社会開発調査部報告書

NO. 102

THE STUDY ON DOMESTIC AND INDUSTRIAL WATER SUPPLY IN JAKARTA

JULY 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

REPUBLIC OF KENYA

MINISTRY OF WATER DEVELOPMENT

THE STUDY

ON

THE NATIONAL WATER MASTER PLAN

SECTORAL REPORT
(D)

DOMESTIC AND INDUSTRIAL WATER SUPPLY

JULY 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

LIST OF REPORTS

EXECUTIVE SUMMARY

MAIN REPORT

1. Vol.1 Water Resources Development and Use Plan towards 2010
2. Vol.2 Master Action Plan towards 2000
   Part 1 : National Water Master Action Plan
3. Vol.3 Master Action Plan towards 2000
   Part 2 : Action Plan by Province/District

SECTORAL REPORT

1. A Socio-economy
2. B Hydrology
3. C Groundwater Resources
4. D Domestic and Industrial Water Supply
5. E Agriculture and Irrigation
6. F Livestock, Wildlife and Fishery
7. G Flood Control Plan
8. H Dam Development Plan
9. J Dam Geology
10. K Topographic Survey of 11 Damsites
11. L Power Development Plan
12. M Integrated Water Resources Development Planning
13. N Environmental Conservation
14. P Laws and Institutions
15. Q Database
16. R Remote Sensing Analysis
17. S GIS-based Analysis

DATABOOK

1. DB.1 Hydrological Data (Study Supporting Data)
2. DB.2 Groundwater Data (Aquifer Test and Well Survey)
3. DB.3 Groundwater Data (Study Supporting Data)
4. DB.4 Topographic Survey Data
5. DB.5 Inventory of Irrigation/Drainage Schemes
6. DB.6 Project Sheet for Urban Water Supply

PREFACE

Interpretation of Report

The original objective of this NWMP Study is to propose a nationwide framework for orderly planning and development of water resources in the country. The Study also deals with the formulation of individual development schemes. However, it should be noted that the plans formulated in this Study remain at a national level and do not provide complete details at local level. Further details should be examined in subsequent studies on each river basin, district, and project basis which are separately recommended in this Study.

Administrative Division of Districts

In this Study, the original 41 districts were considered and various statistical data, particularly socio-economic information, were collected for these districts. During the progress of the Study, six districts were detached from the original ones and established as new districts. In the report, the data on these new districts are grouped together with the corresponding original districts as shown below.

	Original Districts	New Districts	Data included in:
1.	Machakos	Makueni	Machakos/Makueni
2.	Kisii	Nyamira	Kisii/Nyamira
3.	Kakamega	Vihiga	Kakamega/Vihiga
4.	Meru	Tharaka-Nithi	Meru/Tharaka-Nithi
5.	Kericho	Bomet	Kericho/Bomet
6.	South Nyanza	Migori	South Nyanza/Migori

(Note: The last three Districts were established very recently.
The report refers only to the names of the original 41 districts.)

The administrative boundary map used in this Study is the latest complete map set covering the whole country (41 Districts, 233 Divisions and 976 Locations), prepared in 1986 by the Survey of Kenya, Ministry of Land, Housing and Physical Planning.

Data and Information

The data and information contained in the report represent those collected in the 1990-1991 period from various documents and reports made available mostly from central government offices in Nairobi and/or those analyzed in this Study based on the collected data. Some of them may be different from those kept in files at some agencies and regional offices. Such discrepancies if any should be collated and adjusted as required in further detailed studies of the relevant development projects.

Development Cost

The cost and benefit estimate was based on the 1991 price level, and expressed in US$ equivalent according to the exchange rate of US$1 = KShs25.2 prevailing at that time. The same exchange rate was used in calculating the development cost in K£/KShs currency.

THE STUDY ON THE NATIONAL WATER MASTER PLAN

SECTORAL REPORT (D)
DOMESTIC AND INDUSTRIAL WATER SUPPLY

TABLE OF CONTENTS

		Page
D1.	**INTRODUCTION**	D-1
1.1	Sector Background	D-1
1.2	Objective of Water Supply Study	D-1
1.3	Unit of Water Supply Study	D-1
1.4	Source of Data	D-2
D2.	**PRESENT WATER SUPPLY SITUATION**	D-3
2.1	Introduction	D-3
2.2	Water Supply Undertakers	D-3
2.3	Legal Administration	D-4
2.4	Water Supply Systems	D-4
2.5	Water-related Services in Service Centres	D-5
2.6	Water Supply Coverage	D-5
2.7	Total Amount of Water Produced and Sold	D-6
2.8	Water Tariff	D-6
2.9	Water Tariff Collection	D-7
2.10	Staffing in Water Supply Sector	D-7
2.11	Contribution of Water Supply Sector to GDP	D-8
2.12	Description of Major Urban Supplies	D-8
2.13	Issues in the Present Water Supply Sector	D-12
D3.	**DOMESTIC AND INDUSTRIAL WATER DEMAND PROJECTION**	D-15
3.1	Introduction	D-15
3.2	Domestic Water Demand Projection	D-15
3.3	Industrial Water Demand Projection	D-18
3.4	Livestock Water Demands	D-18
3.5	Total Potential Water Demand	D-19
D4.	**WATER SUPPLY DEVELOPMENT PLAN**	D-20
4.1	General	D-20
4.2	Urban Water Supply Development Plan	D-22
4.3	Rural Water Supply Development Plan	D-25
4.4	Sewerage Development Plan	D-29
4.5	Project Cost	D-32
4.6	Economic Efficiency of Development Plan	D-32
4.7	Financial Internal Rate of Return of Selected Service Centres	D-36

D5. PROJECT IMPLEMENTATION PLAN D-37
5.1 Urban Water Supply Development D-37
5.2 Sewerage Development D-39
5.3 Rural Water Supply Development D-39
5.4 Implementation Programme for Alternative Development Scenarios. D-40

D6. RECOMMENDATIONS D-45
6.1 Financing D-45
6.2 Operation and Maintenance D-46
6.3 Approach to Water Use Monitoring and Management D-46

REFERENCE

LIST OF TABLES

Table No.	Title	Page
D2.1	Existing Water Supply Works	DT-1
D2.2	Legal Notice Relating Water Act	DT-2
D2.3	Content of MOPND Infrastructure Inventory Format No.5A,B & C	DT-4
D2.4	Extraction from Infrastructure Inventory Format No.5	DT-5
D2.5	Inventory of Water Supply System in Service Centres : 1990	DT-6
D2.6	Inventory of Managing Authority of Water Supply System : 1990	DT-7
D2.7	Inventory of Managing Authority of Sewerage System : 1990	DT-8
D2.8	Inventory of Managing Authorities for Garbage Disposal Service : 1990	DT-9
D2.9	Percent Distribution of All Women to Access to Water Source, 1989	DT-10
D2.10	Water Production and Distribution in Gazetted Urban and Rural Schemes, 1985/86	DT-11
D2.11	Water Tariff Schedule in 1991 for MOWD	DT-13
D2.12	Water Tariff Schedule in 1991 for NWCPC	DT-19
D2.13	Distribution of Employees in Electricity and Water Inventory by Occupation and Citizenship	DT-22
D3.1	Connection Rate by Service Type	DT-23
D3.2	Unit Consumption Rate	DT-24
D3.3	Unit Water Consumption Rate by Industrial Type : 1989-2010	DT-25
D3.4	Industrial Water Demand by District : 1989-2010	DT-26
D3.5	Potential Domestic and Industrial Water Demand in 1990	DT-27
D3.6	Potential Domestic and Industrial Water Demand in 2000	DT-28
D3.7	Potential Domestic and Industrial Water Demand in 2010	DT-29
D4.1	Selected Service Centres for Urban Water Supply Development	DT-30
D4.2	Coverage of Existing Urban Water Supply Systems by Selected Service Centre	DT-34
D4.3	Development Cost of Urban Water Supply Systems of Selected Service Centres	DT-38
D4.4	Development Cost for Rural Water Supply Systems by District	DT-42

D4.5 Construction Cost for Livestock Water Supply Systems by District..... DT-43

D4.6 Total Cost of Urban Sewerage Development DT-44

D4.7 Total Economic Benefit Accruing from Water Supply in Kenya : 2000..... DT-46

D4.8 Economic Efficiency of Urban Water Supply Projects DT-47

D4.9 List of Urban Water Supply Schemes Resulted in Positive Economic Efficiency..... DT-50

D4.10 Economic Efficiency of Rural Water Supply Sector by District DT-51

D5.1 On-going Water Supply Projects DT-52

D5.2 Implementation Programme for Urban Water Supply Schemes..... DT-54

D5.3 Disbursement Schedule of Urban Water Supply Schemes..... DT-59

D5.4 Implementation Programme of Sewerage Development..... DT-61

D5.5 Disbursement Schedule of Sewerage Development..... DT-66

D5.6 Disbursement Schedule for Rural and Livestock Water Supply Development Plan by District..... DT-68

D5.7 Summary of Alternative Implementation Plans for Urban Water Supply Development..... DT-69

D5.8 Implementation Programme of Urban Water Supply Schemes Alternative Scenario - Case 1 ..... DT-70

D5.9 Implementation Programme of Urban Water Supply Schemes Alternative Scenario - Case 2 ..... DT-71

D5.10 Implementation Programme of Urban Water Supply Schemes Alternative Scenario - Case 3 ..... DT-73

D5.11 Implementation Programme of Urban Water Supply Schemes Alternative Scenario - Case 4 ..... DT-75

D5.12 Disbursement Schedule of Urban Water Supply Schemes Alternative Scenario - Case 1 ..... DT-78

D5.13 Disbursement Schedule of Urban Water Supply Schemes Alternative Scenario - Case 2 ..... DT-79

D5.14 Disbursement Schedule of Urban Water Supply Schemes Alternative Scenario - Case 3 ..... DT-80

D5.15 Disbursement Schedule of Urban Water Supply Schemes Alternative Scenario - Case 4 ..... DT-81

D5.16 Summary of Alternative Implementation Plans for Sewerage Development..... DT-83

D5.17 Disbursement Schedule of Sewerage Development Alternative Scenario - Case 1 ..... DT-84

D5.18 Disbursement Schedule of Sewerage Development Alternative Scenario - Case 2 ..... DT-85

D5.19 Disbursement Schedule of Sewerage Development Alternative Scenario - Case 3 ..... DT-86

D5.20 Disbursement Schedule of Sewerage Development Alternative Scenario - Case 4 ..... DT-87

D5.21 Summary of Alternative Development Scenarios..... DT-89

LIST OF FIGURES

Figure No.	Title	Page
D2.1	General Issues	DF-1
D2.2	Development Issue	DF-2
D2.3	Operation and Maintenance Issues	DF-3
D4.1	Construction Cost of Pump	DF-4
D4.2	Unit Construction Cost of Pipeline	DF-5
D4.3	Construction Cost of Treatment Works	DF-6
D4.4	Unit Construction Cost of Storage Tank	DF-7
D4.5	Water Source Allocation for Rural Water Supply	DF-8
D4.6	Unit Construction Cost for Piped Rural Water Supply	DF-9
D4.7	Land Requirement of Waste Stabilization Ponds	DF-10
D4.8	Waste Stabilization Ponds Construction Costs	DF-11
D6.1	Conceptual Flow of Preparation of Financial Plan	DF-12

LIST OF APPENDIXES

Appendix No.	Title
D.1	Present Water Related Services by Location
D.2	Projected Water Demand by Location
D.3	On-Going Water Supply Projects
D.4	Calculation of Finacial Internal Rate of Return for Selected Survice Centres

D1. INTRODUCTION

1.1 Sector Background

This Sectoral Report D presents results of study on the water supply sector in Kenya. Chapter 2 describes the present situation of the water sector in Kenya based on past studies, publications, and information collected through the Study. Water demand projection is presented in Chapter 3. The basic socioeconomic study such as projections of population , urbanization, industrialization and so on are refereed to Sectoral Study A, Socio-economy. On the basis of the present conditions and water demand projection, a master plan of water supply over the whole country is formulated in Chapter 4 in which supply plan and cost estimate for selected towns as urban water supply and all locations as rural water supply are involved. Chapter 5 describes implementation programmes of the development projects for the target year up to 2010. Alternative scenarios of the development plan are also presented in the chapter. Finally recommendations are made in Chapter 6.

1.2 Objective of the Water Supply Study

The objectives of the Study are:

(1) to clarify the present conditions of the water supply sector,

(2) to project future potential domestic and industrial water demand,

(3) to examine possible measures for development of water supplies in the country.

This Study does not intend to cover specific water supply schemes.

1.3 Unit of Water Supply Study

Data relating to the water supplies - such as population, agricultural and industrial production - are organized according to the administration units: Sub-Locations, Locations, Divisions, Districts, Provinces and Nation. Boundaries of these units are determined not only by the natural conditions but also for social, political, and historical reasons. Water demand associated with population and economic activities can be estimated according to these administration units.

Hydrological zones are delineated according to topography. They do not coincide with the administration units. Even the smallest administration unit, which is Sub-Location, often belongs to several hydrological zones. Then, for analysis of water balance between demand and supply, estimated water demands in one administration unit have to be translated into several hydrological zones. Population and water demand usually distribute unevenly in the administration unit. But in translation, uniform distribution of water demand must be assumed in the administration unit. Hence, if a large administration unit is

selected, the difference between actual and assumed distribution of water demand in one hydrological zone may become large. If small administrative units such as Sub-Location and hydrological zones such as small tributaries are selected, the accuracy of the study may increase to a certain extent, but the work volume for demand estimation, hydrological analysis, and water balance analysis would increase enormously and require a long period of study. The Water Resources Assessment Programme (WRAP) uses Sub-Location as administration unit for demand analysis but spends several years covering only one District. To balance between required accuracy for the National Water Master Plan and the available time for this Study, Location was selected as the smallest unit of the water supply study.

