社会開発調査部報告書

REPUBLIC OF KENYA

MINISTRY OF WATER DEVELOPMENT

THE STUDY

ON

THE NATIONAL WATER MASTER PLAN

EXECUTIVE SUMMARY

JULY 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

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EXECUTIVE SUMMARY

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PREFACE

In response to a request from the Government of the Republic of Kenya, the Government of Japan decided to conduct a development study on the National Water Master Plan and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Kenya a study team headed by Mr. Michito Kato, Nippon Koei Co. Ltd., composed of members from the Nippon Koei Co., Ltd., CTI Engineering Co., Ltd. and Construction Project Consultants, Inc., four times between January 1990 and May 1992.

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

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

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

July, 1992

Kensuke Yanagiya
President
Japan International Cooperation Agency

JAPAN INTERNATIONAL COOPERATION AGENCY
THE STUDY ON THE NATIONAL WATER MASTER PLAN

Mr. Kensuke Yanagiya
President
Japan International
Cooperation Agency
Tokyo

July, 1992

Dear Sir,

LETTER OF TRANSMITTAL

We are pleased to submit herewith the Final Report of "the Study on the National Water Master Plan". The Report has been prepared for the Government of Kenya as a guideline for consideration when implementing the country's future water resources developments and management in line with the nation's socioeconomic development objectives.

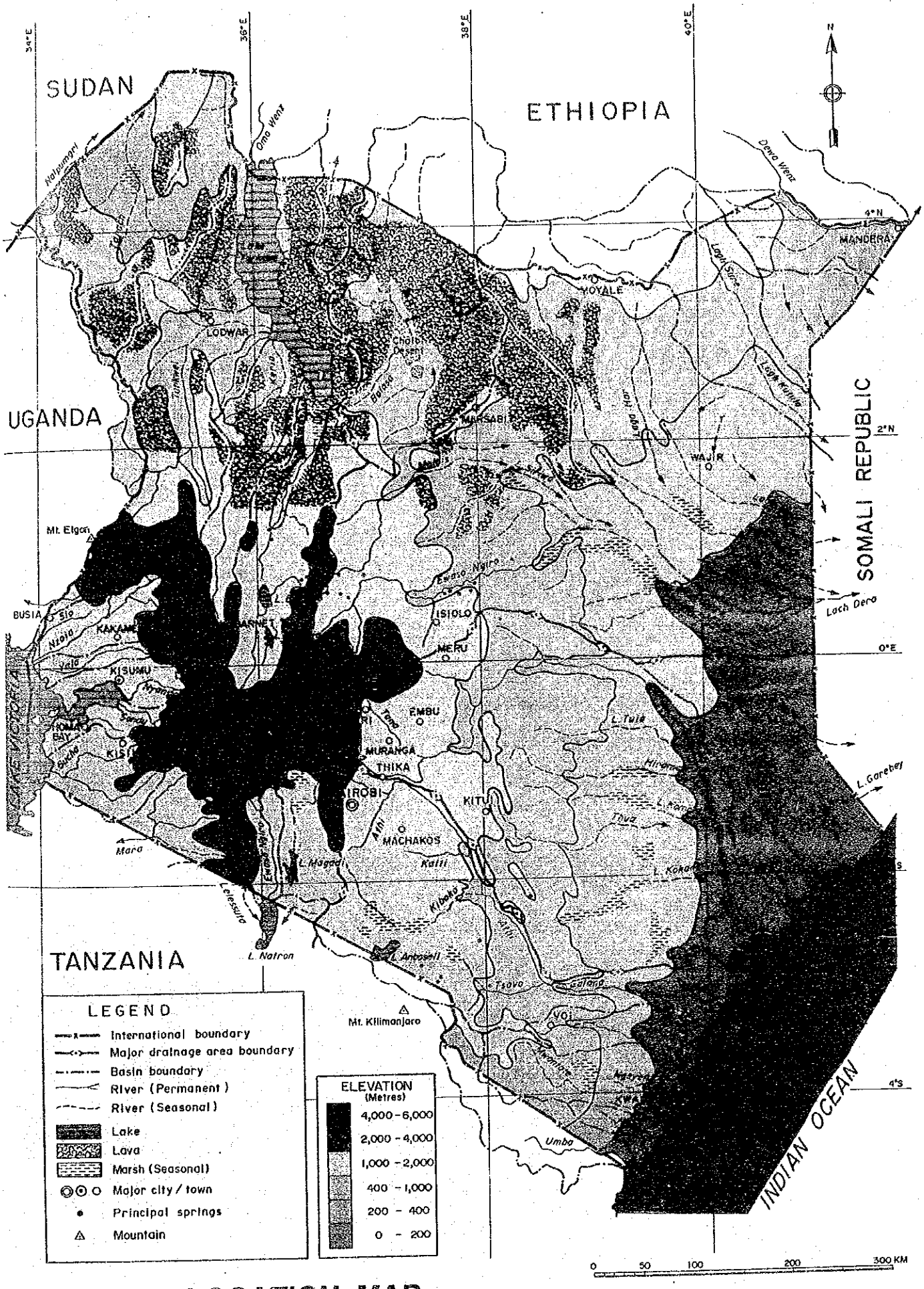
The main outputs from the Study are broadly grouped into two components. One is Water Resources Development and Use Plan towards the year 2010 (Main Report Volume I) which shows the general direction of future water resources development based on the national water development policy. The Plan indicates that it is time to expedite water resources development to a greater extent if the declared goal of the national socioeconomic development is to be attained.

The other output is the Master Action Plan towards the year 2000 (Main Report Volume II and III), which deals with recommendations of various actions to be undertaken by the Government to ensure the co-ordination of relevant activities for the integrated development and management of water resources which are one of the essential and most important resources in Kenya for the improvement of people's lives and national economic development, while serious water stress has increasingly taken place in various parts of the country. A framework scenario of the proposed implementation programmes is also presented.

All members of the Study Team wish to express grateful acknowledgement to the personnel from your Agency, Advisory Committee, Ministry of Foreign Affairs, Ministry of Construction, and Embassy of Japan in Kenya as well as the officials and individuals from Kenya for the kind assistance extended to the Study Team. The Study Team sincerely hopes that the results will contribute to the future water resources development of Kenya in particular and to her socioeconomic development and well-being in general.

Yours sincerely,

Michito Kato
Team Leader



LOCATION MAP

SYNOPSIS

OBJECTIVE OF THE STUDY

This study on the National Water Master Plan (NWMP) has been carried out by the Study Team of the Japan International Cooperation Agency (JICA) in collaboration with the officials of the Government of Kenya for about 2.5 years since January 1990. The Study aimed at formulating a framework for planning and implementation of water resources development consistent with the nation's social and economic development objectives. On this basis, the Study projected future water demand/development need, evaluated the available water resources, and then formulated water development plans required for achievement of the National Water Development Policy/Target which foresees to meet all the water demand and development need arising towards the year 2010.

NATIONAL WATER DEVELOPMENT POLICY/TARGET

1.	Maintenance of low flow	:	• Conservation of minimum flow, for which river maintenance discharge is to be assessed for each major rivers
2.	Domestic/industrial water supply	:	• Provision of safe and sustainable water supply towards the year 2010 for all people
3.	Sewerage development	:	• Provision of adequate sewerage facilities in urban centres for people's well-being
4.	Agriculture/irrigation development	:	• Attainment of food self-sufficiency. • Promotion of irrigation development to contribute to improving the production efficiency in agriculture and the farmers' well-being
5.	Livestock development and wildlife conservation	:	• Provision of water sufficient for promotion of livestock breeding meeting dairy and meat production requirements • Conservation of watering points for protection of wildlife resources
6.	Hydropower development	:	• Exploitation of economically viable hydropower projects in line with the national power development plan
7.	River and flood control works	:	• Provision of flood control, river improvement, and drainage works for improving people's social well-being

PROPOSED WATER DEVELOPMENT PLAN

The proposed development plans are presented in the figure titled "National Water Resources Development Plan" attached at the end of this report.

1. Domestic/industrial water supply

(1)	Urban water supply	:	Implementation of 158 urban water supply schemes (towns having a population more than 5,000 in year 2000)
(2)	Rural water supply	:	Provision of safe and sustainable water sources up to 2000 and supply of piped water up to 2010, covering the whole country

2. Sewerage development : Provision of adequate sewege disposal systems including public sewer facilities for 158 urban centres

3. Irrigation development

(a)	Major irrigation schemes	:	Implementation of 18 projects
(b)	Small scale irrigation schemes	:	Implementation of 140 schemes (identified as of September 1991) scattered over the country

4. Livestock development and wildlife conservation

(a)	Livestock water supply	:	Conservation of surface water and provision of various water sources
(b)	Enhancement of nomadic pastoralism	:	Provision of about 560 boreholes/shallow wells in nomadic pasturage area (as experimental work)
(c)	Wildlife watering	:	Conservation of natural water sources and existing water facilities

5. Hydropower development : Construction of six (6) hydropower projects assessed to be economically viable

6. River and flood control works

(a)	Major flood control works	:	Implementation of five (5) economically viable flood control projects
(b)	Urban drainage work	:	Provision of drainage facilities for 47 major towns
(c)	Minor river improvement works	:	River improvement work in various rivers where problems arise, particularly in urban areas
(d)	Stabilization of Lower Tana River channel	:	Rectification of meandering and bank erosion as a pilot work for the long-term improvement

FINANCIAL REQUIREMENT

1. Development cost required for implementation of the above proposed development plans is estimated as follows:

	Development Sector	Required Development Cost US$ million Equivalent	Required Development Cost K£ million Equivalent
(1)	Domestic/industrial water supply	7,576	9,546
(2)	Sewerage development	705	888
(3)	Irrigation development	973	1,226
(4)	Livestock water supply	755	951
(5)	Hydropower development	1,034	1,304
(6)	River and flood control works	1,067	1,343
	Total	12,110	15,258

Remarks : US$ 1 = Kshs 25.2 = K£ 1.26 (February 1991)

2. A very rough projection of total available development budget towards the year 2010 is US$ 6,300 million or K£ 7,950 million (based on an assumption that present development expenditure would be increased in proportion with the projected GDP growth). If this figure represents the most likely future condition, the financial resources available are extremely insufficient. The Government should consider distributing as much budget as possible to the water sector, which is essential to achieve the national water development targets set forth above.

