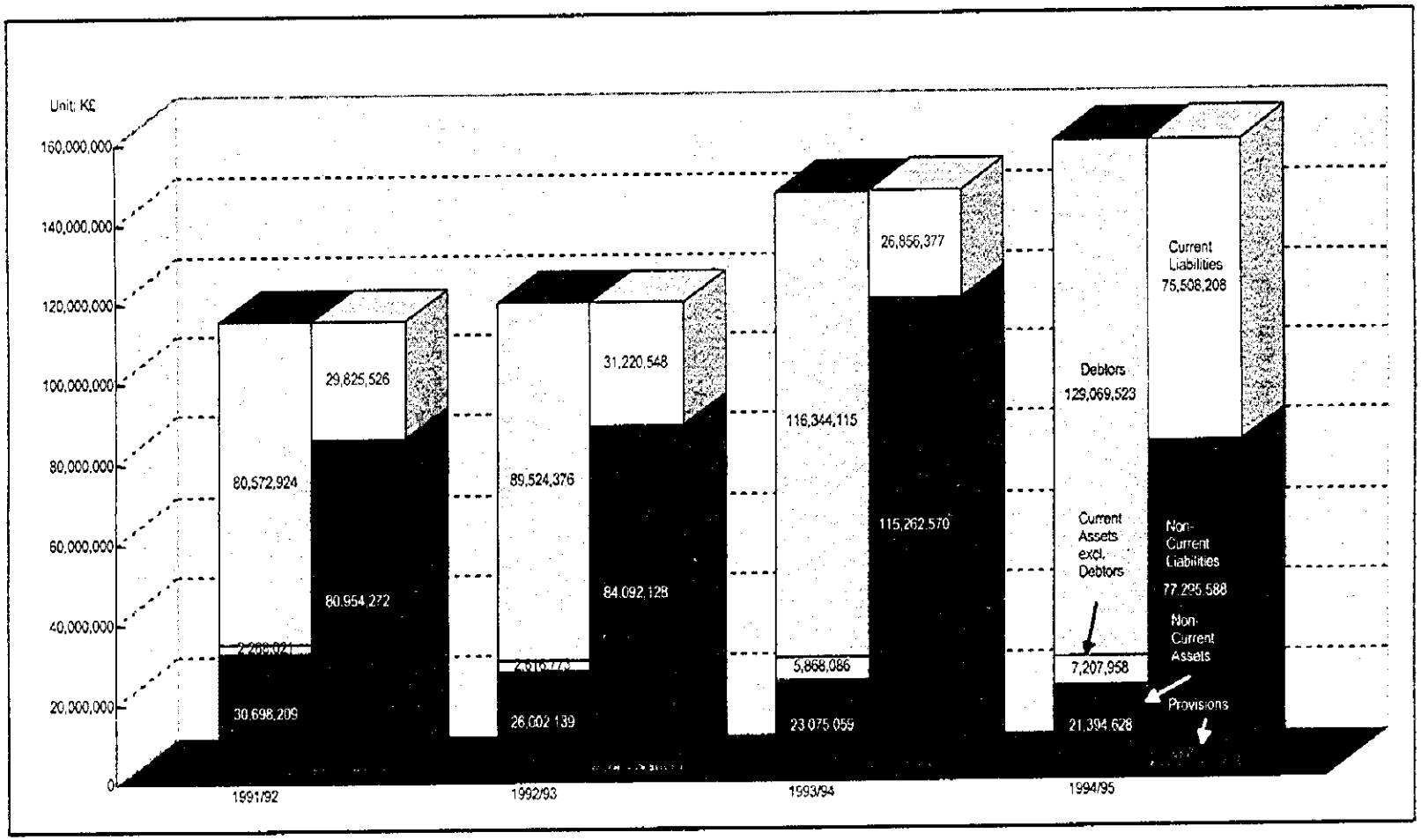
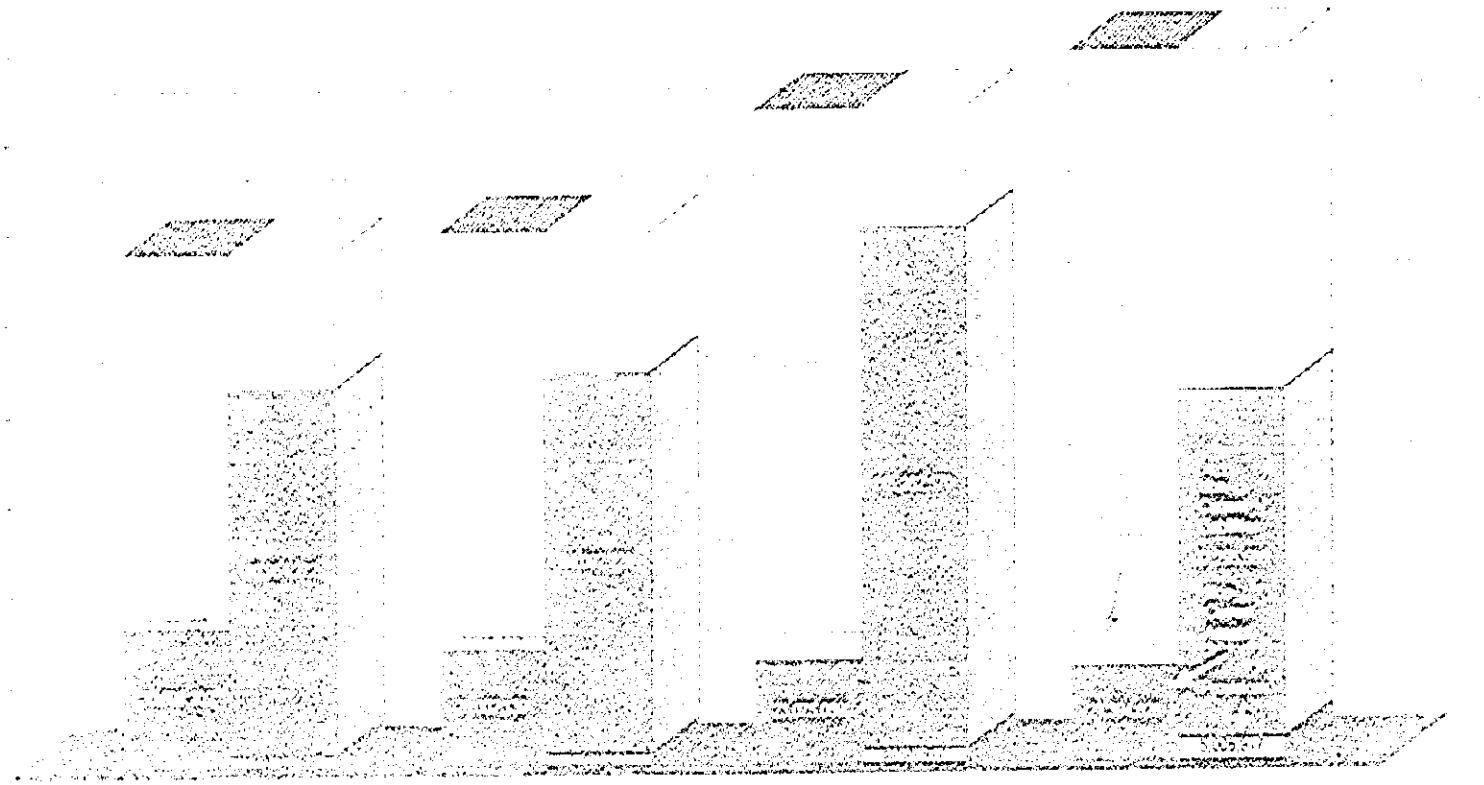