Administrative boundaries and number of administration units are changing from time to time. At present (1991), the number of Districts have increased from 41 to 44. The newly created districts are Makueni which was derived from Machakos, Nyamira from Kisii, and Vihiga from Kakamega. In this study, however, the 41-district structure was maintained because the latest administration boundary maps and the related socioeconomic data have been organized on the basis of the 41 districts. Thus, the names of the new districts are noted down with the original district names as follows: Machakos/Makueni, Kisii/Nyamira, and Kakamega/Vihiga.

1.4 Source of Data

The sources of raw data and information relating to the water supply sector are mainly:

- Rural Infrastructure Inventory Survey by MOPND
- Socioeconomic Survey conducted under this Study
- Questionnaire Survey conducted under this Study

All the above were answered by the District Water Engineers and their staff who know the local conditions and situations. However, as shown in various tables presented in this Report, there are still lots of blanks, which were not filled by the District Engineers, probably due to lack of basic information. Such information gaps will not affect results of this Study, but it is considered necessary to fill them in the future.

D2. PRESENT WATER SUPPLY SITUATION

2.1 Introduction

In this chapter, the present situation of the water supply sector is discussed in terms of the water supply undertakers, legal administration, water supply coverage, water supply systems, water-related services in the service centres, water tariff, water tariff collection, and staffing in the water supply sector.

2.2 Water Supply Undertakers

The entities who supply water to others are defined as "water supply undertaker" and the Water Act stipulates that:

> 124.(1) For the purpose of the distribution of water supplies, the Minister, after consultation with the Water Resources Authority (currently the Water Apportionment Board), may appoint water undertakers who shall be responsible for the provision of an adequate supply of water for the area within their limits of supply, and who shall comply with the provision of this Act.
>
> 124.(3) The area of the limit of supply of a water undertaker shall be determined by the Minister, after consultation with the Water Resources Authority (currently the Water Apportionment Board), and water shall not be supplied by the water undertaker to any person outside such limits of supply without prior consent of the Minister.

The followings are the various water undertakers currently in operation:

Ministry of Water Development (MOWD)
National Water Conservation and Pipeline Corporation (NWCPC)
Nairobi City Commission
Municipal Councils
Town Councils
Urban Councils
County Councils
Institutions such as schools and prisons
Kenya Railway Corporation
Religious Organizations
Water Supply Associations (self-help)
Private

The exact number of currently operating water undertakers is unknown. Many of the community level water supplies which do not collect water charges do not obtain the title of water supply undertaker. The number of gazetted water supply is as shown in Table D2.1. This table contains some old systems which had been absorbed by new large systems.

Outlines of the major water undertakers are described as follows:

1) Ministry of Water Development
The Ministry of Water Development is responsible for water development, catchment protection, water quality and pollution control in Kenya, and also responsible for operation, maintenance, and rehabilitation of major water supply systems. The Ministry has three levels for administration: National, Provincial and District level.

2) National Water Conservation and Pipeline Corporation
The Corporation was established in 1986 under the State Corporation Act. Demarcation of responsibility between the Ministry and the Corporation is still under examination. (The coming IBRD sponsored corporate plan study will clarify it.)

3) Kenya Railway Corporation
The Kenya Railway Corporation which has changed its name from time to time is the first constructor of water supplies for its own use in operating steam locomotives. At present, there is no necessity to retain the water supply systems as the steam locomotives are no longer in use. The water supply systems are now being transferred to MOWD and NWCPC.

2.3 Legal Administration

Legal administration such as modification of water tariff and limits of supply have been made through issuance of legal notice from time to time. Table D2.2 shows a list of legal notice issued since 1972 to date.

2.4 Water Supply Systems

The Ministry of Planning and National Development has conducted a rural infrastructure inventory survey. Table D2.3 shows the contents of the inventory survey on the water supply systems (Ref. D.04). Under this Study, a questionnaire on the water supply systems was filled by District Water Engineers. Coverage of the answers to the questionnaire largely differs from District to District. Some Districts cover only MOWD systems while others include self-help systems and water pans. Table D2.4 shows the district summary of the survey results.

According to the survey, the sources for existing water supply systems are: rivers (43%), groundwater (31%), dams (20%), lakes (10%), and others (3%).

A supplemental questionnaire survey was carried out under this Study on the water supply systems requesting for a list of all the water supply systems within a District including urban systems. Nine(9) Districts did not return respond.

Based on the combined data, District-wise total supply capacity and supply coverage ratio (percent of served District population to District total population) was calculated.

However, many figures worked out were deemed to be quite strange (coverage over 100% and so on) and considered unreliable. Compilation of an accurate list covering all the water supply systems is of quite necessity for each District.

2.5 Water-related Services in Service Centres

As a part of socio-economic survey under this Study, condition of water-related services (water supply, sewerage and garbage collection) was surveyed. The service centre is classified into the five categories : principal, urban, rural, market and local centres depending on the degree of urban agglomeration as discussed in Sectoral report A "Socio-economy". The criteria of the classification is given as below.

	Residential population	Served population
Local centre:	negligible	approx. 5,000
Market centre:	less than 2,000	approx. 15,000
Rural centre	2,000 - 10,000	40,000 - 50,000
Urban centre	excess of 5,000	100,000 - 150,000
Principal centre	excess of 100,000	approx.1,000,000 or more

In this JICA survey, the number of service centres in Kenya totalled 1,783 and the distribution in districts are as shown in Table D2.5. Out of which 1,570 centres are reported to have water supply systems while 377 centres have sewerage systems and 706 garbage collection systems, respectively. They are managed by the following authorities as shown below and the District-wise summaries are shown in Tables D2.6, D2.7, and D2.8 in which Principal centres are classified into Urban centres.

	Water supply system	Sewerage system	Garbage collection system
MOWD systems	579	6	3
NWCPC systems	188	0	9
Community systems	339	55	85
Self-help systems	243	26	0
Local authority systems	164	287	607
NGO systems	53	3	2
Donor systems	4	0	0
Total	1,570	377	706

The condition of water related services for each service centre is shown in Appendix D.1.

2.6 Water Supply Coverage

The water supply coverage in Kenya is a very difficult figure to obtain as discussed in the previous section. Table D2.9 shows a results of the Demographic and Health Survey carried out in 1988 (Ref. D.11). From this table, the proportion of women who have access to the protected water sources (piped into house, public tap, well with pump and well without pump) accounts 46.7%. Then, more than a half of the women in Kenya still

depends on the unprotected water sources. This table might show the approximate figures of coverage of the water supply system.

2.7 Total Amount of Water Produced and Sold

The total amount of water produced and sold in Kenya is hardly known since many systems are operating without master meters and self-help while community systems keep no records. Table D2.10 shows a result of survey by MOWD/SIDA in 1988 (Ref. D.03). The total amount of water produced in 1985/86 was 83.3 million m^3/year, and total amount sold was 76.7 million m^3/year.

2.8 Water Tariff

The present water tariffs of the water supply systems under operation and management of the MOWD and NWCPC are determined in the Legal Notices No. 496 to 501 in October, 1991 as follows:

(a) Legal Notice No. 496
cited as THE WATER (WATER DEVELOPMENT DEPARTMENT) (GENERAL) (AMENDMENT) REGULATIONS, 1991,
which is the amendment of the First Schedule of LN74/1962 regarding Service Charges of MOWD.

(b) Legal Notice No. 497
cited as THE WATER (WATER DEVELOPMENT DEPARTMENT) (GENERAL) (AMENDMENT) (NO.2) REGULATIONS, 1991,
which is the amendment of regulation 12 of LN74/1962 regarding Water Deposits of MOWD.

(c) Legal Notice No. 498
cited as THE WATER (WATER DEVELOPMENT DEPARTMENT) (TARIFF) REGULATIONS, 1991,
which is the replacement of LN94/1975 regarding Tariff Schedules of MOWD.

(d) Legal Notice No. 499
cited as THE WATER (WATER DEVELOPMENT DEPARTMENT) (GENERAL) (AMENDMENT) (NO.3) REGULATIONS, 1991,
which is the amendment of the Second Schedule of LN74/1962 regarding Application Forms of MOWD.

(e) Legal Notice No. 500
cited as THE NATIONAL WATER CONSERVATION AND PIPELINE CORPORATION (TARIFF) REGULATIONS, 1991,
which is the Tariff Schedules of NWCPC.

(f) Legal Notice No. 501
cited as THE WATER (WATER DEVELOPMENT DEPARTMENT) (TARIFF) (AMENDMENT) REGULATIONS, 1991,
which is the replacement of LN194/1981 regarding Tariff Schedules of MOWD for rural water supplies.

The water tariff schedules of MOWD are as shown in Table D2.11, and those of NWCPC are shown in Table D2.12, respectively.

These new tariffs are double of the old ones and become much more progressive. According to MOWD and NWCPC, the water tariffs will be reviewed every year.

The water tariff of the municipal water systems is determined differently and there are several types of tariff table while the systems themselves are almost the same as those for MOWD and NWCPC.

2.9 Water Tariff Collection

One of major issues of the water supply sector had been low level of water tariff collection as shown in Table D2.10 in 1985/1986 in which a percentage of the amount collected over the amount due was only 40.3%. The low level of collection together with the low water tariff made operation and maintenance of the water supply sector difficult.

However, the situation has been much improved for the last two years and the percent revenue collection is estimated to be approximately 70 %.

According to the present regulation, District Water Engineer of MOWD is collecting the water tariff and depositing it in the District treasury office. NWCPC collects water tariff which is banked in Commercial Banks and used for operation, maintenance and repair of water supply systems within the District.

2.10 Staffing in Water Supply Sector

The number of MOWD staff is about 13,600 (as of 1991) consisting of:

HQ, General Administration	1,117
HQ, Water Development	595
HQ, Electrical, Mechanical	557
Water Quality Laboratory	132
Kenya Water Institute	289
Rural Water Supply	8,854
Urban Water Supply	2,086
Others	16

In addition, Water Apportionment Board (WAB) has staff of about 1,000 including water bailiffs posted to the regional offices (Ref.D.07), and NWCPC retains staff of about 1,200 in total as of July 1991 covering its headquarters and four regional offices.

Detailed data of staff specialities in the water supply sector is not available. However, the National Manpower Survey 1986 - 1988 presents combined figures in the electricity and water industries as shown in Table D2.13

District water engineers are key persons both in engineering and administrative matters at the District level

2.11 Contribution of Water Supply Sector to GDP

The contribution of the water supply sector to the gross domestic product (GDP) appears under two headings: "water collection in the non-monetary economy" and "electricity and water in the monetary economy". The former has continuously increased from 0.64% of GDP in 1983 to 0.68% in 1989. The latter has increased from 0.80% to 0.92% in the same period. No separate estimate was made available for the electricity sector and the water sector. If the contribution of the water supply sector is assumed to be 43% of 0.92%, the total contribution of the water supply sector in the monetary and non-monetary economy was 1.08% in 1989.

In terms of the constant 1982 prices, the product of the water supply sector (a sum of non-monetary and monetary) was assumed to be 33.7 million pound in 1983 and 43.7 million pound in 1989. Then, the annual growth rate of the water supply sector in this period was to be around 4.4%.

2.12 Description of Major Urban Water Supplies

According to the population projection given in the Sectoral Report A, there are 10 cities/water supplies whose population in year 2000 will be over 100,000. The table below shows the population and water demand of these 10 cities/water supplies in 1990, 2000 and 2010. The water demand in the table was obtained in the demand projection of this Study to be discussed in the next Chapter.

Urban name	Population(1000 nos)			Water Demand(1000 m^3/day)		
	1990	2000	2010	1990	2000	2010
Nairobi	1,413	2,261	3,465	333	553	802
Mombasa	480	673	904	100	152	203
Nakuru	172	470	870	35	87	152
Kisumu	176	376	579	26	55	89
Eldoret	113	273	487	20	48	84
Nyeri	97	219	371	16	35	60
Machakos	91	215	356	14	34	56
Meru	79	193	320	13	32	53
Kitale	56	142	249	9	23	41
Thika	59	136	218	11	25	39
Total	2,736	4,958	7,819	577	1,044	1,579
Proportion to National Total	12%	16%	19%	35%	38%	38%

It is obviously shown that Nairobi is the far greatest service centre in the country followed by Mombasa and Nakuru and the water demand of these 10 service centres will occupy 38 % of the national total in year 2000.

Brief descriptions on five major urban water supplies are given as follows.

(1) Nairobi

The present water system in Nairobi is organized into the following water distribution systems from three major sources and a minor source with a piped water distribution system supplying treated water.

	Water Sources	Treated Water (m^3/day)	Treated Water (m^3/sec)
1.	Chania River	177,000	2.049
2.	Sasumula Dam	57,000	0.660
3.	Ruiru Dam		
4.	Kikuyu Spring	23,000	0.266
	Total	257,000	2.975

In 1988, it was estimated that about 89 % of the current population were served by the water distribution system through direct house connections, communal watering points and kiosks in the shanty areas. The remaining 11% obtained their water supplies from boreholes. In addition, some industries were supplied with additional water from their own boreholes.

The Third Nairobi Water Supply project is on going, under which the Thika dam on the Thika river is being constructed and is expected to be completed in 1993.

(2) Mombasa

Presently, Mombasa is supplied with water from the Mzima pipeline, Marere pipeline and others as shown below.

(Unit: m^3/day)

	Water Supply System	Supply	Ratio
1.	Mzima pipeline	34,560	42%
2.	Marere pipeline	9,150	11%
3.	Sabaki pipeline	35,000	42%
4.	Tiwi boreholes	3,890	5%
	Total	82,600	100%

Water shortage already occurred in early 1980's and a feasibility study on Water Supply Augmentation Project of Mombasa-Coastal Area-Hinterland was carried out by JICA in 1980 and 1981, and a combination of the Second Mzima pipeline and Rare dam was recommended. However, the recommended plan has not been realized due to lack of financing.

GOK has asked for assistance from IDA. The Mombasa Coastal Water Supply Engineering and Rehabilitation Project will be commenced soon.

Water demand in Mombasa in year 2010 will far exceed the supply capacity of the Mzima pipelines, and further source development will be needed. Candidate sources may be the second Mzima pipeline, Rare dam, Pemba dam, Mwachi dam and Sabaki extension work.