MASTER ACTION PLAN

1. The Study formulated the Action Plans to be deployed henceforth for achievement of water development plans proposed above. The basic principles are that all the development targets set forth above would be achieved by the year 2010, meeting the development demands in the year 2000 as an intermediate target.

2. The Study also examined the implementation programmes under reduced budgetary and development scenarios.

Reduced budgetary scenario :

- Scenario A : Available budgetary resources to be approximately 50% of the required development cost
- Scenario B : Available budgetary resources to be approximately 75% of the required development cost

Reduced development scenario for domestic/industrial water supply:

- In domestic/industrial water supply sector, the development target towards the year 2010 would be reduced to the level of "just meeting the demand projected for the year 2000" (i.e. water demand exceeding the year 2000 level would not be met)

However, these programmes should be regarded as alternative scenarios only to be

applied in case the budgetary constraint would be unavoidable. The basic policy should be to deploy all possible effort for the achievement of the Action Plans propopsed in 1 above.

FURTHER STUDY PROGRAMME

The implementation of the development programmes will require pre-investment and other supporting studies. The Study proposes the following study programmes:

(a)	Studies and design of individual projects	:	For all schemes taken up in the proposed implementation programmes
(b)	Integrated river basin study	:	Nine (9) major river basins
(c)	Groundwater resources study for urban water supply	:	22 urban centres in semi-arid and arid areas
(d)	District water resources study	:	All 41 Districts (plus 6 Districts recently established)
(e)	Data collection and water management, comprising • Surface water management • Groundwater management • Water quality and pollution control • Various supporting studies associated with the promotion of development activities	:	Country-wide
(f)	Environmental studies • Preparation of environmental guidelines • Regional environmental study	:	 Country-wide 3 selected areas not covered by the river basin studies

LEGAL AND INSTITUTIONAL ASPECTS

The general framework of legal and institutional set-up in Kenya appears to have no substantial problems on the whole. Nevertheless, there are still issues needing improvement in terms of the implementation of laws and the management of water resources and use. Therefore, the Study recommended the betterment of a number of issues in these aspects; particularly the issues relevant to the formulation and implementation of undertakings proposed in this National Water Master Plan.

IMPLEMENTATION OF MASTER PLAN

This Study formulated a nationwide water resources development plan to be deployed for the achievement of the National Water Development Policy Target (towards year 2010). In a context that there may be some extent of budgetary constraint in carrying out the implementation, the most appropriate method of implementation should be discussed thoroughly within the Government of Kenya. In addition, the implementation of the plans should accompany the utmost attention to social and environmental aspects.

NOTE

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.

EXECUTIVE SUMMARY

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ABBREVIATION

CBK	Coffee Board of Kenya
CBS	Central Bureau of Statistics
CRF	Coffee Research Foundation
CSS	Computer Service Section of MOWD
DAO	District Agricultural Officer
DC	District Commissioner
DDC	District Development Committee
DO	District Officer
DRSRS	Department of Resource Surveys & Remote Sensing
EAMD	East Africa Meteorological Department
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GIS	Geographical Information System
GRDP	Gross Regional Domestic Product
GTZ	German Agency for Technical Cooperation
HCDA	Horticultural Crops Development Authority
IBRD	International Bank for Reconstruction and Development
ICDC	Industrial and Commercial Development Corporation
IDA	International Development Association
ILUS	Integrated Land Use Survey
IPC	Investment Promotion Center
IRS	Integrated Rural Survey
JICA	Japan International Cooperation Agency
KBS	Kenya Bureau of Standard
KIRDI	Kenya Industrial Research & Development Institute
KIE	Kenya Industrial Estates Limited
KMD	Kenya Meteorological Department
KPCU	Kenya Planters' Cooperative Union
KPLC	Kenya Power and Lighting Co.
KS	Kenya Standard
KSA	Kenya Sugar Authority
KSB	Kenya Sisal Board
KSS	Kenya Soil Survey
KTDA	Kenya Tea Development Authority
KVDA	Kerio Valley Development Authority
KWAHO	Kenya Water and Health Organization
LBDA	Lake Basin Development Authority
LU	Livestock Unit
MOA	Ministry of Agriculture
MOCSS	Ministry of Culture and Social Services
MOE	Ministry of Energy
MOED	Ministry of Education
MOENR	Ministry of Environment and Natural Resources
MOF	Ministry of Finance
MOH	Ministry of Health
MOHANH	Ministry of Home Affairs and National Heritage
MOI	Ministry of Industry
MOL	Ministry of Labour
MOLD	Ministry of Livestock Development
MOLG	Ministry of Local Government
MOLH	Ministry of Lands and Housing
MOMDE	Ministry of Manpower Development and Employment
MOPND	Ministry of Planning and National Development
MOPW	Ministry of Public Works
MORD	Ministry of Region Development
MORDASAW	Ministry of Reclamation and Development of Arid, Semi-arid and Wasteland
MORST	Ministry of Research, Science and Technology
MOSM	Ministry of Supplies and Marketing
MOTC	Ministry of Transport and Communication
MOTW	Ministry of Tourism and Wildlife
MOWD	Ministry of Water Development
NCC	Nairobi City Commission
NCPB	National Cereals and Produce Board
NES	National Environment Secretariat
NIB	National Irrigation Board
NMWP-I	National Master Water Plan (Stage I)
NWCPC	National Water Conservation and Pipeline Corporation
NWMP	National Water Master Plan
OECD	Organization for Economic Cooperation and Development
OECF	Overseas Economic Cooperation Fund of Japan
OP	Office of the President
PC	Provincial Commissioner
PPCSCA	Presidential Permanent Commission on Soil Conservation and Afforestation
ROK	Republic of Kenya
RTPC	Rural Trade and Production Center
RWSDP	Rural Water Supply Development Project
SEFC	Small Enterprise Financial Corporation
SOK	Survey of Kenya
SP1	Sessional Paper No.1 of 1986 on Economic Management for Renewed Growth
SWAP	Surface Water Extraction Permit
TARDA	Tana and Athi River Development Authority
UNDP	United Nations Development Programme
UNEP	United Nation Environment Programme
UNESCO	United Nations Educational, Scientific, and Cultural Organization
UNICEF	United Nations International Children's Emergency Fund
UNIDO	United Nations Industrial Development Organization
UNPEP	United Nation Population Fund Programme
UON	University of Nairobi
USAID	United States Agency for International Development
WHO	World Health Organization

ABBREVIATION OF MEASURES

Length

mm	=	millimetre
cm	=	centimetre
m	=	metre
km	=	kilometre

Area

ha	=	hectare
m^2	=	square metre
km^2	=	square kilometre

Volume

l, lit	=	liter
m^3	=	cubic metre
m^3/s, cms	=	cubic meter per second
MCM	=	million cubic metre
m^3/d, cmd	=	cubic metre per day

Weight

mg	=	milligram
g	=	gram
kg	=	kilogram
t	=	ton
MT	=	metric ton

Time

sec	=	second
hr	=	hour
d	=	day
yr	=	year

Money

Kshs.	=	Kenya shilling
K£	=	Kenya pound (Kshs.20)
US$	=	U.S. dollar
USc	=	U.S. cent

Energy

Kcal	=	Kilocaloric
KW	=	kilowatt
MW	=	megawatt
KWh	=	kilowatt-hour
GWh	=	gigawatt-hour

Others

%	=	percent
o	=	degree
'	=	minute
"	=	second
°C	=	degree Celsius
cap.	=	capital
LU	=	livestock unit
md	=	man-day
mil.	=	million
no.	=	number
pers.	=	person
mmho	=	micromho
ppm	=	parts per million
ppb	=	parts per billion

1. INTRODUCTION

1.1 Objective and Framework of the Study

Kenya's rapid development has begun to strain her water resources. Increasingly water stress has occurred in places where previously water was found in abundance. The responsibility for water resources development and management in Kenya has been fragmented among various departments and agencies in accordance with their respective functions and activities related to water. In the absence of a comprehensive system to coordinate the multifarious activities in water resources development and management, these activities tend to take place in isolation. This may lead to competition in water use and even duplication of activities and functions. An integrated approach to water resources development and management is therefore necessary to ensure future efficient use of water and other resources, and a study in this regard has become necessary.

This National Water Master Plan (NWMP) Study has been carried out by the Japan International Cooperation Agency (JICA) Study Team in collaboration with the officials from the Government of Kenya for about 2.5 years since January 1990. The Study aimed at formulating a framework plan for the planning and implementation of water resources development consistent with the nation's social and economic development objectives. On this basis, the Study projected future water demand/development needs, evaluated the available water resources, and then formulated water development plans required for achievement of the National Water Development Policy/Target which foresees to meet all the water demand and development needs arising towards the year 2010.