Figure J.1-1 Comparative Balance Sheet of NCC



The reason why such situation in the balance sheet is brought about is as follows:

Firstly, the budgetary management procedure of NCC is not based on the actual cash inflow. Revenue is credited to the general revenue fund on demand and then debited to debtor accounts until they are paid in cash. In other words, revenue is hypothetically counted to be expendable before it is actually paid in cash.

Secondly, money collection system is very poor. Not all taxes and fees collectable are gathered because there is no adequate information system which registers all people and corporate bodies. In addition, when debts are collected, the Code of Civil Procedure should be applied. It takes long time to finish. The United Nations' report, *Solid Waste Management as a function of local government, 1996*, proposes an idea of establishing a solid database to provide a coordinated money collection system which identifies all debtors.

As a result, "revenue" represents bad debts and balancing expenditure will inevitably lead to similar debt.

On the income statement of NCC for last four years, the most noticeable point here is that the income statement shows deficit except 1993/94. In the balance of K£39,937,541 deficit in 1992/93, one of the major items of losses is Currency Losses on Foreign Loans of K£42,287,825 while approximately 39% of surplus in 1993/94 thanks to Currency Gains on Foreign Loans. See **Table J.1-8.**

Salaries & wages increased by 71.4% in 1994/95 since new salary scales were implemented. Furthermore, it was announced in May that again new salary scale will be implement in 1997. It is expected that the budgetary deficit will increase much further without any reduction of other budgetary items or number of employees of NCC.

"Income from Services" includes interdepartmental recharges since NCC budgetary system directs to charge all expenditure to its services as "end product". As mentioned above transactions are not backed by cash. Thus, the system requires complex adjustments of budget and make it very difficult to compare budgets with progress.

Balance of General Fund Revenue Account accumulates deficit of K£107,926,850 in 1994/95, resulting deficit increase by K£41,147,174 from the previous year. Out of this deficit increase, K£28,888,122 is attributed to provision for arrears of the implementation of new salary scale. NCC is de facto insolvent.

Table J.1-8 Comparative Income Statement of NCC

Unit: K£

	1991/92	1992/93	1993/94	1994/95
Tax and Service Charge Revenue				
Rates	30,780,764	37,745,764	50,148,642	56,126,041
Income from Services	16,169,343	22,633,586	24,732,276	42,099,696
Applied from Services Charge Account	6,175,237	5,134,331	8,098,956	7,558,134
Total	53,125,344	65,513,681	82,979,874	105,783,871
Cost of Services				
Gross Expenditure excl. S & W	43,710,360	36,932,899	42,400,134	71,117,254
Salaries & Wages	26,745,026	28,568,581	26,039,651	44,642,605
Total	70,455,386	65,501,480	68,439,785	115,759,859
Operating Profit	-17,330,042	12,201	14,540,089	-9,975,988
Other Revenues and Gains				
Interest & Dividends	144,239	93,245	253,652	265,845
Directors' Fees K.B.S.	15,000	0	13,117	9,996
Capital Receipts Applied	0	2,412,051	3,618,241	1,998,023
Currency Gains on Foreign Loans	0	0	11,190,002	24,307
Total	159,239	2,505,296	15,075,012	2,298,171
Other Expenses and Losses				
Additional Payments to Provident Fund	244,663	167,213	219,018	260,979
Terminal Benefits	0	0	0	1,694,579
Currency Losses on Foreign Loans		42,287,825		
Total	244,663	42,455,038	219,018	1,955,558
Surplus/Deficit of the Year	-17,415,466	-39,937,541	29,396,083	-9,633,375
Provision for Bad Debts	0	0	500,000	1,700,000
Net Surplus/Deficit of the Year	-17,415,466	-39,937,541	28,896,083	-11,333,375

Source: *NCC*

Outstanding long-term foreign borrowings of NCC are summarized in **Table J.1-9**.