(3) Greater Nakuru

The Greater Nakuru includes Nakuru, Gilgil and Naivasha in the east and Njoro, Molo, Elburgon and Londiani in the west. In this area, surface water is scarce excepting Malewa river.

Under the Greater Nakuru Water Supply project (East), Turasha dam is going to built. However, water demand in this area is forecasted to grow rapidly and to exceed the planned supply capacity. Candidates for further source development are Chemesusu dam, Londiani dam, Itare dam and Malewa dam.

The Lake Nakuru basin is a closed basin and water transfer into the basin will cause an environmental problem of increase of the lake water level and dilution of the lake water.

(4) Kisumu

Kisumu receives its water from two sources, the Kibos River and the Lake Victoria. The water from both sources receives treatment by sedimentation and filtration prior to being distributed to people.

The most abundant and unfailing source of water for Kisumu is the Lake Victoria. While the Kibos River is advantageous to continue a water supply since the water from the river does not need pumping and provides the abstraction point which is in the vicinity of the existing intake.

At present , Kajulu treatment works and Lakeside treatment works are under operation.

1) Kajulu Treatment Works

The works was constructed in the late 1930s and is located approximately 11 km north east of the Kisumu town at the foot of escarpment. The filters themselves are in a very poor state of repair at present. Externally they appear to be in a sound condition, having been cleaned and painted, however, internally it is highly probable that they are beyond repair. It appears that the daily supply from Kajulu was estimated at 950 cmd although they were designed originally at 1,300 cmd. The reason for the apparent decrease in output is a combination of the deterioration of the filters and carrying capacity of the trunk main.

2) Lakeside Treatment Works

The works were originally built in 1956 to supplement the supply from Kajulu and had a capacity of 4,550 cmd. To keep up with increasing demand the works were extended in 1964 and 1970 to produce 6,820 cmd and 9,100 cmd, respectively. The extension of the works was completed in 1980. The treated water of 15,100 cmd is available from this source.

Treatment comprises sedimentation, rapid gravity filtration and disinfection with chlorine. Treated water is pumped into supply and to the storage reservoirs at Watsons Bank and Kibuye.

(5) Eldoret

The water supply system of Eldoret town was first constructed in 1927. The intake structure is located in the Kaptagat Forest. The water was conveyed over 23 km through a 125 mm diametre gravity main with a capacity of 520 cmd. The water works were extended in 1951 when an additional 150 mm diametre gravity main was installed A water treatment plant with a capacity of 2,300 cmd was also constructed at Kapsoya in 1951.

Twin Rivers Dam was completed in 1963 Its Sociani treatment works with a capacity of 2,300 cmd was constructed at Kaptaget on the North/Eastern boundary of the Eldoret town.

As the town continued to grow, it became necessary to find additional source of water supply. In 1989, the Ellegirini Dam was completed in the Kipkarren River. In 1990, the water supply system has a maximum daily demand of 16,250 cmd.

2.13 Issues in the Present Water Supply Sector

(1) Financial Issues

Figure D2.1 shows the financial issues.

The Government of Kenya spent Kenyan pounds 400 - 500 million to finance the development programmes of the MOWD between 1974/75 to 1989/90. This represents about 12 per cent of the net total gross actual expenditure of all ministries during the same period.

Three major problems have reduced the effects of the MOWD's efforts towards the provision of safe and sufficient water to every household in Kenya:

1) Inadequate provision of funds for development and operation and maintenance of water supplies.

The world-wide economic recession of early 1980's, the droughts in 1979-80 and 1983-84 and change of government investment priorities by the Structural Adjustment and Budget Rationalization Policies have lead to declines in the annual budgetary expenditure allocation to the water sector. (The Policies give priority to productive and foreign-exchange-earning investment. It seems that the water supply sector has not been regarded as the sector to fall into this category, notwithstanding the sector itself contributes various productions and also foreign-exchange-earning in terms of enhancing the industrial activities including tourism).

2) Rapid increase in the costs of inputs used in the constructions and operation and maintenance of water supplies.

Further, exhaustion of cheap and reliable water sources which have been developed first makes the source development expensive.

3) Adverse changes in the overall composition of the MOWD budget.

Between 1975 to 1980, the recurrent budget of the MOWD was less than 30% of the combined recurrent and development budget. Presently, slightly less than 50% of the

combined recurrent and development budget is recurrent, according to increase of the burden of the operation and maintenance of completed water supplies. Furthermore, personnel costs which are fixed costs and can not be cut, account for more than 70% of the total recurrent budget. These changes have left the MOWD with inadequate and declining expenditure outlays for development programmes, complementary facilities and operation and maintenance of water facilities.

4) Rapid population growth

Financial requirement for domestic water supply is increasing with rapid population growth. In many cases, project implementation could not catch up the growing water demand.

(2) Issues of Water Supply Development

Figure D2.2 shows issues relating to the development of water supplies.

All communities and households desire to have water supplies. Since water supplies are one of the basic human needs, it is very difficult to reject their desire. Hence, many proposals are submitted and many projects are initiated.

According to the Project Brief of the MOWD, there are about 500 on-going water supply projects including new, expansion, augmentation and rehabilitation. Excepting donor assisted projects, these projects have to share the limited development funds. The thinly distributed funds for each project make it difficult to complete the project in time. In the worst case, facilities constructed at the initial stage have been deteriorated or some parts have been lost at the time of completion of other parts, which tends to cause a large investment requirement to complete the project.

In some case, water demands exceed the supply capacity at the time of completion of facilities, or some projects have to be completed in smaller supply capacity (treatment and/or distribution) than designed, in order to respond inhabitants' strong desire to have water supply earlier. This produces unsupplied peoples within the supply area and invites distrust of water supplies among the inhabitants.

During the construction, it is difficult for supervision staff who are limited in number to supervise construction and installation properly.

(3) Issues of Operation and Maintenance

Figure D2.3 shows several issues relating to operation and maintenance of water supplies. These issues are closely interrelated with each other.

Although the percentage of revenue collection has been improved in recent years, there are still many cases that the revenue collected could not cover the requirement of

O & M expenditure. And moreover, there are some difficulties in collecting revenue in rural areas because of dispersing service points especially for borehole water supplies.

The shortage in O & M funds leads to insufficient operation, maintenance and repair, for instance it makes difficult to check water leakage and illegal connections.and further to unreliable supply of water. Inhabitants become further reluctant to pay for unreliable supply.

Completed water supply facilities are sometimes operated and maintained by operation staff who have little knowledge and experience on water supply facilities. This causes unnecessary broken down of the facilities by mis-operation and decreases the system reliability.

D3. DOMESTIC AND INDUSTRIAL WATER DEMAND PROJECTION

3.1 Introduction

In this chapter, potential domestic and industrial water demand projection is presented.

3.2 Domestic Water Demand Projection

(1) Standards and Criteria

The Design Manual for Water Supply in Kenya (Ref. D.01) stipulates standards and criteria for water demand projection.

Domestic water demand consists of residential and non-residential water demands and they are estimated for urban and rural areas, respectively. The non-residential demand is further classified into institutional water demand and commercial water demand. It is assumed that these demands are all linearly related to the population concerned. The definition of "urban" is given in Sectoral Report A "Socio-economy". The number of town centres in which population is classified as urban population totals 278.

Population was projected for each Location in terms of urban and rural population as explained in Sectoral Report A. The resulting projected Location and urban population in years 1990, 2000 and 2010 are presented in Table A9.4 and A9.5 in Sectoral Report A, where the population in 1990 represents the estimated figure based on the provisional results of 1989 Census. The Location population is also reproduced in Appendix D2 as presented later.

(2) Planning horizon

In order to prepare projections, it is necessary to set a planning horizon. The Manual stipulates the future and ultimate planning horizon as 10 years and 20 years, respectively after commencement of operation of a water supply system, and assumes 4 years for design and construction of the system after completion of pre-investment study. In this Study, the planning horizon of this Study is year 2010 for master plan and year 2000 for action plan. So the future year of 2000 and the ultimate year of 2010 were selected. Thus planning was made for the following three target years;

1990 : initial year
2000 : future year
2010 : ultimate year

(3) Residential water demand

Residential water demand is calculated by the following equation.

$$D_{kt} = P_{kt} \sum_{i} \sum_{j} C_{ij} H_j UD_{ijt}/1000$$

where;

k : target year	1= 1990
	2= 2000
	3= 2010
t : demand area	1= urban
	2= rural
i : tap connection condition	1= individual connection users
	2= non-individual connection users
j : housing classification	1= high
	2= medium
	3= low

D_{kt} : projected demand in year k for demand area t (m^3/day)
P_{kt} : number of population
C_{ij} : connection rate (%)
H_j : housing class (%)
UD_{ijt} : unit water consumption rate (l/c/d)

The Design Manual presents indicative figures for the distribution between individual connection users and non-individual connection users according to housing class in urban areas and land potentials in rural areas as shown in Table D3.1. It was assumed that urban housing class would consist of high class of 5%, medium class of 70%, and low class of 25% which was considered as the proportion of average cities in Kenya on the basis of previous studies. For rural areas, proportion of high, medium and low potential areas within Location was measured by overlapping the agro-climatic map on the administration boundary map by the GIS method.

The unit consumption rates of various domestic water uses were taken as shown in Table D3.2.

(4) Non-residential water demands

The non-residential water demand including institutional and commercial water demands is calculated by the following equation.

$$I_{kt} = P_{kt} \sum_{m} N_{mt} UD_m/1000$$

where;

k : target year	1= 1990
	2= 2000
	3= 2010
t : demand area	1= urban
	2= rural
m : institutional user type	1= boarding schools
	2= day schools
	3= other hospitals
	4= outpatient
	5= administrative officer
commercial user type	6= hotels
	7= shops

I_{kt} : projected non-residential demand in year k for demand area t (m^3/day)
N_m : ratio of user to population
UD_m : unit water consumption rate (l/c/d)

For estimating institutional water demand, the following figures for N_m were assumed on the basis of analyses of the previous studies:

	Rural	Urban
Boarding schools (pupil/pop.)	2%	2%
Day schools (pupil/pop.)	28%	28%
Hospital (bed/1,000pop.)	0	29.9
Outpatient (pop./1,000pop.)	2.5	2.5
Government. officers (pop./1,000pop.)	0	83.6

For estimating commercial water demand, the following figures for N_m were assumed;

		Rural	Urban
Hotels	High (bed/1,000pop.)	0	4
	Medium (bed/1,000pop.)	0	8.7
	Low (bed/1,000pop.)	5	4.5
Shops (no./1,000pop.)		0	23.6

The unit consumption rates of institutional and commercial water uses were assumed as shown in Table D3.2. referring to the Design Manual

(5) Total domestic water demands

The domestic water demand projection was made on Location basis. Results were presented in Appendix D2. District-wise domestic water demand is as shown in Tables D3.5, D3.6, and D3.7 together with other water demands. In these tables

the institutional and commercial demands are grouped under the heading of non-residential demands.

3.3 Industrial Water Demand Projection

As discussed in Sectoral Report A, industrial water requirement was estimated as a product of three components: 1) the number of manufacturing establishments by industrial type; 2) value added (VA) of respective industrial types; and 3) unit water consumption rates (cubic meter per value added (K Shs. billion)) by industrial type.

The former two components were already combined and estimated as "District" distribution of VA aggregated with all industrial types into a manufacturing sector in Table A7.6 in Sectoral Report A. The distribution is broken down to the "Location" level up to the target year 2010.

Since information on unit water consumption rates by industrial type were not made public in Kenya, consumption rates which were surveyed in Japan in 1986 as indicative of industrialized conditions were applied for estimation of water requirement with the following modification:

1) Monetary values such as production and value added are transferred by the following foreign exchange rates: K Shs 21.6/US$ and J.Yen143/US$ (exchange rate in 1989).

2) In the water consumption process in a factory, the water recirculation system is not taken into consideration as of 1988. However, for around 20 years, water recovery is assumed to reach to half of the industrialized countries' level. For instance, food, beverages and tobacco industry consumes 5,617 cu.m/day/K Shs. billion of value added in 1989, but it will be reduced to 4,459 cu.m./day/K Shs. billion in 2010, as seen in Table D3.3.

3) Through the distribution of both value added by industry and unit water consumption, water requirement by "Location" is estimated for the future.

Table D3.4 shows the water requirement of manufacturing industry by District to the year 2010. In 2010, water demand in Nairobi is estimated to be 282,000 m^3./day, accounting for 57% of the national total industrial water requirement. Secondly, Mombasa accounts for 67,000 m^3./day or 14%. Manufacturing establishments in Nakuru, Machakos and Kisumu Districts will also consume plenty of water.

3.4 Livestock Water Demands

Livestock population was projected on a District basis as presented in Sectoral Report F "Livestock and Wildlife". Distribution of livestock to Locations was made in proportion of Location population. It was assumed that livestock holding in urban areas are one forth of that in rural areas.

The unit rate of livestock water consumption was assumed as shown in Table D.3.2. The resulting livestock water demand is 621 thousand cu.m./day in 2010 which is equivalent to 20% of the domestic water demand.

3.5 Total Potential Water Demand

The summary of the projected domestic and industrial water demand for the whole of Kenya is presented below for the year of 1990, 2000 and 2010.

Potential Water Demand in Kenya

unit : Thousand m^3/day

		1990	2000	2010
Rural	Residential	376.2	560.2	932.6
	Non-residential	155.9	189.1	229.1
	Sub-total	532.1	749.3	1,161.8
Urban	Residential	491.2	1,004.5	1,642.8
	Non-residential	82.2	164.4	263.2
	Sub-total	573.4	1,168.9	1,906.0
Livestock		326.7	426.5	621.4
Industry		218.7	377.5	494.0
Total		1,650.9	2,722.2	4,183.2
Overall per capita (l/c/d)		73	89	104

As shown above, the potential demand for residential water in the urban areas and industrial water was projected to grow rapidly due to rapid urbanization and industrialization. Per capita levels of water consumption including livestock consumption seem moderate when taking into account the large livestock population in the country.