The proposed development plans include the listing of individual projects. However, they are listed as one of the components of the proposed framework plan, and it was not the Study's intent to go into detail on the individual projects. Further details should be examined in subsequent studies.

The implementation of the plans is presumed to encounter budgetary constraints, and hence the Study examined alternative development plans under the reduced budgetary scenarios. The Study also described the important issues of environmental conservation relevant to water development.

1.2 Output of the Study

The Study contains the following two plans and recommendations: (i) the National Water Master Plan towards the year 2010 and (ii) the Master Action Programme towards the year 2000. The output of the study was submitted to the Ministry of Water Development (MOWD), the executing agency for the Kenyan Government. The report is comprised of (i) one volume for the Executive Summary, (ii) three volumes for the Main Report, (iii) 17 volumes for the Sectoral Report, and (iv) six volumes of the Data Book. This volume is an executive summary of all the reports. The complete set of the reports is listed up in Table 1.1 below.

Table 1.1 List of Draft Final Report

Serial Vol. No.1 EXECUTIVE SUMMARY

MAIN REPORT

Serial Vol. No.	Vol. No.	Title
2	Vol.1	Water Resources Development and Use Plan towards 2010
3	Vol.2	Master Action Plan towards 2000 Part 1 : National Water Master Action Plan
4	Vol.3	Master Action Plan towards 2000 Part 2 : Action Plan by Province/District

SECTORAL REPORT

Serial Vol. No.	Vol. No.	Title	Serial Vol. No.	Vol. No.	Title
5	A.	Socio-economy	14	K.	Topographic Survey of 11 Damsites
6	B.	Hydrology	15	L.	Power Development Plan
7	C.	Groundwater Resources	16	M.	Integrated Water Resources Development Planning
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1.3 Acknowledgement

The Government of Kenya organized the Steering Committee and the Technical Sub-committee for the purpose of managing the execution of the study. In the same manner, the Japan International Cooperation Agency (JICA) set up the Advisory Committee. All members of the Committee are listed in Appendix 1 which include the members of the Study Team as well.

For implementing the Study, JICA Study Team has appreciatively been supported by the Steering Committee, the Technical Sub-committee, and the Advisory Committee who have given a lot of helpful assistance and advice. The Team wishes to express grateful acknowledgement to all the members of the Committees. Besides, the Team has received a lot of cooperation in the fields of data collection and information presentation through the public entities and agencies concerned from the Government of Kenya. The Team sincerely expresses many thanks to the officials and individuals from these groups.

2. MACRO-FRAMEWORK FOR NATIONAL WATER MASTER PLAN

To formulate a water resources development plan in the future, a macro-framework towards the year 2010 is projected on the basis of socio-economic conditions, water requirements, potential water resources, and water balance.

2.1 Socio-economic Conditions

The socio-economic conditions to the year 2010 were forecasted as follows:

Table 2.1 Socio-economic Indices

Item	1990	2000	2010	Increment to 1990
Population (1,000)				
Original Projection	24,396*1	34,795*1	47,818	(196%)
- Urban	4,778	9,098	15,965	(334%)
- Rural	19,618	25,697	31,851	(162%)
Revised Projection *2	22,749	30,712	40,305	(177%)
- Urban	3,965	7,933	12,698	(320%)
- Rural	18,784	22,779	27,607	(147%)
GDP at 1989 Constant Prices				
Total Amount (US$ Million)	7,188	12,807	18,922	(263%)
Per Capita (US$)	316	415	468	(149%)
Major Agricultural Products (Thousand Metric Tonnes)				
Maize	2,774	3,631	4,700	(171%)
Wheat	286	424	590	(206%)
Beef	175	249	339	(194%)
Milk	1,709	2,345	3,176	(182%)

Remark: *1 Official projection by CBS (before the release of the 1989 census provisional results).
*2 Revised on the basis of the 1989 census provisional results

The future population was revised from the original projection down to the new projection (shown in the above table as "Revised Projection") at the final stage of the Study, since the 1989 census provisional results were published in the "Economic Survey 1991" in May 1991. However, these projection figures should be replaced by the official projection which will be released by the Government. The population projection in this report has been prepared for the sole purpose of estimating the water requirement in this current study.

2.2 Overview of Needs for Water Development

Most water is used for domestic, industrial, irrigation, livestock, wildlife, and hydropower generation purposes. This should continue in the future, particularly for domestic/industrial, purposes.

Although no definite statistical figure has been disclosed, it is believed that more than half of population is not provided with a public water supply system. Urban water

supply systems are overloaded and the majority of rural people have difficulty in getting access to a water source. Water fetching is still a great burden to women in rural areas.

Production of major crops (maize, wheat, sorghum/millet, rice), at present, is nearly at self-sufficiency level under normal climatic conditions. However, irrigated agriculture land (53,000 ha) accounts for only 1.1% of the total agricultural land (4.65 million ha) and most of the land is still subject to vagaries of climate. Food demand in 2010 will be nearly double of the present demand. To support the required agricultural production, irrigation development is deemed to be a paramount requirement.

Livestock production requirement in 2010 will also be almost double the present. Conservation of the wildlife ecology is becoming increasingly important many reasons including tourism. Existing water sources for livestock and wildlife appear to be fragile in dry years, which need to be improved.

Hydropower is a leading power supply source in Kenya, providing 70% of the total power supply. There are still several attractive schemes for further development. Hydropower and to a lesser extent geothermal power are the most important resource available for attaining self-reliant energy production. Maximum development should be pursued.

2.3 Water Demand

On the basis of the above socio-economic framework projection, the water requirements were estimated to the year 2010 as shown in the following table.

Table 2.2 Projection of Water Requirements

	Item	1990	2000	2010	Increment to 1990
(a)	Domestic and Industrial Water ($1000m^3$/day)				
	- Urban	573	1,169	1,906	(332%)
	- Rural	532	749	1,162	(218%)
	- Industry	219	378	494	(226%)
	Sub-Total	1,324 *1	2,296	3,562	(269%)
	per capita (l/day)	58	75	88	(152%)
(b)	Irrigation ($1000m^3$/day)	3,965	7,810 *3	11,655	(294%)
(c)	Livestock ($1000m^3$/day)	326	427	621	(191%)
(d)	Inland Fishery ($1000m^3$/day)	44 *2	61 *3	78	
(e)	Wildlife ($1000m^3$/day)	21 *2	21	21	
	Total ($1000m^3$/day)	5,680	10,615	15,937	
	(MCM/year)	2,073	3,874	5,817	

Remark: *1 The figure above, (a) Domestic and Industrial Water for 1990, is a theoretical estimate of potential demand. It does not mean that all the demand is being met by water facilities.

*2 The figures above, (d) Inland Fishery and (e) Wildlife, were estimated roughly because of a lack of data, so indicated simply for reference. The number of wildlife animals is assumed to be constant even in the future. Water demand is assumed to be constant in future (no sufficient information for projection).

*3 This depends on the actual development towards 2000. A median value of 1990 and 2010 figures is tentatively shown above.

2.4 Water Resources and Water Balance

2.4.1 Potential water resources

The annual volume of potential water resources was estimated as follows.

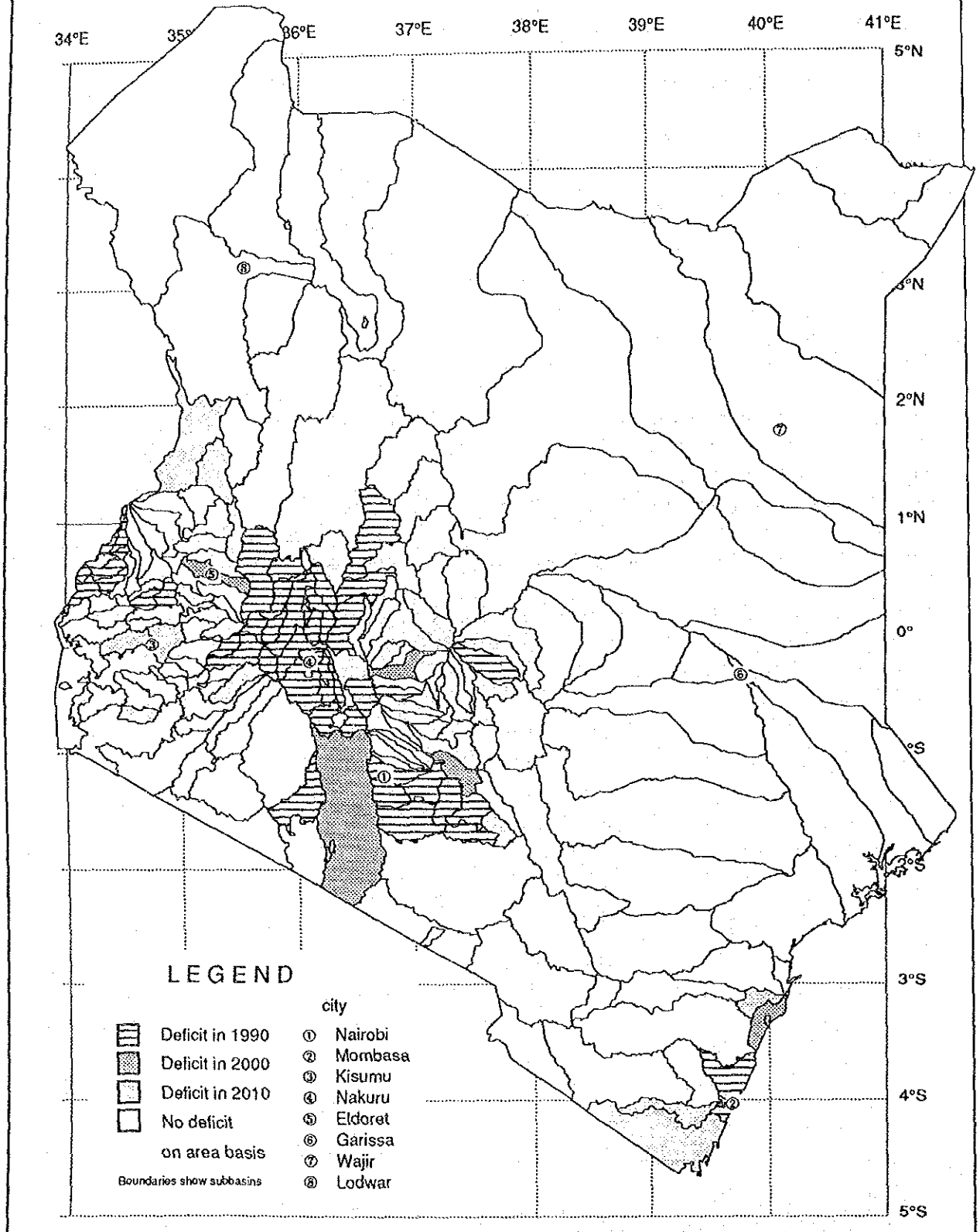
(a)	Surface water	19,590 MCM	(including only perennial rivers of which discharge data are available)
(b)	Groundwater	619 MCM	
	– Boreholes	193 MCM	
	– Shallow wells	426 MCM	
	Total	20,209 MCM	