Table J.1-9 Outstanding Long-Term Foreign Loans

Lender	Commonwealth Development Corp.	USAID	USAID
Loan No.	L223901	615 HG 003 A01	615 HG 005 001
Purpose of Loan	Buru Buru Housing	Umoja I Housing	Umoja II Housing
Agreement Date	20.4.79	1.1.72	1.9.85
Loan Amount	Stg£ 1,600,000	US$ 10,000,000	US$ 17,000,000
Interest	8%	8.7%	Floating
Loan Period	20 years	25 years	20 years
First Repayment	30.6.81	1.7.79	1.9.95
Last Repayment	31.12.00	1.1.05	1.3.15
Loan Balance as of 31.12.96	£657,000	$5,915,134	$15,725,000

Source: *NCC*

1.5 Financial Conditions of Cleansing Section

1.5.1 Budget

The budget of Cleansing Section, which is in charge of the solid waste management, consists of the following four accounts: Administration, Conservancy, Refuse Removal and Cleaning-General. Budgetary share of Administration (approved estimate base) has been increasing recently as 11.4% in 1991/92, 12.6% in 1992/93 and 14.9% in 1994/95. (1993/94 budget is excluded from this consideration because it includes wages of other accounts.)

Capital expenditure is financed by General Fund as well as Services Charge Account. Up to 50% of income in Services Charge Account can be used for General Fund Revenue Expenditure. See **Table J.1-10.**

Table J.1-10 Capital Expenditure of Cleansing Section

Year	Finance (K£)
1991/92	1,249,500
1992/93	997,400
1993/94	2,983,000
1994/95	70,000

Source: *NCC*

Refuse removal account in the Cleansing Section shows net profit from 1992/93 on actual basis although the amount is reducing. It should be noticed, however, that running expense of refuse vehicles are not realised fully until 1993/94 and major part of supplies, services and equipment items are not realised. It may be due to expenditure estimates compiled with inadequate revenue estimate.

Examination of NCC financial data needs much care since there are sometimes delay or mistake of data input to the computer and they are not correct properly due to frequent system down of the computer, according to the information by the staff of City Treasurer's Office.

1.5.2 Revenue from Refuse Removal

Revenues are categorised into two: those paid directly to NCC including tip charges and those paid through the water bills. Revenues from solid waste removal in the latter category are further separated as follows:

(1) *Container hire:* Solid waste are collected with several types of containers. Fees are charged on the containers. Even after the containers are worn out and they are not replaced with new ones, people pay the charges as long as they get refuse removal services.

(2) *Refuse removal:* If people get refuse removal services, fees are charged on the basis of the types of container in addition to the container hire fees. However, refuse removal fees for households are not actually charged on dustbins.

Increase in solid waste charges for households to Kshs 130 was approved by MOLG. However, it was not enforced because they were suspended by the chairman of the commission following a public outcry. Later, increase to Kshs 40 was approved. Again, it was not enforced because NCC could not provide sufficient services to the people and feared the public outcry. Charges presently enforced are set in 1984. Thus, revenues are absolutely short for covering the costs.

1.5.3 Charging System of Solid Waste Collection

Solid waste collection services offered by NCC are charged with same bills of water related tariffs. Water charge, sewerage charge, other water related charges and solid

waste (dust bin) charge collected are pooled in the Water Fund. The total billing amount is Kshs 100 - 120 million per month. About 10% is dust bin charges.

All the money collected by the water bills are at first poured into the Water Fund. Then, dust bin charges are transferred to the refuse removal account in the General Fund at the end of the fiscal year. See **Figure J.1-2**. Water Fund is separated from General Fund which is spend for other general services. The money in the Water Fund must be spent only for the water related projects/expenses including salaries and wages. About Kshs 1 billion is poured into the fund every year. Only small part of the fund can be lent to the General Fund (Kshs 8 million in 1997) although it accrues no interest.

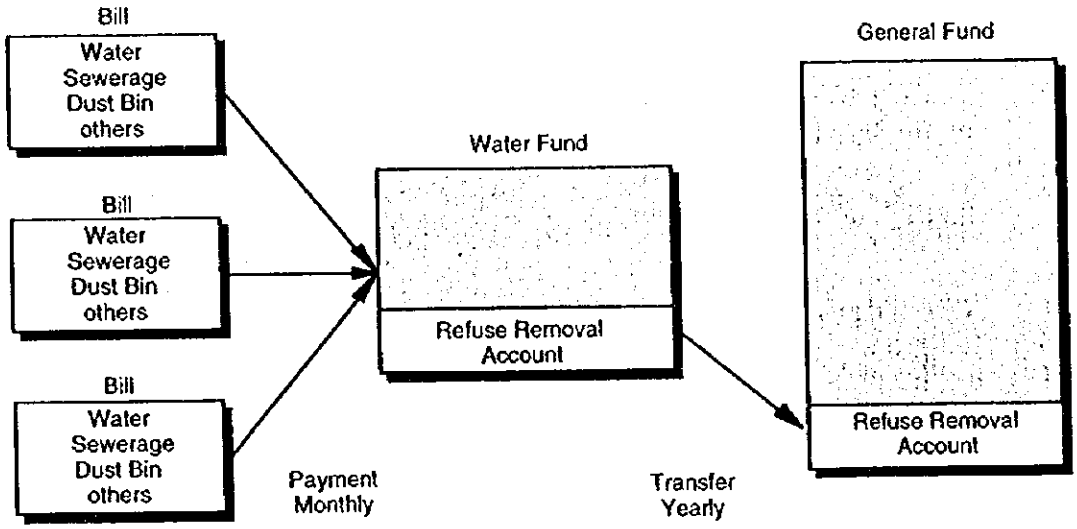


Figure J.1-2 Charging System

Presently, Kshs 10 is charged per dust bin per month. In 1996, an increase of tariff rate to Kshs 30 was proposed. But it has been suspended so far.

The biggest problem of the computerized collecting system is its over-aging. It was set up in 1970. When it was started, the number of accounts was around 40,000. It was increase to 200,000. It exceeds the capacity of the computer system. Thus, it sometimes goes system-down. In addition, data are input manually. Since January in 1997, no new accounts has been added into the data file. New computer billing system will start in June, 1998 with the assistance of the World Bank. This new system will continue the billing of waste collection.