District-wise potential water demand is summarized in Table D3.5, D3.6, and D3.7 for the target year 1990, 2000 and 2010, respectively. The potential water demand on Location basis is compiled in Appendix D2.

D4. WATER SUPPLY DEVELOPMENT PLAN

4.1 General

(1) Domestic water supply policy

The latest statement on the water supply policy is shown in the current Five-Year National Development Plan for the period from 1989 to 1993 as "during 1974, the Government promulgated the National Water Plan with the express aim of ensuring the availability of potable water within 4 kilometers of every household by the provision of the year 2000".

Target during the current five-year development plan period is to increase the proportion of the population having access to water in the rural areas from 26% (4.91 million people in 1987) to 50% (11 million people) by 1993 and in the urban areas from 75% to 95% by 1993. The target growth rate for the water sector during the current Five-year Development Plan, 1989 - 1993 is set at 7.0% per annum. This rate is larger than the target rate of 5.4% per annum for the whole economy. This rapid growth rate is essential for promoting the expansion of Rural Trade Promotion Centres (RTPCs) and diversification of economic activities. Growth of the RTPCs receives high priority in Kenya because they have potential for increasing off-farm employment/income generating opportunities in the rural areas.

Taking into account the Government policy on the water supply sector, this study assumes provision of safe and reliable water within a reasonable distance to all the population in the year 2010.

(2) Urban and rural areas

Water supply development plan was prepared for urban and rural water supply systems. In selecting towns to which urban water supply systems will be provided, two criteria were taken;

- towns nominated as urban centre , or
- towns to have population more than 5,000 in year 2000

Then, 158 urban areas were selected. They are listed in Table D4.1 and the location map is presented in the drawing attached to this Report.

(3) Potential water sources

Available water sources development in Kenya was classified by the following methods:

(a) Water supply from perennial main rivers and lakes
(b) Water transfer from the other sub-drainage areas
(c) Groundwater, and
(d) Water harvesting

As for selecting water sources, the Design Manual describes the following:

- Sources which require little or no treatment of the water should be chosen in the first instance provided the required quantity of water can be obtained. Hence springs and groundwater resources should always exploited first.

- For household and small-scale community supplies, rainwater harvesting may serve well in most medium and high potential areas in Kenya.

- Surface water from river streams and lakes will almost always require some treatment to render it safe for human consumption. However, for large supplies surface water will often still be the most economical alternative. Rivers which have the bulk of their catchment in forest areas should be preferred.

- Sub-surface water drawn from a riverbed or river bank can sometimes be a viable alternative in dry areas with only seasonal flow in the river, or in rivers with a high silt load.

- It should be studied whether a combination of sources may give a more economical and reliable water supply than a system based on only one source. Mixing can also be used to reduce the content of certain constituents, eg. fluoride, to acceptable levels.

- Sources from which water can be supplied by a gravitational system are particularly favorable.

(4) Supply Measures

Long Term Guideline of Infrastructure Facilities in Various Level of Centres (source: PPD's Chart for Urban and Rural Organization) in the Design Manual stipulates the following guideline for the water supply:

Centre	Population Served	Population Resident	Water Supply
Principal	>1,000,000	>100,000	Piped Water Supply
Urban C.	>100,000	>5,000	Piped Water Supply
Rural C.	>50,000	>2,000	Piped Water Supply
Market C.	>15,000	Negligible	Communal Points Water Supply
Local C.	>5,000	Negligible	Communal Points Water Supply

In this Study, bulk water supply systems were planned for the above 158 service centres including Principal Towns and Urban Centres, and the other service centres are considered to be covered by area/rural water supply. In principle, rural water supply in the high potential areas and part of the medium potential areas where permanent surface water is available, will be covered by piped water supply from surface water sources. The remainder of the medium potential areas and low potential areas will be covered by spot supply from groundwater, rain water harvesting or others.

4.2 Urban Water Supply Development Plan

(1) Available water sources

In Kenya, meteorological and hydrological conditions are largely different from location to location, and there are few or no reliable surface water sources in ASAL areas.

Demand of water supply is almost constant throughout the year and therefore unregulated seasonal rivers can not be relyed on as water sources, while safe yield of perennial rivers are to be set at reasonable occurrence of supply failure.

Safe yield of the surface water development is determined to be 10-year drought which is almost equivalent to the recorded minimum monthly discharge for 10-year period as discussed in Sectoral Report B "Hydrology".

Availability of groundwater resources both in terms of quantity and quality is as explained in Sectoral Report C "Groundwater Resources". The groundwater sources, if its quality is suitable for drinking use, require the least cost for treatment. However, uncertainty of successfully exploiting the bulk quantity of groundwater, the often shortening of lifetime of boreholes owing to screen trouble, etc. and the high exploitation, operation and maintenance costs of boreholes may give in some instances rather low priority to groundwater development. Hence, groundwater development for the urban domestic water supply might be limited to the following locations;

- Location having no reliable surface water source
- Locations with low demand density which will result in a high cost of surface water supply

In the two types of locations mentioned above, methods of rain water harvesting will also be taken into account.

Springs, in general, provide good quality of water at low cost. However, most of the major spring sources are already utilized. Then, spring source utilization in

future is considered as continuation of present use with improvement (spring protection).

(2) Supply area

The supply area of the water supply system was estimated assuming population density of three income classes and their shares as follows:

Income Class	Density (persons/ha)	Ratio (%)
High income - low density	40	5
Medium income - medium density	130	70
Low income - high density	300	25

(3) Planning procedure

Water supply systems were planned for the selected 158 urban areas. For each urban area, checking was made on the following points referring project reports, information from answers to questionnaires, information from MOWD, NWCPC and Provincial and District Water Engineers, etc.

- present supply capacity
- present and future water sources

Table D4.2 shows the existing supply capacity, water source, and the coverage of the existing water supply system against 1990, 2000 and 2010 water demand for all the selected towns. The coverage is calculated to be 53%, 27%, and 17 % on an average against 1990, 2000 and 2010 demands, respectively although it is widely dispersed from 0% to more than 100%.

Possible water sources were checked on the 1:50,000 topographic maps. However, water source study based on the 1:50,000 topographic maps is still macroscopic study, and water source for specific urban area is to be looked into on the project basis. Since the urban water demands are bulky, surface water sources were given priority. The future water source of each urban area is presented in Project Sheet in Data Book DB6.

Due to insufficient river run off with the required dependability, several urban areas will have to rely on water from storage reservoirs and/or interbasin water transfer. The numbers of the schemes are as follows:

19 single purpose dams
3 multipurpose dams
20 intra-basin transfer schemes

15 inter-basin transfer schemes

The development plans of these large facilities are described in Sectoral Repot M.

On the other hand, 23 urban centres have to depend their future water sources mainly on groundwater, of which 5 urban centres are planned to use combinational water sources of boreholes and subsurface dams /surface water /spring while remaining 17 urban centers are solely depending on boreholes.

Table D4.2 also shows the present and future water sources for the above 158 towns including the dams, intra-basin transfer and inter-basin transfer schemes.

As for the distribution of the water, piped water supply with treatment is essential for the surface water while groundwater is supplied by piped water system basically without treatment. If treatment is necessary from water quality aspect, such development is to be planned in the later period of the planning horizon after year 2000.

(4) Cost estimates

The construction costs of the proposed water supply systems were estimated at the construction price in Feb, 1991. The construction costs are organized into direct construction cost, engineering and administration, land acquisition and physical contingency. The direct construction costs were estimated based on the actual costs and estimates for similar projects in Kenya. Where cost curves were available, such curves were utilized in the estimate. The construction costs are expressed in US$ assuming exchange rates of 25.2 K Shs/US$ and 132.2 Japanese Yen/US$ (1991).

Development cost of each system includes costs of intake, pipeline, raw water pumps, treatment plant, storage tanks having capacity equivalent one-day demand, grid distribution system and allowance of 20%, but excludes costs of dams which were estimated separately (Ref.Sectoral Report H). Unit costs of several works in the above were referred to those presented in Design Manual after due up-dating. Then the cost are calculated in the following manner.

1) Source work (intake)

Q (incremental supply capacity : m^3/s) $^{3/4}$x US$300

2) Pump cost (raw water pumps)

apply magnitude of Q to the cost curve in Figure D4.1

3) Raw water main (pipeline)

apply magnitude of Q to the cost curve in Figure D4.2
assuming that flow velocity in the pipe is 0.5m/s

4) Treatment

apply magnitude of Q to the cost curve in Figure D4.3

5) Storage

apply magnitude of Q to the cost curve in Figure D4.4 assuming that storage volume is equivalent to one day supply volume.

6) Distribution

served area (ha) x US$8

7) Miscellaneous

20 % of [sum of above 1) to 6)]

8) Administration and engineering

10 % of direct cost [sum of above 1) to 7)]

9) Allowance (contingency)

20 % of [sum of above 1) to 8)]

The estimated costs are as given in each project sheet and the summary is presented in Table D4.3. Unit development cost (development cost / daily supply volume) was compared with those of already planned or designed water supply schemes and found to be within the range of those schemes.

(5) Allocation of Dam Cost

The above urban water supply plan does not include the cost of source development by dam. In total, 28 damsites were selected for source development towards year 2010. The construction cost was allocated tentatively in proportion to the quantity of water use by purpose; they are, (i) hydropower, (ii) irrigation water and (iii) water supply developments. The cost for water supply development was further allocated in proportion to the quantity of domestic water use by major demand center. While, the whole cost was allocated for hydropower development. As discussed in Sectoral Report M, the dam construction cost was allocated as follows: US$ 656.7 million for hydropower development, US$175.6 million for irrigation water development and US$577.3 million for urban water supply. The total development cost was estimated at US$1,409.6 million .

4.3 Rural Water Supply Development Plan

In view of the vastness of the study area and varying type of water sources envisaged, it was thought almost impracticable to formulate definite water supply plans specific to each rural area. The study therefore attempted to evaluate potential water sources available in each area and to estimate the conceptual costs of the development. The following approaches were taken in this Study:

(1) Land potential

According to the agro-climatic zoning, Locations are classified into high (PT index - 1), medium (PT index - 2) and low (PT index - 3) potentials (same as

demand estimate), and the individual connection rates were differentiated as shown in Table D3.1 in the previous Chapter.

(2) Potential water source

According to assessment of accessibility to the surface water sources (rivers and streams - PR index), sources of the rural water supplies were allocated to surface water and/or non-surface water as follows:

PR index - 1	:	100% surface water
PR index - 2	:	75% surface water
PR index - 3	:	50% surface water
PR index - 4	:	25% surface water
PR index - 5	:	100% non-surface water

As the representative of non-surface water sources, groundwater (boreholes or dug wells) was assumed. In evaluating groundwater resources, the following four parameters were introduced.

GA: groundwater development activity
GQ: ground water quality
GS: Share between borehole/shallow well developments
GC: ground water exploitation cost

For other potential water sources, roof catchments, small dams, subsurface dams, rock catchments, and other water harvesting measures as water pan, small ground catchment, water holes and paved ground catchments were examined.

The basic concept of source allocation is i) main water supply sources would be surface water and groundwater and then ii) other water harvesting measures are planned as subordinate measures to supplement and/or substitute the surface water /groundwater sources.

Detailed discussion for water sources is given in Sectoral Report M " Integrated Water Resources Development Planning".

(3) Concept of development sequence

This study assumed that the development of water sources in rural areas will be undertaken in the following two (2) stages:

Stage 1: Provision of water sources within walking distance, i.e. within 1 km in high potential area and within 4 km in semi-arid/arid areas, wherein the water available is not always a grade of "potable water".

Stage 2: Provision of piped water supply systems with water treatment, wherein the water would be "potable".

For each of the water sources, the development sequence would be;

	Stage 1	Stage 2
Surface water	Water as available on the site (abstraction of water by people themselves)	Piped water supply, with treatment (except for spring water)
Groundwater	Spot supply at the borehole/well sites	Piped water supply, with treatment where necessary from water quality aspect
Roof catchment	Rainwater as stored	Same as Stage 1. No water treatment is deemed necessary.
Small dam	Water as impounded, with protection from contamination sources (e.g. livestock)	Piped water supply, with treatment
Subsurface dam	Water as stored and supplied at pipe outlet (sand dam) or well (subsurface dam)	Piped water supply, with treatment
Rock catchment	Water as stored, with protection of catchment	Same as Stage 1. No water treatment is deemed necessary.
Pipeline (built for urban supply and passing in rural areas)	Supply of water at water stands provided on the pipeline route. Water is treated.	Extension of branch pipeline system. Water is treated.

Of the above programmes, the Study recommends the implementation of Stage 1 work towards year 2000 as much as possible within the framework of available financial resources, leaving the rest of development towards year 2010.

(4) Livestock water

A basic assumption is that neither piped water supply nor water treatment is required for livestock watering, i.e. livestock water supply is planned at "Stage 1" level.

However, it was assumed that the livestock water demands will be met by the project water supply facilities, 50% in the low potential areas and 20% in the medium potential areas. Since surface water is available in the high potential areas, no provision of the piped facilities was considered for the livestock water demands in these areas.

(5) Development plan

On the basis of the above consideration, requirement of rural water supply development for service centres and Locations was assessed as shown in Appendix M7 in Sectoral report M.

The source allocation plan for rural water supply over the whole country is summarized in Figure D4.5

(6) Cost estimate

The construction cost of rural water supply consists of water development cost and water distribution cost.

Unit water exploitation cost for the above water sources was enumerated by sub-drainage area as given in Table M10.3 in Sectoral report M. The average unit water exploitation cost was estimated as follows:

Unit Water Exploitation Cost

(Unit:US$/$m^3$)

	Water Source	Cost
1.	Groundwater	
	- Borehole	0.53
	- Shallow well	0.12
2.	Small Dam	0.18
3.	Roof Catchment	2.92
4.	Subsurface Dam	0.53
5.	Sand Dam	0.39
6.	Rock Catchment	0.39

The water exploitation cost was summarized in Appendix M7 and M10 in Sectoral Report M. Cost of water exploitation for surface water and existing pipeline was

counted under the construction cost for urban water supply. The total water exploitation cost for rural domestic water supply was estimated at US$ 1,414 million . For the livestock water use, the water exploitation cost was estimated at US$ 743 million.