The water requirement estimated in Section 2.2 was 2,073 MCM or approximately 10% of the available water resources in 1990, and 5,817 MCM or 28% in 2010. In other words, this simple calculation of water balance proves that the potential water resources are sufficient for the water requirement in 2010.

2.4.2 Balance between demand and potential available water by zone

Regional and geographical maldistribution of water demand as well as water resources is one of the salient features in Kenya. This characteristic is illustrated in Figure 2.1 which shows the balance between water demand and potential available water resources (surface water + groundwater) by zone in the year 2010. It identifies many zones as the areas suffering from water deficit. Formulation of water development plans in the succeeding chapters will examine the measures for solving this water shortage issue.

Fig. 2.1



Note ; This figure shows the balance between projected water demand and potential available water "on area basis". Even in the areas classified above as "no deficit", there may still be water shortage on local area basis.

Figure 2.1 Balance between Demand and Potential Available Water (Groundwater + Surface Water)

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3. NATIONAL WATER DEVELOPMENT POLICY AND TARGET

3.1 Policy Set-up

The National Water Development Policy has been formulated to guide public actions in water resources development and management in support of development of all socio-economic sectors related to water resources consistent with national development goal and to adjust various development activities to the limitation in availability and conservation of water resources.

The general objective of the National Water Development Policy is to free the nation from water constraints, and thereby to contribute to national economic development, regional development, improvement of the environment, and social well-being.

Specific objects are;

(1) The requisite quantity of flow will be maintained in main rivers in order to sustain normal water use and to preserve environmental quality.

(2) A public water supply will be developed to improve the social well-being and to support industrial development. It will be a prerequisite to provide sewerage facilities for disposal of waste water.

(3) An irrigation development will be undertaken to assure the desired level of food self-sufficiency and to increase farmers' real income.

(4) Sustainable water sources will be provided for livestock husbandry and wildlife conservation.

(5) The hydropower potential will be developed to the maximum extent possible to provide self-reliant energy.

(6) Floods will be mitigated to protect peoples' life and to reduce flood damage.

3.2 Hydrological Planning Criteria

(1) Domestic and Industrial Water

- Urban : 1/10 dry year (roughly equivalent to MOWD Design Manual; 96% probable daily flow)
- Rural : 1/2 dry year (roughly equivalent to MOWD Design Manual; 96% probable monthly flow)
  To be improved to 1/10 in the long run

(2) Irrigation : 1/5 dry year

(3) Minimum river flow : Recorded minimum daily discharge is provisionally assumed in this study as the minimum flow to be conserved in the river. It is

necessary to determine the required river maintenance discharge on each river basis.

3.3 Domestic and Industrial Water Supply

(1) Development target : To provide "safe and sustainable water supply" to all people by the year 2010.

- Urban : Provision of piped water supply, meeting the demands in year 2000 and 2010, respectively

- Rural : Provision of access to safe and sustainable water sources towards the year 2000 :
  - Principally, supply of water at source points
  - Water available at sources is not necessarily potable

  Provision of piped water supply system towards the year 2010 :
  - Water is supplied by a combination of individual connections and communal points
  - Water is treated as required and hence potable

(2) Proposed facilities

- Urban : Piped grid water supply
- Major rural : Piped grid water supply
- Rural : Communal/spot water supply

(3) Priority order of projects

- On-going projects listed in the current "District Development Plans" including rehabilitation and augmentation plans
- Studied and planned schemes given high priority
- Newly proposed schemes

  - Urban :
    (a) Tourism centres (Nairobi, Coast, etc.)
    (b) Major regional centres defined as towns having population of more than 10,000 and/or the District headquarters
    (c) Other secondary towns (population of less than 10,000)
  - Rural :
    (a) No specific priority criteria among the Districts in view of the importance of attaining equitable development over the country
    (b) Within each District, the priority order may be given with the following criteria:

- Rural areas supplied in low cost water, because of economic viability
- Rural areas relatively backward in terms of availability of sustainable water sources, in consideration of regional equity
- Rural areas covered by low quality ground water, where rainwater harvesting should be promoted

(4) Non-structural measures

(a) Reduction of water leaks from water distribution pipes and unaccounted-for-water

(b) Water saving : (i) Ascending tariff structure
(ii) Metering individually

(c) Cost recovery policy : (i) Full cost recovery in urban areas
(ii) O&M cost recovery in rural areas

3.4 Sewerage Development

In the long-run, all people should be provided with adequate sewage facilities or equipment. The current study assumed that the priority for implementation would be given firstly to urban centres, at least for the period up to the year 2010. In principle, the sewerage facilities will be recommended in conjunction with a provision for water supply facilities.

3.5 Agriculture and Irrigation

3.5.1 Agriculture development

(1) Development target : Food self-sufficiency

Food self-sufficiency could be attainable through the following two measures:
(i) Improvement of farming practices which will increase yields.
(ii) Expansion of cultivated area

This study presumes that the crop production in 2010 could be attained as follows:

Table 3.1 Projection of Major Crop Production in 2010

Crop	Present (1990)			Future (2010)		
	Production (1000 tons)	Yield (tons/ha)	Cultivated Area (1000 ha)	Production (1000 tons)	Yield (tons/ha)	Cultivated Area (1000 ha)
Maize	2,762	1.8	1,500	4,700	2.8	1,679
Wheat	298	2.1	140	590	3.4	173
Sorghum/Millet	219	0.8	270	547	1.5	364
Rice	44	2.9	15	205	3.0	68
Total			1,925			2,284

In addition to the above major crops, coffee (275,000 ha), tea (124,000 ha), and other crops (approximately 2 million ha) will be cultivated by the year 2010. The total cultivated area will be approximately 5.2 million ha (including fallow land) in 2010. Figure 3.1 shows a very preliminary assessment of future land use assuming the implementation of the water development master plan.

(2) Agricultural development potential

According to the land classification assessment in the current study, there are about 5.0 million ha of arable lands for maize, 1.4 million ha for wheat, 7.2 million ha for sorghum/millet and 1.3 million ha for rice in the country. Thus, Kenya has sufficient potential arable land for agricultural production.

3.5.2 Irrigation development

(1) Irrigation development potential

Taking into account the suitability of arable land and available water resources, the potential areas for irrigation development were estimated as follows:

Table 3.2 Irrigation Development Potential

(Unit: ha)

Water Source	Upland Crop	Paddy (out of total)
Surface Water	470,000	340,000
Groundwater	1,500	1,000

Since the present irrigated land covers 65,000 ha or 14% of the above potential land, the country has sufficient lands available for irrigation development.