Concerning the bill of charges, when you open the water account, you will be given a bill which includes water charge, sewerage charge, meter rent and a dust bin automatically. When you do not ask NCC to collect waste, you have to claim to the Water and Sewerage Department (WSD). Then WSD inquires the Depart of Environment whether you are asking waste collection or not. If it is confirmed not, billing of dust bin is deleted from your bill.

2. PROJECTIONS FOR THE ANALYSIS

2.1 Population Projection

2.1.1 Projection of Total Population in Nairobi Province

Demographic data is the very basic one for estimating solid waste generation and others for the study. The latest national census was carried out in 1989. So we have no actual population data of Nairobi Province in the present year 1997. We employ a population projection of Nairobi City prepared by a Kenyan counterpart of the Study. The new projection was made with the following:

(1) The total population of the city for census years in 1979 and 1989

(2) The total by district according to the third Nairobi Water Supply Project Study for the year 1985

(3) The total by district for the year 1990 calculated by interpolation from the figures given in the Third Nairobi Water Supply Project Study for 1985 and 1995

(4) The total by district by the City Planning Department for the year 1992

The projection table shows only year of 1985, 1990, 1992, 1997, and 2000-2007. Since projections in 1998, 1999 and 2008 are not made and they are necessary for the Study, we fulfilled the blank year by regression method. See **Table J.2-1** for the original projection table gained from the Kenyan counterpart and **Table J.2-2** for the projection table with blank fulfillment in 1997-2008 as well as its growth rate.

The projection shows a growth rate of 4.70% p. a. from 1998 to 2008. So, the projected population increases more than one million during the years covered by the study. Although this growth seems rather rapid, adjustments are not made to the projection based on the following:

(1) Kenya has one of the highest rates of urbanization in the world and basically this trend is expected to continue in more than one decade. According to *The Eighth National Development Plan for the Period 1997 to 2001*, urban population is expected to increase from 5.28 million in 1995 to 7.44 million in 2000. In *Economic Survey 1996*, the Nairobi's share of the total urban population is 36% in 1979 and 34% in 1989. If 30%, for example, is employed for the share, Nairobi's population growth in the period of 1995-2000 amounts to approximately 0.65 million [7.44 million - 5.28 million x 30% = 0.65 million]. Thus, the more than one million population growth in the period 1998-2008 is not surprising one.

(2) Although the birth rate in Nairobi would be reduced owing to urbanization, it is anticipated that migration from rural areas will account for a larger proportion of the growth of the urban population over the next decade.

2.1.2 Population Projection of Sub-areas in Nairobi Province

Locational distribution of population is keen for the formulation of the solid waste management plan, especially for the collection and transportation plan. Populations in

Districts are shown in the estimation for the total population gained above. See **Table J.2-2.**

The sub-area "Districts" used in the projection are different from the administrative boundaries of NCC. Thus, estimated populations were converted to those in such boundaries for the purpose of formulating the collection and transportation plan and others. In converting the data, populations were distributed in accordance with the sizes of areas. Conversion is carried out with the following process:

Table J.2-1 Original Projection Table

District	1985	1990	1992	1997	2000	2001	2002	2003	2004	2005	2006	2007
1	52,000	54,000	54,400	55,400	56,000	56,000	56,000	56,000	56,000	56,000	56,000	56,000
2	125,000	130,000	131,000	133,500	135,000	141,750	148,838	156,279	164,093	172,298	180,913	189,959
3	45,000	48,000	48,800	50,800	52,000	54,600	57,330	60,197	63,206	66,367	69,685	73,169
4	55,000	58,000	59,000	61,500	63,000	66,150	69,458	72,930	76,577	80,406	84,426	88,647
5	25,000	40,000	41,200	44,200	46,000	48,300	50,715	53,251	55,913	58,709	61,644	64,727
6	12,000	14,000	14,200	14,700	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000
7	105,000	110,000	111,600	115,600	118,000	118,000	118,000	118,000	118,000	118,000	118,000	118,000
8	170,000	185,000	188,000	195,500	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000
9	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
10	90,000	116,000	128,400	159,400	178,000	186,900	196,245	206,057	216,360	227,178	238,537	250,464
11	63,000	73,000	75,400	81,400	85,000	89,250	93,713	98,398	103,318	108,484	113,908	119,604
12	16,000	36,000	49,200	82,200	102,000	108,120	114,607	121,484	128,773	136,499	144,689	153,370
13	10,000	25,000	36,000	63,500	80,000	84,000	88,200	92,610	97,241	102,103	107,208	112,568
14	50,000	70,000	75,000	87,500	95,000	99,750	104,738	109,974	115,473	121,247	127,309	133,675
15	34,000	198,000	242,400	353,400	420,000	445,200	471,412	500,227	530,240	562,055	595,778	631,525
16	23,000	25,000	26,000	28,500	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000
17	30,000	46,000	60,800	97,800	120,000	126,000	132,300	138,915	145,861	153,154	160,811	168,852
18	150,000	232,000	294,600	451,100	545,000	577,700	612,362	649,104	688,050	729,333	773,093	819,478
19	0	0	30,000	105,000	150,000	159,000	168,540	178,652	198,372	200,734	212,778	225,545
20												
Total	1,065,000	1,470,000	1,676,000	2,191,000	2,500,000	2,615,720	2,737,458	2,867,078	3,012,477	3,147,567	3,299,779	3,460,583