Water distribution cost for rural water supply was estimated by District on the basis of the cost curves which includes the costs of intake facilities, 5-km raw water main, full treatment, storage with capacity equivalent to one-day demand and distribution. The cost was estimated by applying the cost curves with treatment for surface water source and that without treatment for groundwater source, by applying the following formula and the cost curve illustrated in Figure D4.6.

For surface water and water harvesting

$$Y = 27{,}500\,x + 110{,}000$$

For ground water

$$Y = 23{,}182\,x + 9{,}040$$

where x = water demand (m^3/day/km^2)
Y = construction cost of rural water supply system per supply area (K Shs/km^2)

The resulting water distribution cost is estimated at US$ 1,213 million and the total development cost which is the sum of water exploitation cost and water distribution cost is estimated at US$ 2,627 million as summarized in Table D4.4 on district basis by applying the exchange rate of 25.2.K Shs/US$. The construction cost of live stock water supply is given Table D4.5.

4.4 Sewerage Development Plan

(1) Requirement of Sewerage Development

In the previous sections, water supply development is examined. In order to protect the environmental health, effluent from water supply systems should be treated to protect the environment.

The requirement for effluent from sewerage treatment plants is as follows:

BOD concentration	=<20 mg/l
Suspended solid loading	=<30 mg/l
Coliform content	=<1,000/100 ml

For industrial waste water, pre-treatment of industrial waste water is deemed to be the responsibility of such industries, thus pre-treatment cost was not considered.

(2) Method of Treatment

There are various methods used in waste water treatment. However, they can be classified into two : ones relying solely on natural contributions such as sunshine and temperature for promotion of biological purification process, and the other employing mechanical equipment to aid and accelerate biological purification process.

Two methods have distinct differences in cost implications as follows: (advantage to other : +, disadvantage : -)

First Method

+ less capital cost requirement
+ less foreign exchange requirement
+ less O & M cost requirement
+ less skilled manpower requirement
- large land requirement

Second Method

- large capital cost requirement
- more foreign exchange requirement
- large O & M cost requirement
- large requirement for skilled manpower
+ less land requirement

Excepting some areas, lands for treatment plants are not serious constraints in Kenya, provided that land use planning be made properly. However, constraints of fund availability both for capital cost and O & M cost and manpower are recognized to be remarkable. So the first method (waste stabilization ponds) was given priority.

(3) Land Requirement for Waste Water Treatment Plan

Land requirement of waste stabilization ponds was estimated in order to present only indicative figures based on the following assumptions:

Influent standards
BOD loading : 500 mg/l
Effluent standards
BOD loading : =< 20 mg/l
Suspended solid loading : =< 30 mg/l
Coliform count : =< 1000/100ml of discharge
Rate of BOD removal Kt=0.22

The required area for waste stabilization ponds is estimated by the relationship illustrated in Figure D4.7.

(4) Cost estimate

The sewerage systems should be of practical facilities to be selected for each centre. The following three menus of sewage disposal were assumed for purpose of a preliminary cost estimate:

Population of Town	Facilities Assumed (%)		
	Public Sewer System	Septic Tank	Pit Latrine
(a) Over 100,000	50	25	25
(b) Over 10,000	25	50	25
(c) less than 10,000	25	25	50

In the cost estimate, it was assumed that only the cost of public sewer facilities is to be included as the government's undertaking and the rest would be borne by private households. Waste water from the manufacturing industries were assumed to be pre-treated by the industries concerned.

Sewerage development cost was estimated only for indicative purpose referring to the Third Nairobi Water Supply Project, Sewerage and Sewage Treatment Study, September 1987 (Ref.D.12).

The public sewerage development would consist of sewer system and treatment facilities. Rates of waste water against water supplied is usually observed at some 0.8 but 1.0 was assumed in this master plan study for the sake of safety. Sewer system was assumed to cover the same area of water supply while waste stabilization ponds method is considered for the treatment facilities. The unit construction cost of waste stabilization ponds was estimated by the following formula (Ref D.12).

Up to 40,000 m^3/day

$$Y = -0.03366\,x + 7631.2$$

Equal to or more than 40,000 m^3/day

$$Y = -0.00098\,x + 6323.33$$

where x is treatment capacity (average flow m^3/day) and

Y is construction cost of waste stabilization ponds per sewer flow (K Shs per m^3)

The cost curve is shown in Figure D4.8. An allowance of 30% of construction costs was added for covering construction contingencies, engineering and

administrative expenses. The construction cost is converted to US$, by applying 25.2 K Shs/US$.

Table D4.6 shows the estimated development cost of the sewerage system and area for waste stabilization ponds in each selected town. The total cost of urban sewerage development was estimated at US$ 705 million .

It was considered that the urban sewerage system development be made in keeping pace with the urban water supply development.

4.5 Project Cost

The construction cost for urban and rural water supply development was summarized as follows:

(Unit:1,000 US$)

	Purpose	Project Cost
(1)	Urban Water Supply	
	– Water supply system	4,949*
	– Sewerage system	705
(2)	Rural Water Supply	
	– Domestic water supply system	2,627
	– Livestock water supply system	743
	TOTAL	9,024

Note ** includes dam cost of US$ 577 million

4.6 Economic Efficiency of Development Plan

(1) Pre-conditions for Economic Evaluation

In estimating the economic costs and benefits of the proposed plans, the economic values are estimated applying the following preconditions and assumptions.

Price level

The basic price level for cost and benefit estimates is set at the end of February, 1991. Foreign exchange rate is set at KShs.25.2 to US$1.00 in agreement to the official exchange rate at the same time.

Opportunity cost of capital

Opportunity cost of capital represents the permissible economic rate of return for development projects. In Kenya, 10% of this opportunity cost of capital is applied as a discount rate for assessing economic viability of proposed projects, which is also used by IBRD.

Economic value

In economic analysis, all goods and services applied in the project costs and benefits are estimated on the basis of real economic value. In terms of non-tradable goods and services in local market, the following points have to be considered in the case of converting their financial values to economic ones: (a) internal transfer payment and (b) shadow wage of unskilled labour in particular because of taking unemployment and underemployment conditions into account. On the other hand, the tradable goods and services are estimated based on the international market prices, so their values reflect real economic ones. In this current report, however, economic values are tentatively estimated to be 90% of total financial values of both local and foreign portions.

Economic life

The economic life of the projects is taken as 35 years after completion of the construction works. In urban schemes, since the implementation is assumed to be divided into two phases, the evaluation period would be 35 years from the completion of the second phase works. In rural schemes, since the implementation period is assumed as four years from 1993 impartially, the evaluation period would be 35 years from the completion, as well.

(2) Economic Costs

Construction costs

The financial construction costs of the proposed projects in urban and rural areas are estimated in the previous Sections. The costs are given as the economic costs by making adjustments based on the aforesaid conversion method. The construction schedule is assumed to be divided into two phases. The construction works of the first phase are assumed to start in 1994 and end in 1997, of which the capacity fully covers the year 2000 water demand. Those of the second phase are between the years 2001 and 2004, covering the 2010 water demand.

Operation and maintenance (O&M) costs

O&M costs are annually required during the economic life of the projects beginning just after completion of the construction works. O&M costs are also given by making adjustment to economic prices. The costs are assumed to be 5% of the total construction costs.

Replacement costs

While the economic life is assumed to be 35 years, some mechanical facilities such as pumps have shorter life than the civil and plumbing works. They are

assumed to be 20 years for such mechanical equipment for water supply system. The replacement costs are assumed to be 5% for the total construction costs.

(3) Economic Benefits

The economic benefits are estimated on the basis of present socioeconomic conditions applying the preconditions mentioned in the previous sections. Economic values of benefits at present and even in the future are mainly estimated under the present social and economic situation in February 1991. Future changes in the current study are set to be on the same trend as the present ones in accordance with the development policy.

Domestic water

The basic idea of economic benefits for water supply schemes is based on maximum affordable value. It is generally adopted for water supply project as a traditional rule, i.e., commonly 3 to 5 per cent of household income. These percentage figures are also recommended in the World Bank publications such as "Investing in Development, Lessons of World Bank Experience, 1985". On the other hand, according to "Urban Household Budget Survey, 1983, CBS", an urban household expenditure for water accounted for only 1.3% on average, as shown in Table A2.38 in Sectoral Report A.

Yet, in this master plan study, the benefit of domestic water is estimated to be 5% for all water supply schemes as the maximum affordable value. Thus the benefit increases in proportion to the growth of GRDP per capita in the District where the scheme is located. Applying this rule, incidentally, the total annual benefit of the entire urban water supply schemes in the country could be estimated at US$461 million in 2000, distributed as US$289 million in urban areas and US$172 million in rural areas, as shown in Table D4.7.

Industrial water

For industrial use, economic benefit is based on maximum affordable payment for water consumption, which is basically estimated through water cost in industrial final products. In this study, a percentage of water cost to value added of all manufactured products is adopted for benefit estimation, from the point of view of data availability. Manufacturing industrial sector disbursed K£13.4 million for water in 1986. This expense accounted for approximately 1.4% of the value added of this sector in the same year. Thus, the industrial sector is assumed to impose a burden of 1.5% on water, as maximum affordable value. As a result, the annual economic benefit for industrial water in the country is estimated at US$27.5 million in total in the year 2000.

Non-residential (municipal) water

The non-residential or municipal water consumers are assumed to be represented by trade, catering and government services. In the same manner as the foregoing industrial water, the annual benefit for municipal water is expected to be 0.5% of

gross value added in the aforesaid services' sector, as the maximum affordable value. Hence, the annual economic benefit for municipal water in the country is estimated at US$16.5 million in total in the year 2000.

Livestock water

The annual benefit of livestock water is also assumed to be 2.0% of gross value added of the livestock sector. Furthermore, the value added of livestock sector is assumed to account for 20% of the agricultural value added, because of data availability. Hence, the annual economic benefit for livestock water in the country is estimated at US$12.3 million in total in 2000.

(4) Economic efficiency of Urban Water Supply

The entire urban schemes of 158 systems were examined in economic efficiency through factors of Net Present Value (NPV), Benefit-Cost Ratio (B/C), and Internal Rate of Return (IRR). Table D4.8 shows the results of the examination. Of 158 schemes, only 4 schemes exceeded 10%, the opportunity cost of capital mentioned above. They are Embu, Thika, Mariakani and Nairobi, in order of economic efficiency. In addition to these four schemes, 36 schemes had positive IRR, as shown in Table D4.9. The other schemes, 118 schemes, resulted in negative efficiency. In other words, they would not be expected fully to return the capital investment through their accruing economic benefits, from the economic point of view.

(5) Economic Efficiency of Rural Water Supply

Preconditions for rural water supply schemes are almost the same as those mentioned in urban water supply in the previous Section. However, the following two points are different from the urban schemes.

- Since it is difficult to identify as a rural water supply scheme for economic evaluation in an administrative "Location", rural water supply schemes are brought together into a total form of a District.

- The construction schedule for economic evaluation is assumed as follows: (i) exploitation works of water sources are implemented during 1994 and 1995, and (ii) supply facilities are installed during 1996 and 1997. O&M costs and benefits start from the completion of these works, i.e., at the year 1998.

The economic efficiency of every District's rural water supply is calculated in the factors of NPV, B/C and IRR. Table D4.10 shows the results of the calculation. No Districts, excluding Nairobi and Mombasa, have a positive IRR as shown in the table. Incidentally, the total costs for the entire schemes in the country aggregated to US$2,627 million. On the other hand, the benefits of the rural water supply were estimated at US$172 million in the year 2000, as shown in Table

D4.7. Taking these figures into consideration, the benefits accounted for only 6% of the total costs. This connotes that the benefits only cover O&M costs because O&M costs are estimated at 5%. From the economic point of view, most of rural water supply schemes might, therefore not be viable. Thus, the rural water systems should be considered to introduce not based on the economic point of view but based on other policies such as basic human needs (BHN) and promotion of public hygiene.

4.7 Financial Internal Rate of Return of Selected Service Centres

In addition to the economic efficiency, a financial viability of the urban water supply development was briefly studied for two selected urban centres; Embu and Thika municipalities which would have the highest economic efficiency as examined in the previous section. This section describes the brief results of the study and a detailed description of assumptions and calculations are compiled in Appendix D4.

The assumptions introduced were :

1) Water charges were based on the current "fees and charges". Water rates applied for calculation were arranged into average flat rates as shown below, because respective consumers were quite diversified and complicated.

Residential unit	US$7.19/year/capita in Embu Municipality US$4.71/year/capita in Thika Municipality
Non-residential unit	US$0.19/cu.m.in Embu Municipality US$0.11/cu.m in Thika Municipality
Industrial unit	US$0.55/cu.m.in Embu Municipality US$0.12/cu.m in Thika Municipality
Livestock use	same as non-residential unit

2) Construction costs and construction period were based on the same conditions done in the economic evaluation, and all the monetary values were indicated in financial prices while inflation and interests were omitted, with a view to simplifying financial evaluation

The results show that the FIRR is negative for both Embu and Thika service centres if the current rates were applied, and therefore the rates should be raised by some 30% for Embu and by 75 % for Thika to obtain positive FIRR. Sensitivity of FIRR is illustrated in Appendix D.4.

5. PROJECT IMPLEMENTATION PLAN

5.1 Urban Water Supply Development

In order to attain economy of development of the water supply sector, speedy implementation of water supply projects is of vital importance. Since the available resources (funds and manpower) are limited, speedy implementation can be realized only by concentration of the limited resources. Hence, the number of projects under implementation will have to be limited to an appropriate level. Although it will be socially difficult to limit the number of projects under implementation, efficient and effective development of the water supply sector is necessary.

(1) Priority order

In preparing an implementation programme, the priority of development will be given in the following order.