(2) Role of irrigation development

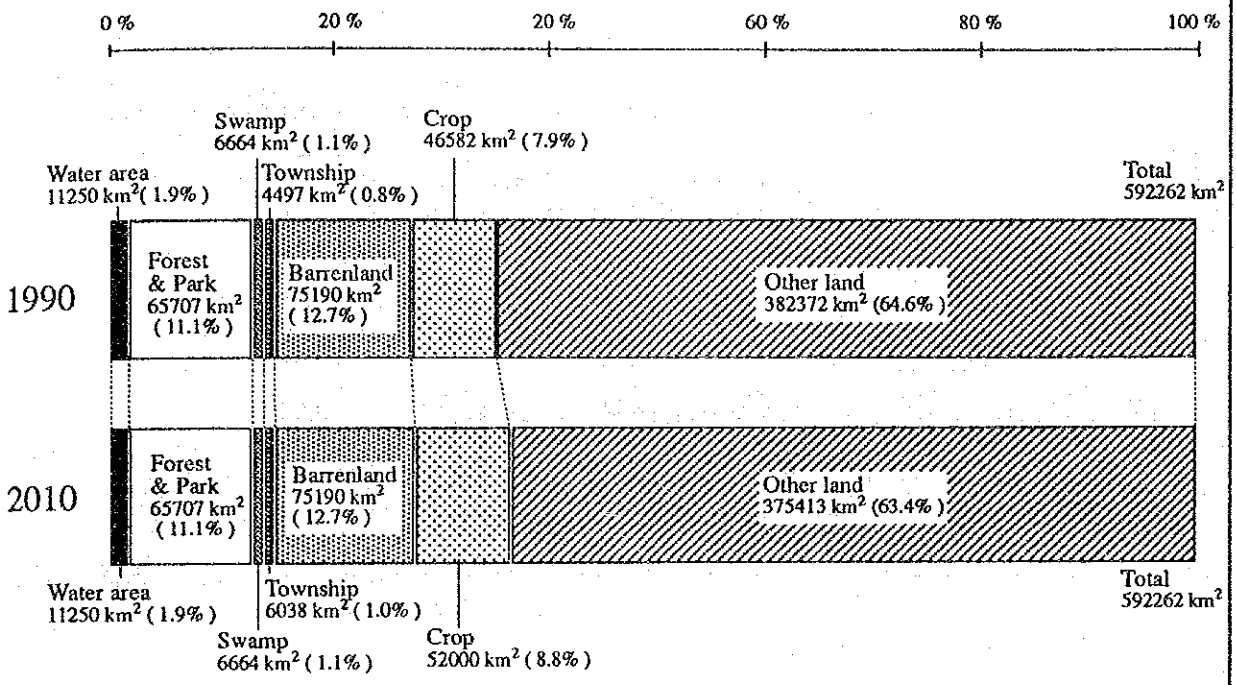
It is envisaged that self-sufficiency in major food production will be achievable primarily by promotion of rainfed agriculture. However, the role of irrigation development is still important in respect of the contribution to (i) the enhancement of national economic development through production of crops in a more economical way, (ii) the increase in farmers' real income, (iii) the security for drought, and (iv) the ascertainment of food self-sufficiency.

(3) Priority of projects

- Small irrigation schemes, because they require the least amount of funds and enhance community development
- Schemes having high economic efficiency, e.g., major irrigation schemes

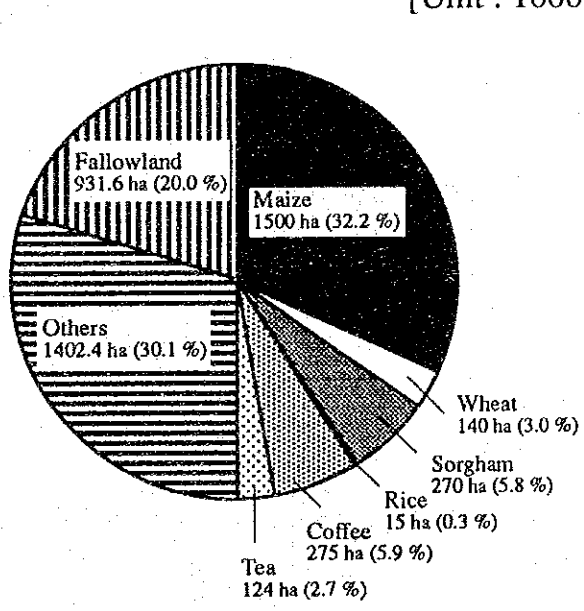
Fig. 3.1

Overall Land Use



Breakdown of Crop Land

[Unit : 1000 ha]



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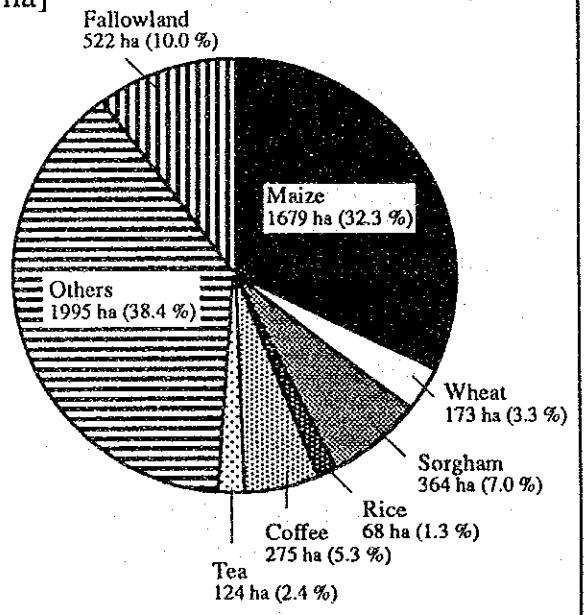

2010

Figure 3.1 Preliminary Assessment of Future Land Use Plan

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3.6 Livestock and Wildlife

3.6.1 Livestock development

(1) Livestock production requirement

To satisfy the total demand of meat and dairy products in the future, the following successive livestock development would be necessary by the year 2010.

Table 3.3 Livestock Projection

(Unit: 1000 head)

Major Livestock	1990	2000	2010	Increment to 1990
Dairy Cattle	2,798	3,302	3,896	(139%)
Beef Cattle	9,133	10,960	13,152	(144%)
Sheep/Goats	15,626	18,751	22,502	(144%)
Camel	719	849	1,002	(139%)

(2) Water development need

The water requirement for the above livestock production is as estimated in Section 2.2. Necessary water sources should be conserved or exploited to meet the increasing water demand.

3.6.2 Wildlife conservation

Water for wildlife should also be conserved or exploited in the areas where the ecology of wildlife is to be protected.

3.7 Hydropower

National power development plan was Kenya is formulated by the Ministry of Energy (MOE) and the Kenya Power Company Ltd. (KPC). The hydropower development projects in this current study conform to the plans contemplated by MOE and KPC. Basically, development projects that have been selected are competitive with thermal alternatives from the point of economic efficiency.

3.8 River and Flood Control Works

(1) Policy of flood control projects

Flood control projects, which are assessed to be economically viable, should be selected and implemented towards the year 2010.

(2) Urban drainage projects

Major densely inhabited urban areas such as Nairobi, Mombasa and major municipalities should be installed with urban drainage systems.

(3) Other river improvement projects

Rivers with problems such as erosion and insanitary water stagnation should be improved in accordance with necessity. Rivers in urban area will be accorded a priority.

4. WATER DEVELOPMENT PLAN (TOWARDS TARGET YEAR 2010)

4.1 Domestic and Industrial Water Supply

(1) Urban water supply

By the target year 2010, 158 urban centres each having a population of more than 5,000 in the year 2000 will be served by piped grid water supply systems, provided that the required financial resources are made available. These centres and the water systems are shown in Table 4.1. The plan envisages to augment the present supply capacity to the level which will meet future water demand (2000 and 2010) as shown in the Table. Their locations are shown in Figure 4.1.

(2) Rural water supply

Of the entire rural centres in respective to "Locations", the major rural centres will be covered by a piped grid water supply system and the other rural centres by a piped point supply system. However, some rural centres will still have to depend on rainwater harvesting facilities such as roof catchments, rock catchments, etc for their water supply. The outline of the rural water supply schemes in terms of the source development plan is summarized below and also shown in Figure 4.2, aggregated to District totals.

Table 4.2 Summary of Rural Water Supply Schemes - Source Development Plan

Source Development	Water Exploitation (m^3/day)	(%)	No. of Facilities*
Surface water	695,627	60.0	-
Borehole	144,530	12.5	4,576 holes
Shallow well	162,142	14.0	30,510 holes
Roof catchment	43,876	3.8	1,139,271 tanks
Small dam	34,977	3.0	664 no.
Subsurface dam	2,171	0.2	389 no.
Sand dam	1,917	0.2	354 no.
Rock catchment	2,147	0.2	292 no.
Existing pipeline	72,333	6.1	-
Total	1,159,720	100.0	

Note: * Based on a typical design assumed for each source development measure
Roof catchment : 3 m^3 tank equivalent
- Not estimated. No. of facilities subject to detail planning on each project basis.

Table 4.1 List of Proposed Urban Water Supply Schemes (1/2)