Table J.2-2 Projection Table with Blank Years Fulfilled

District	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	55,400	55,600	55,800	56,000	56,000	56,000	56,000	56,000	56,000	56,000	56,000	56,000
2	133,500	134,000	134,500	135,000	141,750	148,838	156,279	164,093	172,298	180,913	189,959	199,457
3	50,800	51,200	51,600	52,000	54,600	57,330	60,197	63,206	66,367	69,685	73,169	76,827
4	61,500	62,000	62,500	63,000	66,150	69,458	72,930	76,577	80,406	84,426	88,647	93,079
5	44,200	44,800	45,400	46,000	48,300	50,715	53,251	55,913	58,709	61,644	64,727	67,963
6	14,700	14,800	14,900	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000
7	115,600	116,400	117,200	118,000	118,000	118,000	118,000	118,000	118,000	118,000	118,000	118,000
8	195,500	197,000	198,500	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000
9	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
10	159,400	165,600	171,800	178,000	186,900	196,245	206,057	216,360	227,178	238,537	250,464	262,987
11	81,400	82,600	83,800	85,000	89,250	93,713	98,398	103,318	108,484	113,908	119,604	125,584
12	82,200	88,800	95,400	102,000	108,120	114,607	121,484	128,773	136,499	144,689	153,370	162,572
13	63,500	69,000	74,500	80,000	84,000	88,200	92,610	97,241	102,103	107,208	112,568	118,196
14	87,500	90,000	92,500	95,000	99,750	104,738	109,974	115,473	121,247	127,309	133,675	140,359
15	353,400	375,600	397,800	420,000	445,200	471,412	500,227	530,240	562,055	595,778	631,525	669,417
16	28,500	29,000	29,500	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000
17	97,800	105,200	112,600	120,000	126,000	132,300	138,915	145,861	153,154	160,811	168,852	177,295
18	451,100	482,400	513,700	545,000	577,700	612,362	649,104	688,050	729,333	773,093	819,478	868,647
19	105,000	120,000	135,000	150,000	159,000	168,540	178,652	198,372	200,734	212,778	225,545	239,078
20												
Total	2,191,000	2,294,000	2,397,000	2,500,000	2,615,720	2,737,458	2,867,078	3,012,477	3,147,567	3,299,779	3,460,583	3,630,462
Growth	-	4.70%	4.49%	4.30%	4.63%	4.65%	4.74%	5.07%	4.48%	4.84%	4.87%	4.91%

(1) Fulfilling Blank Districts

Total number of Districts is 29, in code numbers, 1, 2, ...,19, 20, 20A, 20B, 20C1, 20C2, 20C3, 20E, 20F, 20G and 20J (20D, 20H and 20I are lacking). No figures are found in the projection table from District 20 to 20J. In addition, Districts 20C1, 20C2 and 20C3 are named by the JICA Study Team since there are three 20Cs in the location map of sub-areas. See **Figure J.2-1** for the location map.

Thus, we assume that populations of these vacant Districts such as 20, .., 20G are counted in the adjacent Districts. The reason why this assumption is made is to keep the total population size. And then we allocated the population between the Districts in proportion to the area sizes.

For example, the population in District 20C2 is assumed to be counted in the Sub-area 4. The population in District 4 in 1997 is projected as 61,500. Since the proportion of the two District sizes is

"District 4" : "District 20C2" = 23.2 km^2 : 1.2 km^2 = 0.951 : 0.049,

District 4 population is 61,500 x 0.915 = 58,507 and District 20C2 population is 61,500 x 0.049 = 2,993. Other allocation results in 1997 are shown in **Table J.2-3**. All year results are shown in **Table J.2-4**.

Table J.2-3 Population Allocation

Adjacent Districts	Area Size (km^2)	Proportions	Population (1997)
4	23.1625	95.13%	58,507
20C2	1.1850	4.87%	2,993
total	24.3475	100.00%	61,500
6	3.8000	79.17%	11,638
20C1	1.0000	20.83%	3,063
total	4.8000	100.00%	14,700
7	4.1125	23.45%	72,952
8	7.7750	44.33%	137,922
20	5.6500	32.22%	100,226
total	17.5375	100.00%	311,100
10	36.1000	18.82%	30,006
20E	3.3125	1.73%	2,753
20F	30.2250	15.76%	25,122
20G	122.1375	63.69%	101,519
total	191.7750	100.00%	159,400
11	3.3625	29.30%	23,853
20C3	5.9125	51.53%	41,941
20J	2.2000	19.17%	15,606
total	11.4750	100.00%	81,400
13	24.3750	60.33%	38,312
20A	16.0250	39.67%	25,188
total	40.4000	100.00%	63,500
17	16.4500	90.01%	88,033
20B	1.8250	9.99%	9,767
total	18.2750	100.00%	97,800

Note: Bold typeface in Adjacent Districts is blank in the projection table.