(a) On-going Schemes

According to the Project Status Report prepared by MOWD in February 1991, there are many water supply projects under construction as listed in Table D5.1. The detailed information is shown in Appendix D.3. Most of them are expected to be completed by 1993. Continuation of their implementation should be accorded top priority.

(b) Urban centers in tourism areas

Tourism is one of the most important industries in Kenya. Further promotion of the tourism demands the reliable supply of high quality potable water, and in this context a priority of the development is placed to urban cities which are closely related to the tourism. The cities falling in this category include Nairobi, Mombasa, Malindi, Lamu, Nakuru, Kericho, Kisumu, and Marsabit.

(c) District centers

Rapid urbanization is on-going. Infrastructures of major regional centers should be improved to promote regional development. The major regional centers are defined here as towns having population of more than 10,000 and/or the District headquarters Within this group, the priority of development will be given in the order of seriousness of water shortage expressed as the ratio of existing supply capacity to water demand in year 2000.

(d) Other urban centers

The implementation will then continue for the rest of small urban centers (population less than 10,000). The priority will be given in the order of lesser cost requirement per m^3 of water exploitation.

(2) Assumed improvement of water supply sector

In planning the urban water supply development, several improvements in the water supply sector were assumed.

(a) Reduction of Leakage and Unaccounted For Losses

The present high rates of leakage loss and unaccounted for losses will be reduced gradually but steadily, a total loss almost 20% of the water produced and supplied will be reached by year 2010.

(b) Cost Recovery

It is the Government policy to recover the full cost of urban water supply schemes and the O & M cost of rural water supply through collection of users' water tariff. It is assumed that this Government policy be realized by year 2000. Then, the urban water supply schemes will become self-financing after year 2000 with arrangement of appropriate financing measures such as long-term credit or bond.

In order to facilitate collection of users' water tariff, installation of water meters is assumed.

(c) Water Saving Policy

It is assumed that the Government will take policies to minimize wasteful use of treated water such as ascending tariff structure and phasing out of flat rate system.

(d) Emergency Preparedness

Kenya has suffered from severe drought in the past, which had serious impact on the medium and low potential areas. In this account, a higher supply reliability for raw water sources are sought for : supply failure for less than 20 days in 10 years.

(3) Proposed project implementation programme

The Study assumes that the water demand in years both 2000 and 2010 will be met at all urban centers. In preparing the plan, the following assumptions were introduced.

Period 1 (1993 - 2000)

According to the criteria given above, the priority of project commencement was given to the major cities for tourism activities and service centres having lower coverage of the present supply facilities. A two year construction period was assumed for all the service centres except Nairobi and Mombasa which would need 4 years because of the development scale. Since borehole projects would need two

years of investigation prior to construction, they were planned to be commenced after 1995 and the development would be implemented in a 2 to 5 year period depending on the development scale of each scheme.

Period 2 (2001- 2010)

At the beginning of this period, all the service centres would have had sufficient water supply systems for the year 2000 demand. Thus, the the priority of project commencement was given according to the importance of the cities, in the order of major cities, district centres larger then 35,000 population in the year 2010, district centres less then 35,000 population, and minor centres. Borehole development would need 2 to 10 years for implementation because of the high number of wells to be drilled.

Table 5.2 shows the proposed implementation program for urban water supply sector and the resulting disbursement schedule is shown in Table D5.3 by district.

5.2 Sewerage Development

A basic principle assumed is that sewerage facilities would be developed in conjunction with the provision of water supply facilities. Accordingly, the implementation of sewerage development will be along with the principle and priority order set forth for the urban water supply schemes. The proposed implementation programme and disbursement schedule are shown in Table D5.4, and D5.5.

5.3 Rural Water Supply Development

As described in Section 4.4, rural water supply is proposed to be undertaken in two stages:

Stage	Description	Proposed Implementation Period
1	Provision of access to safe and sustainable water sources – Principally, supply of water at source points – Water available at sources is not necessarily potable	1993 onwards, so as to meet the demands in the year 2000 and 2010
2	Provision of piped water supply system – Water supplied by combination of individual connection and communal points – Water is treated as required and hence potable	2001 - 2010

The implementation was phased with the following concepts:

(a) Priority among Districts

No specific priority criteria is placed in view of the importance of attaining the equitable development over the country. However, priority of the Stage 2 work will be given to several Districts where a relatively high percentage of contraction to water-borne diseases is reported. These include Kwale, Mombasa, Kilifi, Tana River and Lamu, all in the coastal area.

(b) Priority within a District

Although no details are given in this report, it is suggested that the implementation may proceed with placing priorities to the Locations where the implementation cost per m^3 of water exploitation is least. See previous chapter for preliminary estimates of source development (Stage 1) cost and water supply facility cost, respectively.

In this Study, it is assumed that the implementation will continue for the whole period up to the year 2010 to meet the water demand in all rural areas of the country.

The implementation programme of the rural water supply is presented in Table D5.6 together with livestock water supply.

5.4 Implementation Programme for Alternative Development Scenarios

(1) Budgetary Constraints

The implementation programme in the previous section is prepared for the full scale development to meet the projected demand towards year 2010. The projected available budget for the water sector towards year 2010, however, would amount to US$ 3,000 million which is only 34 % of the required development costs of US$ 9,024 million for the water supply sector.

In case the financial constraint is foreseen, the phasing of implementation will have to be slowed down. The Study examined two alternative cases of reduced budgetary scenarios :

Alternative Scenario A : Available budget to be about 50 % of the total requirement
Alternative Scenario B : Available budget to be about 75 % of the total requirement

(2) Alternative Scenarios for Urban Water Supply

Under the restricted budgetary conditions, the Study examined the cutting down of the required development costs by reducing the number of service centres to be implemented and/or reducing the supply level to the projected demand in the following manner.

1) For screening service centres, the following criteria was introduced.
Schemes for major cities in tourism active area (8 cities nominated in Section 5.1 and hereinafter referred as Major cities) were accorded the top priority. The total cost for the major cities would account for about 43 % of the total cost of the urban water supply development.

The second priority was given to the District centres which include district headquarters other than the above 8 cities (hereinafter District headquarters) and other cities larger than 10,000 population in year 2000 (hereinafter Large centres). The number of District headquarters and Large centres are 36 and 44, respectively. The proportion of implementation cost for District headquarters, and Large centres to the total water supply cost would amount to 24 % and 19 %, respectively. Considering areal equity , District headquarters are given priority over Large centres. For further screening of Large centres, seriousness of water supply shortage in terms of ratio of existing supply capacity to the demand in the year 2000 was considered.

2) To select a reduced supply level, the Study examined an alternative case that the development just meeting the demand for the year 2000 level would be effected towards 2010. This implies that the water demand for year 2000 level will be restricted by saving of water and rationing of water supply. The demand level of year 2000 is equivalent to about 60 % of that of year 2010 on average.

3) The minor urban centres were excluded from the implementation programme towards year 2010.

(3) Proposed Plans

The following five cases were worked out as implementation programmes for the Alternative development scenarios for water supply sector, in which Case-1 and Case-2 are for Alternative scenario A and Case-3 and Case-4 are for Alternative scenario B.

1) Alternative Scenario A : available budget = 50 %

Case-1 (Full demand)

In this case, service centres are all the Major cities and all the District headquarters except Isiolo and Lodwar. These two centers were excluded in this case because the estimated development cost of pipeline of borehole systems for Isiolo and Lodwar schemes are extremely high, while the present coverage of the existing systems of these centres are relatively high and there are some possibility of less expensive alternative water sources as described in Sectoral Report M. Thus the number of selected service centres is 42 including 8 Major cities and 34 District headquarters.

For these selected service centres, water supply facilities are to be constructed to meet the full scale of the projected demand towards 2010. The estimated cost was US$ 3,016 million which is about 61 % of the total cost requirement for the full scale development of urban water supply sector.

Case-2 (Reduced demand)

If the water demand can be reduced for the service centres; i.e., the projected demand for year 2000 would be satisfied by 2010, required construction cost would be reduced by some 42% and therefore all the Major cities, District headquarters and Large centres can be included in this case. Number of selected service centres is 88 including 8 Major cities and 36 District headquarters and 44 Large cities. The development cost required for Case-2 would be US$ 2,523 million or 51 % of the total cost requirement.

2) Alternative Scenario B : available budget = 75 %

Case-3 (Full demand)

If the available budget is restricted to 75 % and the target demand level is kept to the full scale of the projected demand towards 2010, all the Major cities and the District headquarters and Large centres whose coverage of the present facilities is less than 10 % against the year 2000 demand would be included. Number of selected service centres is 66 including 8 Major cities and 36 District headquarters and 22 Large cities.The development cost required for Case-4 would be US$ 3,714 million or 75 % of the total cost requirement.

Case-4 (Reduced demand)

On the other hand, if the supply level towards 2010 is reduced to the demand level of year 2000, all the 158 urban cities can be included in the development plan. In addition, for Major cities, supply level can be kept to the full scale of the projected demand towards 2010. The development cost required for Case-4 would be US$ 3,817 million or 77 % of the total cost requirement.

The results of alternative implementation plan for water supply development are summarized in Table D5.7. The implementation programmes and disbursement schedules are shown in Tables D5.8 to D5.15 for the above 4 cases.

(4) Rural Water Supply

The implementation plan of rural water supply development is given in the previous section for full scale development. In the plan, the implementation programme was proposed to be carried out in two stages: Stage 1 will provide source development to supply water at source points without any treatment, and in Stage 2 piped water supply system will be provided with treatment, if required. The total development cost was estimated at US$ 2,627 million consisting of US$ 1,414 million or 54 % for Stage 1 and US$ 1,213 million or 46 % for the Stage 2.

Under the situation of budget constraint, the Study considered that Stage 1 would be implemented towards year 2010 but Stage 2 would not be implemented before 2010 for Alternative A. The development costs in Stage 1 would also need to be reduced so as to meet the available budget for Alternative Scenarios A by decreasing supply area or supply population. On the other hand, for Alternative B, Stage-1 would be fully implemented while Stage 2 would be partially implemented.

The resulting reduced plan is summarized as follows:

Alternative Scenario A : available budget = 50 %

Supply level	Stage 1
Development cost	US$ 1,314 million
Served population	25,650,000 (92.9%)

Alternative Scenario B : available budget = 75 %

Supply level	Stage 1 and Stage 2
Development cost	US$ 1,971 million
Served population	27,610,000 (100%)

If the demand level is reduced, i.e., the demand level in the year 2000 is applied for the development plan of the year 2010, the development cost required for Stage-1 would be US$506 million. Thus, all the reduced demand would be satisfied for Alternative A and Alternative B to meet the available budget. Stage 2 would also be implemented for both cases. For Alternative B, it would be possible to keep the supply level between the year 2000 and the year 2010 demands.

(5) Sewerage Development

The sewerage development shall be executed in keeping pace with the urban water supply development. Thus, the alternative scenarios are to be identified to those

selected for urban water supply. The development costs required for Case-1 to Case-4 do not necessarily coincide with the proportion of the target budget reduction as shown below.

	Target budget level	Development Cost (million US$)	Proportion to Full scale cost (%)
Case-1	50%	588	83
Case-2	50%	407	58
Case-3	75%	621	88
Case-4	75%	563	80

The results are summarized in Table D5.16 and their disbursement schedules are shown in Tables D5.17 to D5.20.

Table D5.21 also summarizes the 4 cases for urban water supply, sewerage and rural water supply development for alternative scenarios.

6. RECOMMENDATIONS

6.1 Financing

As explained in the previous section, share of the development funds in the combined recurrent and development budgets has been decreasing according to the increase of the operation and maintenance costs for the completed projects. Superannuated systems need substantial rehabilitation costs. Substantial increase of the share of water supply development funds in the total government budget or remarkable increase of donors' contribution to the water supply sector would be unrealistic. Under this situation, the development funds to increase the access to safe water will have to continue to decrease.

In order to secure the development funds within the water supply sector, realistic measures will be:

1) To decrease the burden of the O & M costs on the Government budget by increasing cost sharing in the MOWD and NWCPC water supply systems and point source supplies maintained by households.

2) To adjust the tariff level and structure at least to be able to recover the direct O & M costs in the rural systems, and substantial part of the headquarters cost and the full O & M costs in the urban systems.

3) To maximize revenue from water sales

For implementing this policy, it is deemed necessary to prepare financial plans - long term, middle term, and short term - for each water supply system. Without financial plans, it will be impossible to judge whether the system is financially running well or not.

Firstly it will be necessary to formulate procedures, standards, criteria, format for preparation of financial plans. The frameworks will be prepared nationwide and details may be prepared on a District basis, since variations in the socioeconomic conditions are very wide among the Districts.

All the water supply systems are to be obligated to submit financial plans to appropriate authority for their approval.

In selecting development projects (improvement, expansion, new, etc.), projects having reasonable and sound financial plans should be given priority. Figure D.6.1 shows a conceptual flow for preparation of financial plan.

6.2 Operation and Maintenance

Reliable supply of water both in quality and quantity is a basic requirement in the water supply sector. Consumers are not willing to pay for unreliable supply of unsafe water. However, as discussed in the previous chapter, the present situation does not meet the requirement for the water supply sector.

In order to realize reliable supply, sufficient operation and maintenance funds and qualified operation staff must be secured.

Relating to securing the development fund within the water supply sector, the O & M funds should be generated from the revenue from water sales. Several actions are needed:

1) Adjustment of the water tariff reflecting actual operation and maintenance costs,

2) Installation of water meters at all the connections and correct reading and billing,

3) Reduction of leakage, unaccounted for losses, and illegal connections and maximization of the amount of water billed as a proportion of water produced,

4) Management of the revenue collected within the water supply sector

In parallel with the above, strengthening of education of peoples is required on the importance of clean water, beneficiaries to pay, etc.

In order to attain qualified operation staff, training will have to be strengthening.

6.3 Approach to Water Use Monitoring and Management

The Water Act stipulates that utilization of surface and ground water can only proceed after receipt of water abstraction permit from the Water Apportionment Board. The effective permits may number around 15,000 but because of the ill-functioning filing system, accurate number of water permits can not be known. Moreover, illegal water abstraction can not be checked because of insufficient numbers of water bailiffs and transportation. Even though the permitted users concerned, the amount of water actually taken from the surface and ground water sources have not always been measured and reported.