Location Code	Name	Urban Name	City Code	River Basin	Population in 2010	Future Raw Water Source	Demand (m3/day) 1990	2000	2010
110.0	Nairobi	Nairobi	U- 1	3BA	3,465,400	Thika Dam, Ndarugu, Ruiru-A, Chania-B	332,826	552,294	802,168
211.1	Kiambaa	Karuri	U- 2	3BA	46,400	Kiambaa Dam (Rui Ruaka R.)	2,554	5,070	7,557
211.4	Kiambu Municipality	Kiambu	U- 3	3BA	16,600	Kiambaa Dam (Rui Ruaka r.)	1,589	3,212	4,803
212.1	Ngenda	Gatundu & Ngenda	U- 4	3BD	2,000	Thiririka River	170	332	460
213.1	Limuru	Limuru	U- 5	3BA	4,600	Chania P/L	931	1,699	2,337
214.1	Ruiru	Ruiru	U- 6	3BC	40,900	Ruiru River	2,602	5,076	7,456
214.4	Thika Municipality	Thika	U- 7	3CB	217,500	Chania River (Lower)	11,134	24,737	39,416
215.1	Githunguri	Githunguri	U- 8	3BC	14,100	Ruiru river	671	1,523	2,444
216.6	Kikuyu	Kikuyu	U- 9	3BA	22,500	Kikuyu Dam	4,561	8,081	10,567
221.1	Tebere	Wanguru	U- 10	4DA	1,500	Thiba River	181	341	490
222.2	Kiine	Sagana	U- 11	4BC	11,100	Ragati River	518	1,191	1,950
222.3	Inoi	Kerugoya	U- 12	4DA	34,100	Kiringa River	1,395	3,263	5,443
223.2	Kabare	Kutus	U- 13	4DA	23,500	Thiba River	925	2,150	3,575
231.4	Muruka	Kandara	U- 14	4CC	1,800	Thika River	103	193	272
232.3	Nginda	Maragua	U- 15	4BF	91,200	Githanji river	5,183	9,545	13,813
233.4	Iyego	Kangema	U- 16	4BD	3,900	Mathioya River	219	415	590
234.3	Mbiri	Murang'a	U- 17	4BD	70,100	Maragua river	3,841	7,992	12,449
235.1	Makuyu	Makuyu	U- 18	4BF	16,500	Motoho river	745	1,589	2,499
241.3	Ol Kalou	Ol Kalou	U- 19	2GB	37,900	Malewa River	1,740	4,316	6,662
254.2	Kanyu	Karatina	U- 20	4BA	20,700	Ragati River	975	2,152	3,606
256.1	Karima	Othaya	U- 21	4AD	18,400	Tuthi river	702	1,623	2,796
257.0	Nyeri Municipality	Nyeri	U- 22	4AC	370,700	Chania River	15,559	35,042	59,718
311.2	Miriakani	Miriakani	U- 23	3MB	33,100	2nd Mzima P/L	3,954	7,518	10,502
313.2	Tezo	Kilifi	U- 24	3LA	54,500	Rare reservoir	2,119	5,288	8,994
314.3	Gede	Watamu	U- 25	3HD3	9,200	Sabaki pipeline	306	801	1,389
314.4	Malindi Town	Malindi	U- 26	3LB	159,800	Sabaki Pipeline & Rare Dam	5,818	14,805	25,408
314.6	Magarini	Mambrui	U- 135	3HD2	14,400	Sabaki river	466	1,024	2,092
321.1	Shimba North	Kwale	U- 27	3MC	15,200	Marere pipeline	547	1,455	2,325
323.1	Kinango South	Kinango	U- 28	3MC	5,800	Marere pipeline	310	660	885
324.1	Msambweni	Msambweni	U- 29	3K	34,500	Boreholes + Mkurumuji river	1,298	3,394	5,427
324.5	Lungalunga	Lungalunga	U- 136	3K	8,200	Umba river	441	959	1,404
331.0	Witu	Witu	U- 30	4GG	12,500	Mkondo wa Cambi river	494	1,146	1,987
333.2	Lamu Town	Lamu	U- 31	4KB	34,000	P/L from Tana River + B/H	1,691	3,751	6,317
340.0	Mombasa	Mombasa	U- 32	3MD1	904,400	2nd Mzima/Mwachi Dam, Pemba Dam	100,256	151,634	202,823
351.1	Taveta	Taveta	U- 137	3J	28,900	Njoro Spring	2,254	3,890	5,449
352.4	Voi	Voi	U- 33	3LA	36,000	2nd Mzim pipeline	2,177	4,257	6,565
353.2	Werugha	Wundanyi	U- 34	3LA	8,000	Sigaso/Manguri River	403	803	1,237
362.3	Bura	Bura & Madogo	U- 35	4GE	2,800	Tana River	149	334	450
363.3	Zabaki	Hola	U- 36	4GF	34,800	Tana River	1,374	3,615	5,862
364.1	Bilisa	Garsen	U- 37	4GG	11,700	Tana River	570	1,272	1,882
411.8	Kangaari South	Runyenjes	U- 38	4EC	6,100	Ena river	407	821	1,228
412.1	Nthawa	Siakago	U- 39	4EC	800	Ena River	50	88	120
413.7	Embu Municipality	Embu	U- 40	4DC	72,900	Lower Kapingazi River + Upper Rupingazi	3,010	7,201	11,899
421.1	Central	Isiolo	U- 41	5DA	88,100	Boreholes + Spring	3,023	9,559	18,914
421.2	Oldonyonyiro	Ol Doinyo Ng'iro	U- 42	5DD	17,600	Ewaso Ngiro River	788	2,064	3,681
422.1	Garbatula	Garbatula	U- 138	5FA	7,600	Boreholes	340	898	1,590
423.1	Merti	Merti	U- 139	5ED	22,700	Ewaso Ngiro	1,021	2,668	4,757
431.4	Changwithya	Kitui	U- 43	4HA	40,800	Masinga Dam	1,560	4,017	6,759
433.2	Mutomo	Mutomo	U- 44	4HA	1,600	Sub-Surface dam on Tiva river	87	178	242
434.4	Mwingi	Mwingi	U- 45	4ED	32,000	Kiambere Dam	1,076	2,879	4,888
441.1	Muvuti	Machakos	U- 46	3EA	356,400	Athi River P/L	14,309	33,750	56,631
441.2	Mitaboni	Mitaboni	U- 47	3AC	114,000	Kaanbana River	4,288	10,248	17,286
442.3	Settlement Area	Athi River	U- 48	3AB	98,200	Upper Athi Dam	4,891	10,907	17,649
444.3	Kisau	Usani/Tawa	U- 49	3EB	700	Tawa river	37	74	105
445.1	Kangundo	Kangundo	U- 50	3EA	43,900	Pipeline from Athi River	1,695	4,037	6,812
445.2	Matungulu	Tala	U- 140	3EA	6,400	Pipeline from Athi river	667	1,299	1,951
447.4	Kilungu	Nunguni	U- 51	3FA	1,000	Kyangonyo river	62	117	151
448.1	Makueni	Wote	U- 141	3EC	9,000	Kaiti river + Nzuuni river	431	995	1,629
448.3	Nzaui	Emali	U- 52	3FA	800	Nol Tresh P/L	50	89	121
449.4	Mitio Andei	Mitio Andei&Kibwezi	U- 53	3FB	13,500	Pipeline from Athi river	557	1,264	2,049
451.1	North Horr	North Horr	U- 142	5J	6,300	Boreholes	374	795	1,244
452.2	Kargi	Kargi	U- 54	5J	16,600	Boreholes + Subsurface Dam	764	1,910	3,290
453.1	Korr	Korr	U- 143	2GD	17,200	Boreholes	1,030	2,166	3,411
454.1	Mountain	Marsabit	U- 55	5EC	42,700	Boreholes +Small dams/Sub-surface dam/S	2,201	5,350	9,078
455.2	Sololo	Sololo	U- 56	5EB	14,300	Boreholes	658	1,652	2,832
456.1	Moyale	Moyale	U- 57	5EA	26,200	Boreholes + Small Dam	1,493	3,548	5,956
461.4	Nkuma	Meru	U- 58	4FA	319,900	Kathita river	13,209	31,863	53,093
463.1	Nkuene	Nkubu	U- 59	4FA	20,300	Thingithu River	737	1,843	3,102
464.1	Chogoria	Chogoria	U- 60	4EB	2,900	North Mara River	161	329	443
464.3	Karingani	Chuka	U- 61	4EB	12,400	Tungu river	590	1,244	1,894
467.2	Maua	Maua	U- 62	4FB	12,400	Ura river	590	1,244	1,894
513.1	Madogashe	Mudo Gashe	U- 63	5FA	6,700	Boreholes + Subsurface Dam	359	773	1,141
515.2	Ijara	Ijara	U- 64	4KB	3,200	Boreholes + Small dam	173	409	545
515.3	Kotile	Kotile	U- 65	4GG	3,200	Boreholes/Subsurface Dam/Tana	173	409	545
515.4	Masalani	Masalani	U- 66	4GP	3,200	Tana River	173	409	545
519.1	Sankuri	Garissa	U- 67	4GC	115,300	Tana River	4,862	12,392	20,030
521.1	Mandera	Mandera	U- 68	5GB	18,100	Daua River	1,222	2,286	3,602
523.1	Elwak	Elwak	U- 69	5GA	24,400	Borehores	1,730	2,876	4,242
524.2	Rhamu	Rhamu	U- 70	5H	10,200	Daua River	727	1,202	1,772
532.4	Wajir Township	Wajir	U- 71	5EA	75,500	Boreholes + Ewaso Ngiro River	3,428	7,469	12,493
536.2	Buna	Buna	U- 72	5EA	18,700	Boreholes(Lago Bor river)	1,087	2,040	3,094
537.2	Bute	Bute	U- 73	5EA	6,160	Boreholes + Small Dams	353	664	1,008
611.2	Erange	Manga	U- 74	1HE	2,100	Bunyunyu Dam	136	252	320

Table 4.1 List of Proposed Urban Water Supply Schemes (2/2)