Table J.2-4 Allocation Results

District	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	55,400	55,600	55,800	56,000	56,000	56,000	56,000	56,000	56,000	56,000	56,000	56,000
2	133,500	134,000	134,500	135,000	141,750	148,838	156,279	164,093	172,298	180,913	189,959	199,457
3	50,800	51,200	51,600	52,000	54,600	57,330	60,197	63,206	66,367	69,685	73,169	76,827
4	58,507	58,982	59,458	59,934	62,930	66,077	69,380	72,850	76,493	80,317	84,333	88,549
5	44,200	44,800	45,400	46,000	48,300	50,715	53,251	55,913	58,709	61,644	64,727	67,963
6	11,638	11,717	11,796	11,875	11,875	11,875	11,875	11,875	11,875	11,875	11,875	11,875
7	72,952	73,492	74,031	74,570	74,570	74,570	74,570	74,570	74,570	74,570	74,570	74,570
8	137,922	138,941	139,961	140,981	140,981	140,981	140,981	140,981	140,981	140,981	140,981	140,981
9	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
10	30,006	31,173	32,340	33,507	35,182	36,941	38,788	40,728	42,764	44,903	47,148	49,505
11	23,853	24,204	24,556	24,907	26,153	27,461	28,833	30,275	31,789	33,378	35,047	36,800
12	82,200	88,800	95,400	102,000	108,120	114,607	121,484	128,773	136,499	144,689	153,370	162,572
13	38,312	41,631	44,949	48,267	50,681	53,215	55,875	58,670	61,603	64,683	67,917	71,313
14	87,500	90,000	92,500	95,000	99,750	104,738	109,974	115,473	121,247	127,309	133,675	140,359
15	353,400	375,600	397,800	420,000	445,200	471,412	500,227	530,240	562,055	595,778	631,525	669,417
16	28,500	29,000	29,500	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000
17	88,033	94,694	101,355	108,016	113,417	119,088	125,043	131,295	137,860	144,752	151,990	159,589
18	451,100	482,400	513,700	545,000	577,700	612,362	649,104	688,050	729,333	773,093	819,478	868,647
19	105,000	120,000	135,000	150,000	159,000	168,540	178,652	198,372	200,734	212,778	225,545	239,078
20	100,226	100,967	101,708	102,449	102,449	102,449	102,449	102,449	102,449	102,449	102,449	102,449
20A	25,188	27,369	29,551	31,733	33,319	34,985	36,735	38,571	40,500	42,525	44,651	46,884
20B	9,767	10,506	11,245	11,984	12,583	13,212	13,872	14,566	15,294	16,059	16,862	17,705
20C1	3,063	3,083	3,104	3,125	3,125	3,125	3,125	3,125	3,125	3,125	3,125	3,125
20C2	2,993	3,018	3,042	3,066	3,220	3,381	3,550	3,727	3,913	4,109	4,314	4,530
20C3	41,941	42,560	43,178	43,796	45,986	48,286	50,700	53,235	55,896	58,691	61,626	64,707
20E	2,753	2,860	2,967	3,075	3,228	3,390	3,559	3,737	3,924	4,120	4,326	4,543
20F	25,122	26,100	27,077	28,054	29,457	30,930	32,476	34,100	35,805	37,595	39,475	41,449
20G	101,519	105,467	109,416	113,364	119,033	124,984	131,233	137,795	144,685	151,919	159,515	167,491
20J	15,606	15,836	16,066	16,296	17,111	17,967	18,865	19,808	20,799	21,839	22,931	24,077
Total	2,191,000	2,294,000	2,397,000	2,500,000	2,615,720	2,737,458	2,867,078	3,012,477	3,147,567	3,299,779	3,460,583	3,630,462

Table J.2-5 Allocation Proportions of Administrative Boundaries

Unit: %

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	20A	20B	20C1	20C2	20C3	20E	20F	20G	20J
Makadara								46.30																					
Kabolen/Makongeni									12.54																				
Mannge/Mbotela								19.29																					
Viwanda	29.48								87.46	9.70																			
Bahati								23.22																					
Pumwani		6.88																											
Eastleigh		15.99																		100.00									
Kamokunji	12.72							11.19																					
Ngara		38.46																											
Starehe	57.80	38.66																											
Kibera/Woodley											39.03														56.24				100.00
Karen/Langata												100.00																	
Kenyatta/Golf Course										7.48	60.97														43.76	100.00		100.00	
Mugumoini										20.50																			
Waithaka															12.90														
Kangemi															31.11														
Riruta															15.85														
Kawangware															9.94														
Mutuini															11.62														
Parklands			100.00	17.27	78.79	100.00							100.00		18.58						76.44		100.00	47.26					
Kilimani				82.73	21.21																			52.74					
Mathare							74.16																						
Kanobangi																		2.12											
Kahawa																	100.00					100.00							
Kasarani(Kuaruka)							25.84									100.00		13.87											
Ruysambu														100.00							23.56								
Embakasi										62.33								24.63									100.00		
Njiru																		54.08	100.00										
Dandora																		5.31											
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table J.2-6 Population Projection of Administrative Boundaries

Administrative	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Makadara	63,861	64,333	64,805	65,277	65,277	65,277	65,277	65,277	65,277	65,277	65,277	65,277
Kaloleni/Makongeni	1,254	1,254	1,254	1,254	1,254	1,254	1,254	1,254	1,254	1,254	1,254	1,254
Maringo/Mbotela	26,609	26,805	27,002	27,199	27,199	27,199	27,199	27,199	27,199	27,199	27,199	27,199
Viwanda	27,987	28,159	28,332	28,504	28,666	28,837	29,016	29,204	29,401	29,608	29,826	30,055
Buhati	32,019	32,256	32,493	32,729	32,729	32,729	32,729	32,729	32,729	32,729	32,729	32,729
Pumwani	9,188	9,223	9,257	9,291	9,756	10,244	10,756	11,294	11,859	12,452	13,074	13,728
Eastleigh	121,575	122,396	123,217	124,038	125,118	126,251	127,441	128,691	130,003	131,380	132,827	134,346
Kamukunji	22,478	22,618	22,757	22,897	22,897	22,897	22,897	22,897	22,897	22,897	22,897	22,897
Ngara	51,346	51,538	51,731	51,923	54,519	57,245	60,107	63,113	66,268	69,582	73,061	76,714
Starehe	83,640	83,948	84,257	84,566	87,176	89,917	92,794	95,815	98,987	102,318	105,816	109,488
Kibera/Woodley	48,503	49,218	49,933	50,648	53,181	55,840	58,631	61,563	64,641	67,873	71,267	74,831
Karen/Langata	82,200	88,800	95,400	102,000	108,120	114,607	121,484	128,773	136,499	144,689	153,370	162,572
Kenyatta/Golf Course	16,786	17,088	17,390	17,691	18,576	19,505	20,480	21,504	22,579	23,708	24,893	26,138
Mugumoini	128,777	133,343	137,909	142,474	149,598	157,078	164,931	173,178	181,837	190,929	200,476	210,499
Waithaka	45,585	48,448	51,312	54,175	57,426	60,807	64,524	68,395	72,499	76,849	81,460	86,347
Kangemi	109,926	116,831	123,736	130,642	138,480	146,633	155,596	164,932	174,828	185,318	196,437	208,223
Riruta	56,031	59,551	63,071	66,591	70,586	74,742	79,310	84,069	89,113	94,460	100,128	106,135
Kawangware	35,138	37,346	39,553	41,760	44,266	46,872	49,737	52,721	55,885	59,238	62,792	66,559
Mutuini	41,074	43,654	46,234	48,814	51,743	54,790	58,139	61,627	65,324	69,244	73,399	77,803
Parklands	235,057	245,233	255,410	265,586	278,895	292,824	307,690	323,253	339,652	356,927	375,131	394,310
Kilimani	59,356	59,890	60,423	60,957	64,005	67,206	70,565	74,094	77,799	81,688	85,773	90,061
Mathare	54,104	54,504	54,904	55,304	55,304	55,304	55,304	55,304	55,304	55,304	55,304	55,304
Kariobangi	9,543	10,205	10,867	11,529	12,221	12,954	13,731	14,555	15,429	16,354	17,335	18,376
Kahawa	97,800	105,200	112,600	120,000	126,000	132,300	138,915	145,861	153,154	160,811	168,852	177,295
Kasarani(Ruaraka)	109,899	114,879	119,859	124,838	129,372	134,179	139,274	144,674	150,399	156,467	162,899	169,716
Raysambu	93,433	96,447	99,461	102,475	107,599	112,979	118,628	124,559	130,788	137,327	144,193	151,403
Embakasi	154,917	164,330	173,742	183,155	193,655	204,761	216,507	228,931	242,072	255,971	270,674	286,226
Njiru	348,974	380,902	412,830	444,758	471,444	499,731	529,714	570,498	595,187	630,899	668,753	708,878
Dandora	23,940	25,601	27,262	28,923	30,658	32,498	34,447	36,514	38,705	41,027	43,489	46,098
Total	**2,191,000**	**2,294,000**	**2,397,000**	**2,500,000**	**2,615,720**	**2,737,458**	**2,867,078**	**3,012,477**	**3,147,567**	**3,299,779**	**3,460,583**	**3,630,462**