As water demand for domestic, industrial, irrigation and other uses grows, water use problem will become an increasingly serious issue. When it is recognized to be serious, it will be too late to solve the problem, because it takes time to establish monitoring programmes and organization and time to accumulate reliable data.

In this context, the followings are urgently required:

(a) Renovation of filing system of water abstraction permit

(b) Installation of a terminal of the MOWD database system for water abstraction permit within the Water Apportionment Board and direct input of data from the application form,

(c) Pilot water use survey in several critical river basin (checking of all the abstractions and measuring actual intake amount over several seasons) : these surveys should include both surface and groundwater,

(d) Working out naturalized river flow based on the actual abstraction by river basin,

(e) Development of a ground water model based on actual groundwater use by area

(f) Establish the maximum permissible amount for surface and groundwater use by area

It is worth proposing the above undertaking as one of the donor assistance programmes.

REFERENCE

D.01 MOWD, Design Manual for Water Supply in Kenya, 1985

D.02 MOWD, Water Use Study

D.03 MOWD/SIDA, economic and Financial Analysis of Operation and Maintenance of Urban and Rural Water Supply Schemes, 1988, Economic Department, university of Nairobi

D.04 MOPND, 1987 Infrastructure Inventory Guide-lines, 1987

D.05 MOWD, Mini-Evaluation Rural Water Supply Programmes in Kenya, 1981, Brokonsult AB

D.06 MOLG, Status of Water, Sewerage and Refuse Services in Local Authorities in Kenya, 1989

D.07 MOWD, Recurrent and Development Estimates for the Year 1991/92 (District Allocation), 1991

D.08 GOK, Sessional Paper No.11986 on Economic Management for renewed Growth, 1986

D.09 GOK, Development Plan 1989 - 1993, 1988

D.10 MOPND, District Development Plan 1989 - 1993

D.11 MOHANH, Demographic and Health Survey 1989

D.12 Nairobi City Commission, Third Nairobi Water Supply Project, Sewerage Treatment Study, 1988

TABLES

Table D2.1 Existing Water Supply Works

Dis. No:	District	E & F Analysis 1985/86 Urban	Rural	Total	Operational Water Schemes 1989/90 G.U.	G.R.	N.G.	Total	Change
100	NAIROBI PROVINCE				5		4	9	
210	Kiambu	6	5	11	6	6		12	1
220	Kirinyaga	4	4	8	4	4		8	0
230	Murang'a	6	8	14	6	8	1	15	1
240	Nyandarua	1	1	2	1	2	11	14	12
250	Nyeri	3	6	9	3	6		9	0
	CENTRAL PROVINCE	20	24	44	20	26	12	58	14
310	Kilifi	6	3	9	8	1		9	0
320	Kwale	4	1	5	4	1		5	0
330	Lamu	2		2	2			2	0
340	Mombasa	4		4	6			6	2
350	Taita Taveta	3	3	6	3	4		7	1
360	Tana River	1	2	3	1	2		3	0
	COAST PROVINCE	20	9	29	24	8	0	32	3
410	Embu	1	6	7	1	6		7	0
420	Isiolo	1	3	4	1	4	3	8	4
430	Kitui	2	4	6	2	10	1	13	7
440	Machakos	1	7	8	2	8	2	12	4
450	Marsabit	2	2	4	2	2	17	21	17
460	Meru	4	6	11	4	6	1	11	0
	EASTERN PROVINCE	11	28	40	12	36	24	72	32
510	Carissa	1	12	13	1	8	2	11	-2
520	Mandera	1	8	9	1	2	7	10	1
530	Wajir	1	16	17		1	8	9	-8
	NORTH-EASTERN PROVINCE	3	36	39	2	11	17	30	-9
610	Kisii	3	1	4	2	5	4	11	7
620	Kisumu	2	6	8	2	5	3	10	2
630	Siaya	3	5	8	4	5	7	16	8
640	South Nyanza	3	10	13	3	9	2	14	1
	NYAZA PROVINCE	11	22	33	11	24	16	51	18
710	Kajiado	4	4	8	4	3	9	16	8
720	Kericho	5	2	7	6	4	2	12	5
730	Laikipia		1	1		2		2	1
740	Nakuru	2	6	8	7	9	2	18	10
750	Narok	2	3	5	1	5	2	8	3
760	Trans Nzoia		2	2		2		2	0
770	Uasin Gishu	1	4	5	1	6	4	11	6
810	Baringo	2	14	16	2	10	9	21	5
820	Elgeyo-Marakwet	2	5	7	2	5		7	0
830	Nandi	2	4	6	2	5	1	8	2
840	Samburu			0	1	3	3	7	7
850	Turukana	2	9	11	1	10	4	15	4
860	West Pokot	2	4	6	3	3	4	10	4
	RIFT VALLEY PROVINCE	24	58	82	30	67	40	137	55
910	Bungoma	3	5	8	3	6		9	1
920	Busia	1	8	9	2	8		10	1
930	Kakamega	3	11	14	7	8		15	1
	WESTERN PROVINCE	7	24	31	12	22	0	34	3
	TOTAL excluding Nairobi	96	201	298	111	194	109	414	116

Remarks; E& F Analysis represents Ref D.03
G.U. is Gazetted Urban W/S
G.R. is Gazetted Rural W/S
N.G. is Non-Gazetted W/S

Table D2.2 Legal Notice Relating to Water Act (1/2)

Year	Legal Notice No	Contents
1972	9	Rectification
	47	Tariff – Amendment
	130	Tariff – Amendment
	162	Tariff – Amendment
	163	Communal Water Point – Amendment
	223	Tariff – Regulations
	224	Communal Water Point – Amendment
	225	Tariff – Amendment
1973	10	Variation of Limits of Supply
	11	Variation of Limits of Supply
	31	Variation of Limits of Supply
	54	Tariff – Amendment
	55	Communal Water Point – Amendment
	56	Communal Water Point – Amendment
	88	Variation of Limits of Supply
	196	Tariff – Amendment
	197	Communal Water Point – Amendment
	198	Variation of Limits of Supply
	212	Variation of Limits of Supply
	227	Tariff – Amendment
1974	90	Revision
	101	Tariff – Amendment
	123	The City of Nairobi (Water Supply) By-Law
	239	Variation of Limits of Supply
	240	Tariff – Amendment
	241	Variation of Limits of Supply
	242	Communal Water Point – Amendment
	243	Communal Water Point – Amendment
	296	Variation of Limits of Supply
	297	Tariff – Amendment
1975	18	Corrigendum
	94	Tariff – Regulations
	95	General – Amendment
	109	Rectification
	157	Tariff – Amendment
	190	Tariff – Amendment
1976	21	Tariff – Amendment
	32	Tariff – Amendment
	79	Tariff – Amendment
	106	Tariff – Amendment
	138	Tariff – Amendment
1978	185	Tariff – Amendment
	186	Tariff – Amendment

Table D2.2 Legal Notice Relating to Water Act (2/2)

Year	Legal Notice No	Contents
1979	17	The Water (Undertakers) (Open Channel Supplies) Rules
	25	Tariff – Amendment
	42	Variation of Limits of Supply
	85	The Director of Water Development
	86	Tariff – Amendment
	122	General – Amendment
	162	Tariff – Amendment
1980	45	Variation of Limits of Supply
	91	Tariff – Amendment
	179	Yatta Canal Regulations
1981	96	Tariff – Amendment
	159	The Director, Water Engineering Department
	160	Tariff – Amendment
	194	Tariff – Amendment
1982	22	Tariff – Amendment
	161	The Director, Water Engineering Department
	162	Tariff – Amendment
1983	70	Mumwe Investment Ltd.
1984	7	Tariff – Amendment
	30	The Director of Water Development
	31	Tariff – Amendment
	123	The Diocese of Meru
1987	44	Director, Water Development
	45	Tariff – Amendment
	46	Variation of Limits of Supply
	217	The City of Nairobi (Water Supply) (Amendment) By-Laws
1990	392	The Director of Water Development
	393	Tariff – Amendment
1991	496	General - Amendment
	497	General - Amendment (2)
	498	Tariff
	499	General - Amendment (3)
	500	NWCPC Tariff
	501	Tariff – Amendment

Table D2.3 Content of MOPND Infrastructure Inventory Format No. 5A, B & C

			Data often lacking
Format No. 5A	1	Division	
	2	Location/Sublocation	
	3	Name of Facility	
	4	Local Participation yes or no	
	5	Establishing Agency	
	6	Maintenance Agency	
	7	Source ; lake, river, dam, bore hole, etc.	
	8	Size of Service Area (km2)	*
	9	Storage Capacity (m3)	
	10	Delivery Technology	
	11	Distribution Capacity	
	12	Quality high, medium or low	*
	13	Number of Days with Water per Year	***
Format No. 5B	1	Name of Facility	
	2	Type of use ; high, medim or low	
	3	Utilization ; No. of Days	
		Household	***
		Livestock	***
		Irrigation	***
	4	Average Walking Distance	*
	5	Utilization Estimate ; high, medium or low	*
	6	Utilization Remarks	
	7	Condition ; good, fair or poor	**
	8	Condition remarks	
	9	Proposal for Adressing Problem	
Format No. 5C	1	Name of Facility	
	2	Construction Cost (Kshs)	**
	3	Rate ; flat or metered	
	4	Water Produced (m3)	*
	5	Water Sold (m3)	***
	6	Revenue Billed (Kshs)	**
	7	Revenue Collected (Kshs)	**
	8	Operation and Maintenance (Kshs)	*

MOPND: Ministry of Planning and National Development
Sources : Ref D.04

Table D2.4 Extraction from Infrastructure Inventory Format No.5

		Nos of facilities	Water Source						Water Quality				Facility Condition			
			Lake	River	Dam	G/W	Earth	NS	High	Mid.	Low	NS	Good	Fair	Poor	NS
210	Kiambu	71	71	34	13	16	7	1	18	45	2	6	48	12	7	4
220	Kirinyaga	18		18					6	9	2	1		16		2
230	Murang'a	16		14		1		1	12	1	2	1	9	2	1	4
240	Nyandaura	83		5	75	2		1	1	5	77		5	78		
250	Nyeri	23		22	1				13	10			11	8	3	1
	CENTRAL PROVINCE	211	71	93	89	19	7	3	50	70	83	8	73	116	11	11
310	Kilifi	9				9			8	1			3	6		
320	Kwale	5		1		4			5				1	4		
330	Lamu	14	1		9	4			1	3	10		6	5	3	
340	Mombasa	6				5	1		1	5			6			
350	Taita	8		2		5		1	8				3	5		
360	Tana River	10		6	2	2			1	6	3		2	6	2	
	COAST PROVINCE	52	1	9	11	29	1	1	24	15	13	0	21	26	5	0
410	Embu	31		25	1	5			1	22	8		8	13	1	9
420	Isiolo	4				4					4			4		
430	Kitui	9			3	6			5	2	2			7	1	1
440	Machakos	151		56	29	62		4	12	106	28	5	41	66	37	7
450	Marsabit	22		1	1	20			1	19	1	1	5	14	3	
460	Meru	53		53						1	52		11	19	5	18
	EASTERN PROVINCE	270	0	135	34	97	0	4	19	150	95	6	65	123	47	35
510	Garissa	21		8		11		2				21				21
520	Mandera	42		6	28	8			38			4	23	19		
530	Wajir	16				16				12	4		6	9	1	
	NORTH-EASTERN PROVINCE	79	0	14	28	35	0	2	38	12	4	25	29	28	1	21
610	Kisii	21		9	4			8	6	3	4	8	3	4	6	8
620	Kisumu	18	2	11		5			1			17	1	15	2	
630	Siaya	34	8	10	3	11		2	9	18	5	2	13	8	3	10
640	South Nyanza	62	11	31	2	16		2	25	21	16		1	55	2	4
	NYANZA PROVINCE	135	21	61	9	32	0	12	41	42	25	27	18	82	13	22
710	Kajiado	11		2		9			3	8			2	8	1	
720	Kericho	22		17	3	2			6	6	10		13	4	4	2
730	Laikipia	11		6		5			4	6		1	1	8	1	1
740	Nakuru	17		11		6			10	5	1	1	7	5	4	1
750	Narok	10		10					1	8	1		10			
760	Trans Nozoia	5		2	2	1				4	1		1	2		2
770	Usin Gishu	18		12	1	4		1	13	3	1	1	12	3	1	2
810	Baringo	43	1	14		28			4	35	4		8	28	7	
820	Elgeyo-Marakwet	14		8	5			1	13			1	5	5	3	1
830	Nandi	7		5	2					4	3			3	4	
840	Samburu	17		3	3	11			2	12	3		2	4	10	1
850	Turkana	12				12					12					12
860	West Pokot	13		10	1	2			3	7	3		3	8	1	1
	RIFT VALLEY PROVINCE	200	1	100	17	80	0	2	59	98	39	4	64	78	36	23
910	Bungoma	16		8	2	5		1			15	1	6	8		2
920	Busia	32	5	7	6	14			6	16	10		7	9	11	5
930	Kakamega	16		7	3	6			12	3	1		10	4		2
	WESTERN PROVINCE	64	5	22	11	25	0	1	18	19	26	1	23	21	11	9
	TOTAL excluding Nairobi	1011	99	434	199	317	8	25	249	406	285	71	293	474	124	121
	%		10%	43%	20%	31%	1%	2%	25%	40%	28%	7%	29%	47%	12%	12%