Code	Location Name	Urban Name	City Code	River Basin	Population in 2010	Future Raw Water Source	Demand (m3/day) 1990	2000	2010
611.5	East Kitutu	Keroka	U- 75	1KB	6,100	Bunyunyu Dam	596	1,079	1,537
612.2	East Mugirango	Nyamira + Kebirigo	U- 144	1HD	32,400	Kuja river	1,671	3,322	5,090
615.0	Kisii Municipality	Kisii	U- 76	1KA	138,500	Bunyunyu Dam	7,815	15,630	24,020
617.1	Majoge Chache	Ogembo	U- 77	1KB	2,700	Kuja river	162	298	412
622.1	West Kisumu	Maseno	U- 78	1HB	50,600	Edzawa Dam	7,413	13,794	19,934
622.3	East Kisumu	Kisumu A + Kibosws	U- 79	1HB	578,700	Kibos dam	26,032	54,693	89,344
623.2	South East Kano	Ahero	U- 80	1GD	26,900	Nyando river	1,784	3,279	4,864
625.2	Muhoroni	Muhoroni	U- 81	1GD	26,700	Nyando River	1,422	2,937	4,720
632.4	West Sakwa	Bondo	U- 145	1EE	8,600	Yala river	703	1,231	1,771
633.2	East Gem	Yala	U- 82	1FE	6,500	Yala river	683	1,216	1,751
634.1	East Alego	Siaya	U- 83	1FG	57,200	Yala River	3,245	6,283	9,778
635.4	North Ugenya	Ukwala	U- 84	1EF	2,700	Nzoia River	162	284	411
641.1	Kanyada West	Homa Bay	U- 85	1HF	73,900	Lake Victoria	3,945	8,308	12,741
644.3	Suna East	Migori	U- 86	1KC	24,100	Migori river	1,321	2,781	4,253
646.3	Bukira East	Kehancha + Tarang'anya	U- 146	1KC	9,800	Migori river	555	1,038	1,481
646.8	Bugumbe West	Nyabikaye	U- 147	1KC	9,300	Boreholes	525	980	1,405
647.4	Central Kasipul	Oyugis	U- 148	1HD	9,800	Isanta river(Awach Tende)	624	1,155	1,629
648.1	Central Karachuonyo	Kendu Bay	U- 87	1HD	8,700	Lake Victoria	635	1,311	1,974
649.4	South Sakwa	Awendo/Sare	U- 149	1KB	11,000	Sare river	1,082	2,015	2,877
711.1	Odomongi	Oloitokitok	U- 88	3G	24,500	Nol-Turesh Spring	698	2,098	4,034
712.1	Ngong	Ngong	U- 89	2H	81,800	Kerarapon Spring	2,614	7,278	13,474
713.1	Ildamat	Kajiado	U- 90	3FA	34,100	Kiserian P/L	973	2,916	5,617
713.5	Namanga	Namanga	U- 91	3N	27,300	Namanga Spring	779	2,342	4,496
714.1	Magadi	Magadi	U- 92	2H	16,000	Oloibortoto river	524	1,484	2,781
723.1	Keplenudo	Sotik	U- 93	1JF	16,600	Kipsonoi river	1,295	2,443	3,640
725.5	Kericho Township	Kericho	U- 94	1JC	145,000	Dimlitch Dam, Kimugung Dam	8,034	16,974	27,497
726.1	Kipkelion	Kipkelion	U- 95	1GC	7,800	Nyando river	330	730	1,210
727.1	Londiani	Londiani	U- 96	1GC	11,300	Londiani dam	504	1,098	1,816
731.5	Nanyuki	Nanyuki	U- 97	5BE	114,900	Liki river	4,489	11,167	20,546
733.4	Rumuruti	Rumuruti	U- 150	5AA	8,200	Rumuruti Dam + Borehole	485	1,015	1,651
733.9	Nyahururu Township	Nyahururu	U- 98	5AA	60,000	Nyahururu dam + Borehole	2,642	6,505	11,055
743.2	Gilgil	Gilgil	U- 99	2GA	73,800	Turasha P/L & Malewa Dam	2,325	6,340	12,065
744.1	Naivasha	Naivasha	U- 100	2GD	194,500	Turasha P/L & Malewa Dam	6,151	16,752	31,924
746.1	Njoro	Njoro	U- 101	2FC	46,000	Itare Dam	1,463	3,999	7,608
747.3	Elburgon	Elburgon	U- 102	2EC	62,700	Itare Dam	1,953	5,363	10,239
747.5	Molo South	Molo	U- 103	1EG1	55,100	Itare Dam	1,813	4,892	9,259
749.0	Nakuru Municipality	Nakuru	U- 104	2FC	869,900	Turasha P/L + Malewa Dam + Itare Dam	34,623	86,813	151,718
752.1	Lower Melili	Narok	U- 105	2KA	85,700	Upper Narok Dam	2,084	7,240	14,516
752.5	Keekonyoike	Nairagie Ngare	U- 106	2H	2,500	Nasampolai river	82	230	413
754.4	Ussin Gishu East	Kilgoris	U- 151	1KC	16,200	Poroko river	541	1,526	2,686
755.1	Siria East	Lolkoriaa	U- 152	1KC	8,400	Migori river	279	788	1,391
762.3	Kitale	Kitale	U- 107	1BG	249,200	Koitobos river	9,391	23,346	40,986
762.4	Kiminini	Kiminini/Saboti+Spr.Kita	U- 108	1BG	4,200	Kabewyan river	211	450	642
763.5	Endebess	Endebess/Kwanza	U- 109	1BE	6,700	Koitobos river	348	723	1,029
771.2	Moi's Bridge	Moi's Bridge	U- 153	1BE	10,100	Nzoia river	454	975	1,577
772.4	Turbo West	Turbo	U- 154	1CB	14,000	Sosiani river	644	1,342	2,185
772.5	Eldoret Municipality	Eldoret	U- 110	1CB	486,800	Moiben Dam + Nzoia river	20,374	47,755	84,415
774.6	Olare	Burnt Forest	U- 111	1CC	7,200	Kipkaren river	330	687	1,124
812.5	Kabarnet Mosop	Kabarnet	U- 112	2EH	34,700	Kirandich Dam	1,475	3,249	5,558
814.3	Maji Mazuri	Maji Mazuri	U- 113	2ED	19,200	Maji Mazuri river	785	1,745	2,991
814.5	Eldama Ravine	Eldama Ravine	U- 114	2EF	20,700	Chemususu Dam	902	1,985	3,372
815.1	Lembus Soi	Mogotio	U- 115	2EG2	10,700	Molo river /Chemususu Dam	436	975	1,662
816.2	Marigat	Marigat	U- 155	2EE	8,600	Perkerra river	452	871	1,340
822.4	Kiptulong	Ilen+Tambach	U- 116	2CB	19,700	Moiben Dam	952	2,035	3,194
831.3	Chemelil	Nandi Hills	U- 117	1FD	4,200	Mokong River	877	1,687	2,467
832.2	Chemundu	Kapsabet+Barston	U- 118	1FC	56,300	Mokong river	2,114	5,238	9,002
841.4	Maralal	Maralal	U- 119	5CA	74,800	Loikat/Yamo river	3,036	7,296	13,177
842.4	Wamba	Wamba	U- 120	5DD	15,600	Boreholes	593	1,449	2,651
843.6	Elbarta	Baragoi	U- 121	2D	13,500	Boreholes + Sub-surface dam	512	1,265	2,294
853.5	Lodwar	Lodwar	U- 122	2BD	33,400	Boreholes & sub-surface dam	1,890	4,543	7,881
861.1	Kapenguria	Kapenguria/Makutano	U- 123	2BC	48,200	Kapenguria River	1,846	4,332	7,538
911.4	Malakisi	Mawalie + Malakisi	U- 156	1AB	10,700	Malikisi river	627	1,376	2,084
912.4	Musikoma	Bungoma	U- 124	1AG	142,700	Kuywa River	5,098	13,776	23,561
913.1	Kimilili	Kimilili	U- 125	1DB	31,500	Kimilili River	955	2,735	4,795
914.2	Webuye	Webuye	U- 126	1DA	128,700	Nzoia River	4,054	11,472	19,991
916.1	Chepkoa	Chepkoa	U- 157	1AA	10,000	Sasuri river	468	1,076	1,675
921.5	South Teso	Busia	U- 127	1AH	70,200	Sio river	2,105	6,489	11,113
922.2	Central Bukhayo	Nambale	U- 158	1AH	8,100	Sio river	308	791	1,233
931.3	West Bunyore	Luanda	U- 128	1FF	12,600	Edzawa river	690	1,563	2,478
932.5	Central Maragoli	Vihiga+Majengo	U- 129	1FF	14,400	Edzawa River (Kimondi River)	801	1,591	2,332
933.1	Shamakhokho	Kaimosi	U- 130	1FE	1,300	Galagoli river	188	358	498
934.3	West Isukha	Khayega	U- 131	1EB	1,400	Yala river	188	360	513
935.4	Kakamega Municipality	Kakamega	U- 132	1EB	187,500	Isiukhu River, Mukulusi Dam	7,884	18,648	30,259
939.2	Central Marama	Butere	U- 133	1EG	7,400	Viratsi River	366	758	1,121
93A.4	Central Wanga	Mumias	U- 134	1DD	75,900	Nzoia River	3,886	7,923	11,814