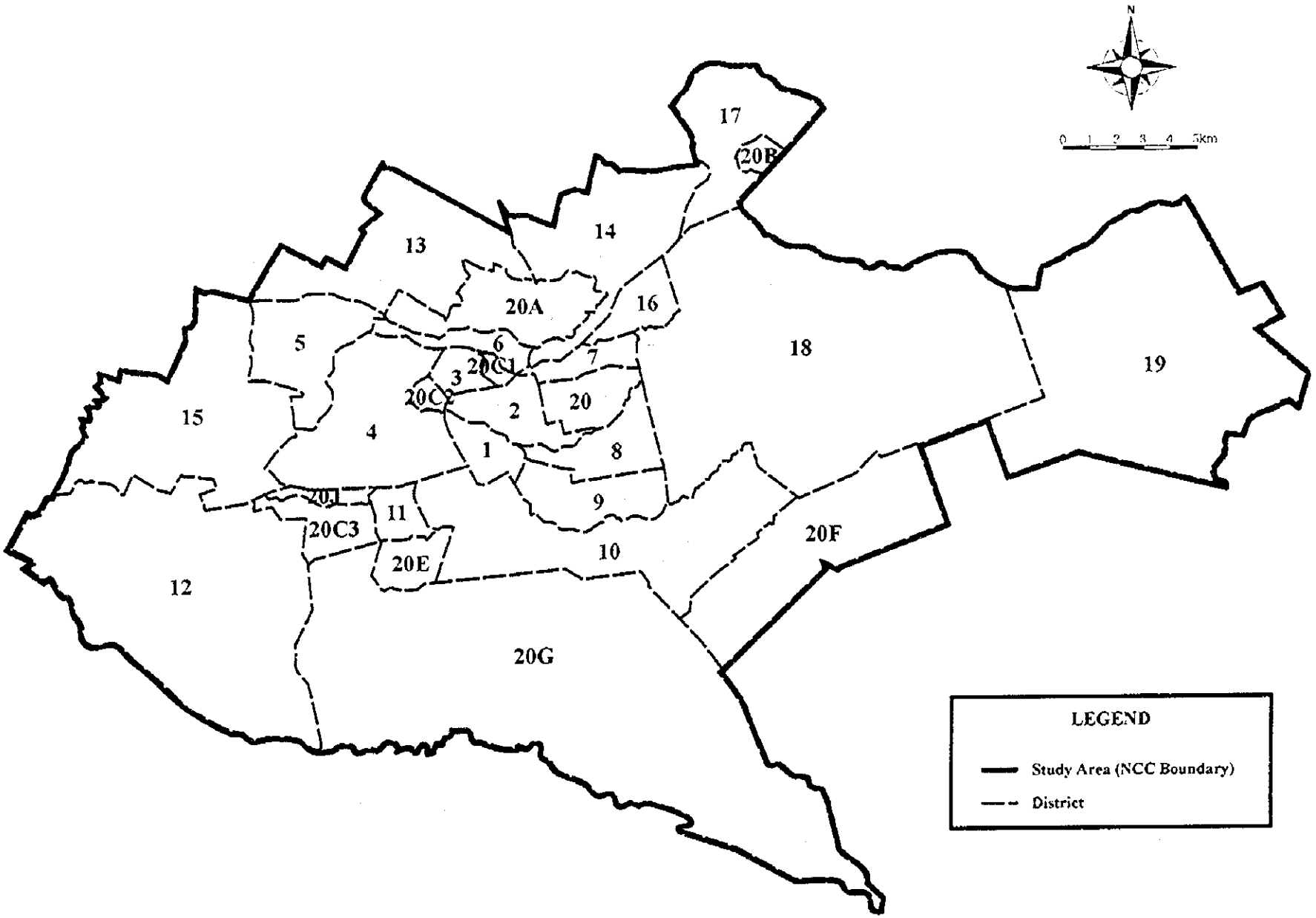


Figure J.2-1 District Map

(2) Conversion to Administrative Areas

After fulfillment of blank sub-areas, all populations of Districts are converted to those in administrative boundaries. Since a administrative boundary area consists of several Districts of the population projection, population of each District is allocated to the boundary area in proportion to the area size included in the administrative boundary.