Source : Ref D.04

Table D2.5 Inventory of Water Supply Systems in Service Centres : 1990

Code	District	Urban Centre				Rural Centre				Market Centre				Local Centre			
		PS	CWP	OS	NA	PS	CWP	OS	NA	PS	CWP	OS	NA	PS	CWP	OS	NA
110	Nairobi	1															
210	Kiambu	8				11		2		17		4		36		2	
220	Kirinyaga	3				3				9				23		5	
230	Murang'a	5				7				21			1	50			
240	Nyandarua	1				4				3	1	5		5	4	13	
250	Nyeri	3				4				19				36	2	2	
310	Kilifi	3				4				18		2		16		3	
320	Kwale	2				1	1			1	5	2		8		14	
330	Lamu	1				1				1	1	3	1			7	2
340	Mombasa	3				1				9				10			1
350	Taita Taveta	2				1				9				18		1	
360	Tana River	3		1		2				3		1				7	
410	Embu	2				3				9				10	6		3
420	Isiolo	1				1		1		1	1	1		1	1		
430	Kitui	3				6		1		10		8		8		20	
440	Machakos	6				10				37				68			
450	Marsabit	1				1				2		1		1	2	4	
460	Meru	4				2		4	2	6	3	8	8	6	1	7	26
510	Garissa	1					3	9			4	12			3	6	
520	Mandera	1				1		2				4		3		11	
530	Wajir	1				1		1				4			6	7	
610	Kisii	2		1	1	3		2	1	9		12	5	4		47	8
620	Kisumu	3				3	2			7		7		24		9	5
630	Siaya	4				4				12				34			
640	South Nyanza	4				7			3	5	3		29	8	1		59
710	Kajiado	2				3				3				11	6		
720	Kericho	3				4		2		12		2		16		15	
730	Laikipia	3				1				2		3		2		6	
740	Nakuru	4				2		1		4	2	2		3	5	16	2
750	Narok	1				2				2		2		3	10	9	
760	Trans Nzoia	1				2				2		2		1		12	
770	Uasin Gishu	1				3		1		5		8		3		17	
810	Baringo	2				5				9		5		11	2	7	5
820	Elgeyo Marakwet	1				4				4	4	2		7	3	13	
830	Nandi	2				5		1		3		5	2	3		12	
840	Samburu	1				3				1		1		3		8	
850	Turkana	1				3				2		1		5	1	9	
860	West Pokot	2				2				5		1		9		14	
910	Bungoma	3				5				10		7		21		16	
920	Busia	1				9		6				1		4	1	17	
930	Kakamega	7				6	1	3		8	1	8		7	1	33	
100	Nairobi	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200	Central	20	0	0	0	29	0	2	0	69	1	9	1	150	6	22	0
300	Coast	14	0	1	0	10	1	0	0	41	6	8	1	52	0	32	3
400	Eastern	17	0	0	0	23	0	6	2	65	4	18	8	94	10	31	29
500	North-Eastern	3	0	0	0	2	3	12	0	0	4	20	0	3	9	24	0
600	Nyanza	13	0	1	1	17	2	2	4	33	3	19	34	70	1	56	72
700	Rift Valley	24	0	0	0	39	0	5	0	54	6	34	2	77	27	138	7
900	Western	11	0	0	0	20	1	9	0	18	1	16	0	32	2	66	0
	Kenya	103	0	2	1	140	7	36	6	280	25	124	46	478	55	369	111
	System Total in Kenya :					1,001	87	531	164	===(Grand Total)===>				1,783			

Source : Socio-Economic Survey, Janaury-March 1991, JICA Study Team
Remark : PS:Piped System, CWP:Communal Water Points, OS:OtherSources, NA:No Answer

Table D2.6 Inventory of Managing Authority of Water Supply System : 1990

Code	District	Community	Self-help	Non-govern. Organ.	Local Authority	MOWD	NWCPC	Donors	No Answer	Total
110	Nairobi	0	0	0	1	0	0	0	0	1
210	Kiambu	0	28	1	3	47	1	0	0	80
220	Kirinyaga	2	6	6	0	11	18	0	0	43
230	Murang'a	0	3	0	1	37	42	0	1	84
240	Nyandarua	18	5	0	0	13	0	0	0	36
250	Nyeri	0	5	2	7	19	33	0	0	66
310	Kilifi	0	7	0	0	3	36	0	0	46
320	Kwale	7	10	0	0	13	4	0	0	34
330	Lamu	7	0	2	1	4	0	0	3	17
340	Mombasa	0	0	0	0	23	0	0	1	24
350	Taita Taveta	0	19	3	1	4	4	0	0	31
360	Tana River	11	0	0	0	4	0	0	2	17
410	Embu	0	8	0	1	18	3	0	3	33
420	Isiolo	0	1	1	1	5	0	0	0	8
430	Litui	29	0	0	7	20	0	0	0	56
440	Machakos	0	4	2	115	0	0	0	0	121
450	Marsabit	6	0	1	0	5	0	0	0	12
460	Meru	4	8	3	1	17	0	0	44	77
510	Garissa	3	7	2	0	25	1	0	0	38
520	Mandera	17	0	0	0	5	0	0	0	22
530	Wajir	2	0	0	0	17	0	0	1	20
610	Kisii	62	2	1	0	9	6	0	15	95
620	Kisumu	2	6	9	6	20	13	0	4	60
630	Siaya	0	17	4	0	33	0	0	0	54
640	South Nyanza	0	0	7	0	13	0	0	99	119
710	Kajiado	8	0	1	0	14	2	0	0	25
720	Kericho	16	11	1	5	13	6	1	1	54
730	Laikipia	0	8	0	5	3	1	0	0	17
740	Nakuru	20	7	0	2	5	6	0	1	41
750	Narok	18	0	1	1	8	0	1	0	29
760	Trans Nzoia	14	0	0	2	4	0	0	0	20
770	Uasin Gishu	27	4	0	1	5	0	1	0	38
810	Baringo	4	0	0	1	23	2	0	16	46
820	Elgeyo Marakwet	22	3	1	0	10	0	0	4	40
830	Nandi	1	2	0	0	9	1	0	18	31
840	Samburu	0	0	1	0	15	0	1	0	17
850	Turkana	6	1	1	0	14	0	0	0	22
860	West Pokot	8	0	0	0	25	0	0	0	33
910	Bungoma	24	2	0	2	33	1	0	0	62
920	Busia	1	21	3	0	14	0	0	0	39
930	Kakamega	0	48	0	0	19	8	0	0	75
100	Nairobi	0	0	0	1	0	0	0	0	1
200	Central	20	47	9	11	127	94	0	1	309
300	Coast	25	36	5	2	51	44	0	6	169
400	Eastern	39	21	7	125	65	3	0	47	307
500	North Eastern	22	7	2	0	47	1	0	1	80
600	Nyanza	64	25	21	6	75	19	0	118	328
700	Lift Valley	144	36	6	17	148	18	4	40	413
900	Western	25	71	3	2	66	9	0	0	176
	Kenya	339	243	53	164	579	188	4	213	1,783

Source : Socio-Economic Survey, Jan.- March 1991, JICA Study Team

Table D2.7 Inventory of Managing Authority of Sewarage System : 1990

Code	District	Community	Self-help	Non-govern. Organ.	Local Authority	MOWD	NWCPC	Donors	Not Existing	No Answer	Total
110	Nairobi	0	0	0	1	0	0	0	0	0	1
210	Kiambu	0	0	0	2	1	0	0	77	0	80
220	Kirinyaga	0	0	0	0	0	0	0	43	0	43
230	Murang'a	0	0	0	0	1	0	0	83	0	84
240	Nyandarua	0	0	0	36	0	0	0	0	0	36
250	Nyeri	0	0	0	3	0	0	0	63	0	66
310	Kilifi	0	0	0	0	0	0	0	46	0	46
320	Kwale	0	0	0	3	0	0	0	31	0	34
330	Lamu	0	0	0	14	0	0	0	0	3	17
340	Mombasa	0	0	0	24	0	0	0	0	0	24
350	Taita Taveta	0	0	0	0	0	0	0	31	0	31
360	Tana River	0	0	0	0	0	0	0	17	0	17
410	Embu	0	0	0	0	0	0	0	30	3	33
420	Isiolo	0	0	0	1	0	0	0	7	0	8
430	Kitui	0	0	0	56	0	0	0	0	0	56
440	Machakos/Makueni	1	0	0	120	0	0	0	0	0	121
450	Marsabit	0	0	0	0	0	0	0	12	0	12
460	Meru	0	0	0	1	0	0	0	76	0	77
510	Garissa	4	2	0	0	2	0	0	30	0	38
520	Mandera	0	0	0	0	0	0	0	22	0	22
530	Wajir	0	0	0	1	0	0	0	19	0	20
610	Kisii/Nyamira	0	0	0	1	0	0	0	79	15	95
620	Kisumu	0	1	0	3	0	0	0	54	2	60
630	Siaya	50	0	0	4	0	0	0	0	0	54
640	South Nyanza	0	0	0	0	1	0	0	118	0	119
710	Kajiado	0	23	1	1	0	0	0	0	0	25
720	Kericho	0	0	1	3	0	0	0	50	0	54
730	Laikipia	0	0	0	3	0	0	0	14	0	17
740	Nakuru	0	0	0	2	1	0	0	37	1	41
750	Narok	0	0	1	1	0	0	0	27	0	29
760	Trans Nzoia	0	0	0	1	0	0	0	19	0	20
770	Uasin Gishu	0	0	0	1	0	0	0	37	0	38
810	Baringo	0	0	0	2	0	0	0	43	1	46
820	Elgeyo Marakwet	0	0	0	0	0	0	0	38	0	38
830	Nandi	0	0	0	0	0	0	0	31	2	33
840	Samburu	0	0	0	0	0	0	0	17	0	17
850	Turkana	0	0	0	0	0	0	0	22	0	22
860	West Pokot	0	0	0	0	0	0	0	28	5	33
910	Bungoma	0	0	0	2	0	0	0	60	0	62
920	Busia	0	0	0	0	0	0	0	39	0	39
930	Kakamega/Vihiga	0	0	0	1	0	0	0	74	0	75
100	Nairobi	0	0	0	1	0	0	0	0	0	1
200	Central	0	0	0	41	2	0	0	266	0	309
300	Coast	0	0	0	41	0	0	0	125	3	169
400	Eastern	1	0	0	178	0	0	0	125	3	307
500	North-Eastern	4	2	0	1	2	0	0	71	0	80
600	Nyanza	50	1	0	8	1	0	0	251	17	328
700	Rift Valley	0	23	3	14	1	0	0	363	9	413
900	Western	0	0	0	3	0	0	0	173	0	176
	Kenya	55	26	3	287	6	0	0	1,374	32	1,783

Source : Socio-Economic Survey, Jan.-March 1991, JICA Study Team

Table D2.8 Inventory of Managing Authorities for Garbage Disposal Service: 1990

Code	District	Community	Non-Self-help	Non-govern. Organ.	Local Authority	MOWD	NWCPC	Donors Existing	Not Existing	No Answer	Total
110	Nairobi	0	0	0	1	0	0	0	0	0	1
210	Kiambu	0	0	0	7	0	0	0	73	0	80
220	Kirinyaga	0	0	0	2	0	0	0	41	0	43
230	Murang'a	0	0	0	2	1	0	0	81	0	84
240	Nyandarua	0	0	0	36	0	0	0	0	0	36
250	Nyeri	0	0	0	5	0	0	0	61	0	66
310	Kilifi	0	0	0	3	0	0	0	43	0	46
320	Kwale	0	0	0	2	0	0	0	32	0	34
330	Lamu	0	0	0	14	0	0	0	0	3	17
340	Mombasa	0	0	0	24	0	0	0	0	0	24
350	Taita Taveta	0	0	0	4	0	0	0	27	0	31
360	Tana River	0	0	0	2	0	0	0	15	0	17
410	Embu	0	0	0	1	0	0	0	29	3	33
420	Isiolo	7	0	0	1	0	0	0	0	0	8
430	Kitui	0	0	0	56	0	0	0	0	0	56
440	Machakos/Makueni	0	0	0	121	0	0	0	0	0	121
450	Marsabit	10	0	0	2	0	0	0	0	0	12
460	Meru	0	0	0	1	0	0	0	76	0	77
510	Garissa	0	0	0	1	0	0	0	37	0	38
520	Mandera	0	0	0	0	0	0	0	22	0	22
530	Wajir	19	0	0	1	0	0	0	0	0	20
610	Kisii/Nyamira	0	0	0	80	0	0	0	0	15	95
620	Kisumu	0	0	0	58	0	0	0	0	2	60
630	Siaya	48	0	0	6	0	0	0	0	0	54
640	South Nyanza	0	0	0	119	0	0	0	0	0	119
710	Kajiado	0	0	0	3	0	0	0	22	0	25
720	Kericho	0	0	1	7	0	0	0	46	0	54
730	Laikipia	0	0	0	8	0	0	0	9	0	17
740	Nakuru	1	0	0	3	1	0	0	35	1	41
750	Narok	0	0	1	19	0	9	0	0	0	29
760	Trans Nzoia	0	0	0	1	0	0	0	19	0	20
770	Uasin Gishu	0	0	0	1	0	0	0	37	0	38
810	Baringo	0	0	0	2	0	0	0	44	0	46
820	Elgeyo Marakwet	0	0	0	1	0	0	0	37	0	38
830	Nandi	0	0	0	2	0	0	0	29	2	33
840	Samburu	0	0	0	1	0	0	0	16	0	17
850	Turkana	0	0	0	0	0	0	0	22	0	22
860	West Pokot	0	0	0	2	0	0	0	31	0	33
910	Bungoma	0	0	0	3	0	0	0	59	0	62
920	Busia	0	0	0	0	1	0	0	38	0	39
930	Kakamega/Vihiga	0	0	0	5	0	0	0	70	0	75
100	Nairobi	0	0	0	1	0	0	0	0	0	1
200	Central	0	0	0	52	1	0	0	256	0	309
300	Coast	0	0	0	49	0	0	0	117	3	169
400	Eastern	17	0	0	182	0	0	0	105	3	307
500	North-Eastern	19	0	0	2	0	0	0	59	0	80
600	Nyanza	48	0	0	263	0	0	0	0	17	328
700	Rift Valley	1	0	2	50	1	9	0	347	3	413
900	Western	0	0	0	8	1	0	0	167	0	176
	Kenya	85	0	2	607	3	9	0	1,051	26	1,783

Source : Socio-Economic Survey, Jan.-March 1991, JICA Study Team