For example, Viwanda consists of 29.48% of District 1, 87.46% of District 9 and 9.70% of District 10 on area size basis. Since population of District 1, District 9 and District 10 in 1997 are 55,400, 10,000 and 30,006 respectively, the population of Viwanda in 1997 is 29.48% x 55,400 + 87.46% x 10,000 + 9.70% x 30,006 = 27,987. Allocation proportions of each administrative boundary are shown in **Table J.2-5**. How administrative boundaries consist of Districts is illustrated in **Figure J.2-2**. Results of conversion to administrative boundary population in all years is shown **Table J.2-6**.

2.1.3 Population of Informal Settlements

According to *A Development Strategy for Nairobi's Informal Settlements* by the Nairobi Informal Settlements Coordination Committee, 55% of the total population are living in informal settlement Areas. Future population in informal settlement is calculated in **Table J.2-7**.

Table J.2-7 Projected Population in Informal Settlements

Unit: 1,000

1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1,205	1,262	1,318	1,375	1,439	1,506	1,577	1,657	1,731	1,815	1,903	1,997

Source: *JICA Study Team*

2.1.4 Number of Households in Formal Areas

It is planned that waste charge is collected from families in formal areas through the water charge system. According to *Welfare Monitoring Survey II, Basic Report, 1996,* average size of family is 3.7 in Nairobi. In addition, NCC's water supply system covers 80% of formal areas, where the water charge system can be used for waste charge. Future number of families in formal areas and those receiving water supply are calculated in **Table J.2-8.**

Table J.2-8 Projected Number of Families in Formal Areas

Unit: 1,000

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Family (all)	266	279	292	304	318	333	349	366	383	401	421	442
Family (water supplied)	213	223	233	243	255	266	279	293	306	321	337	353

Source: *JICA Study Team*

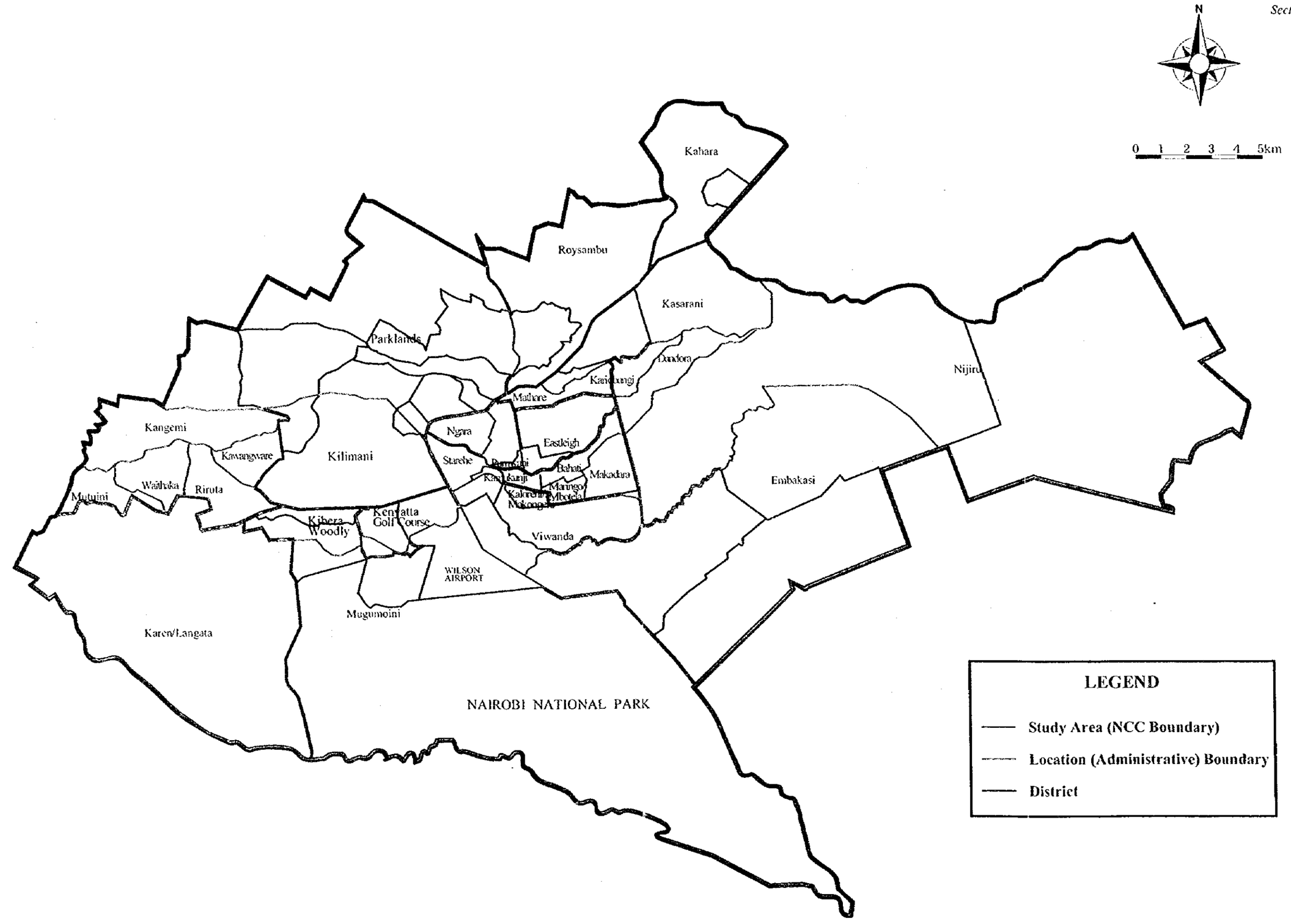


Figure J.2-2 Administrative Boundaries and Districts