Fig. 4.1

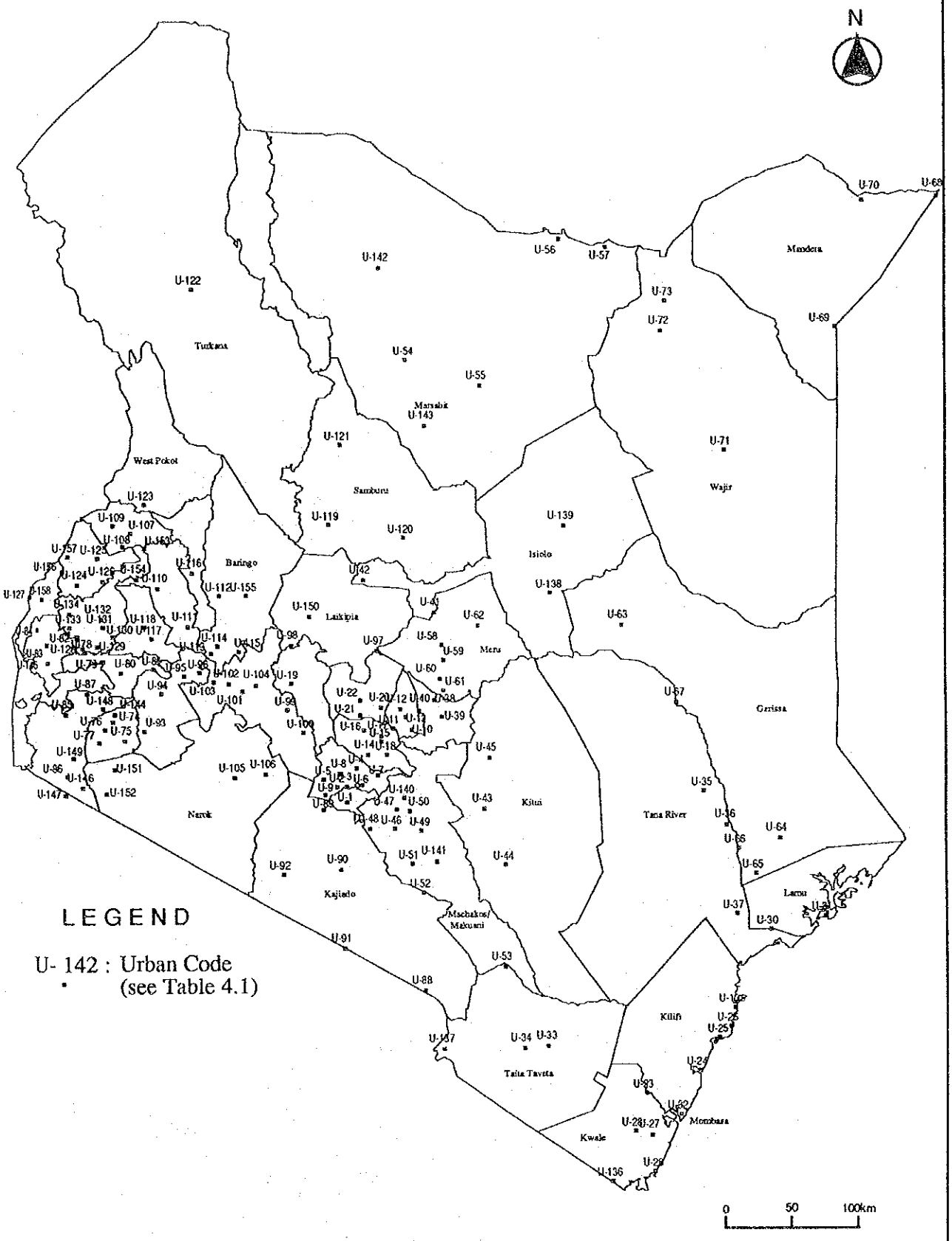

Figure 4.1 Location of Proposed Urban Water Supply Schemes

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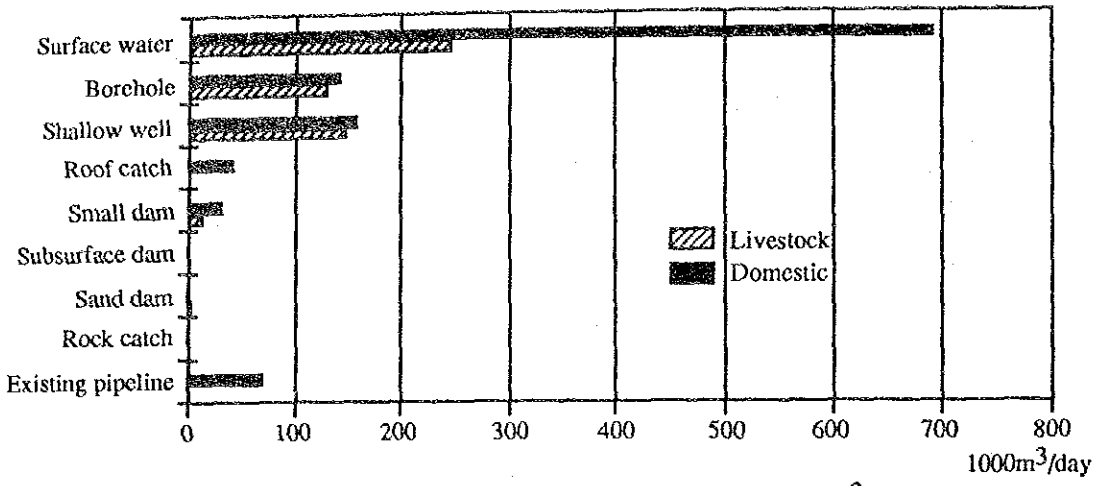
Water Source Allocation for Rural Water Supply



Unit : m^3/day

Water Source	Domestic	Livestock	Total
Surface water	695,627	248,489	944,116
Borehole	144,530	133,675	278,205
Shallow well	162,142	151,320	313,462
Roof catch	43,876	0	43,876
Small dam	34,977	14,404	49,381
Subsurface dam	2,171	3,473	5,644
Sand dam	1,917	4,256	6,173
Rock catch	2,147	0	2,147
Existing pipeline	72,333	3,114	75,447
Total	1,159,720	558,731	1,718,451

Water Source Allocation for Rural Water Supply by Drainage Basin

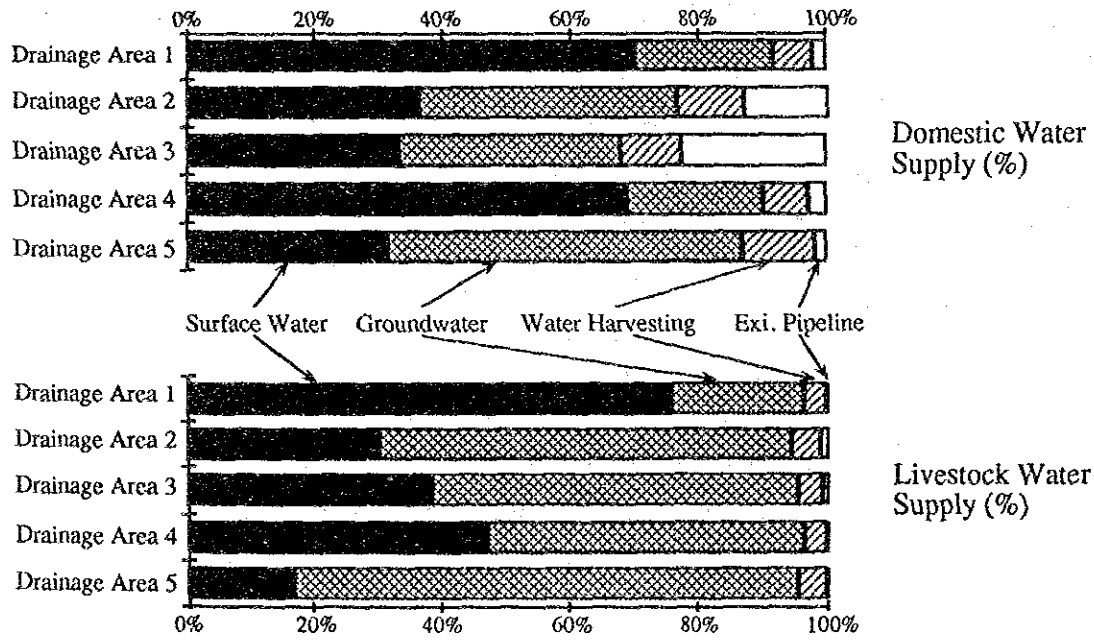


Figure 4.2 Water Source Allocation for Rural Water Supply

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4.2 Sewerage Development

In conjunction with the provision or addition of water supply systems, urban centres will have sewerage systems which should be selected according to the practical facilities required for each centre. The following three sewage disposal alternatives by population have been assumed for the 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) 10,000 - 5,000	25	25	50

Note: Sewerage facilities are only proposed for towns having a population of more than 5,000 in 2000.

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.

The study has proposed for sewerage development projects for 158 urban centres, which is identical to those listed for urban water supply schemes.

4.3 Irrigation

The following schemes are proposed for implementation towards the year 2010:

(1) Major irrigation schemes:

Proposed are 18 projects (all projects having more than 500 ha of irrigated land) having a total are of approximately 110,000.

Table 4.3 Major Irrigation Projects to be Implemented by 2010

Project	Irrigation Area (ha)	River Basin	Source of Water	Main Crop
Arror	1,340	Kerio	Arror River	M, V, F
Bunyala Extension (Lower Nzoia)	10,480	Nzoia	Nzoia River	Ct, M, B, R
Kano Plain	25,640	Nyando	Sondu/Miriu dam Magwagwa dam	M, R, Ct, B
Kanzalu	4,055	Athi	Munyu dam or Ndarugu dam	M, B, Cf, R
Kibwezi	13,200	Athi	Yatta dam	M, B, Ct, V
Kimira	2,000	Awach Kabuan	Awach Kabuan	R, M, Ct, B
Kunati	1,050	Tana	Thanantu River	Ct, M, V, T
Lower Ewaso N'giro	10,000	Ewaso N'giro South	Oldorko dam	M, B
Lower Kuja	1,900	Kuja	Kuja River	M, B, Ct, V
Lower Rupingazi	1,800	Tana	Rupingazi River	Ct, T, M, V
Mwea Extension	2,900	Tana	Thiba dam	R, Hc
Sabaki Extension	3,000	Athi	Sabaki River	M, B, Ct
Taita Taveta	3,780	Lumi	Lumi River	M, B
Tana Delta	12,000	Tana	Tana River	R
Thanantu	2,520	Tana	Thanantu River	Ct, M, T, F
Turkwel	600	Tukwel	Turkwel River	Ct, M, B, F
Upper Nzoia	7,550	Nzoia	Nzoia River	F, M, V
Yala Swamp	7,540	Yala	Yala River	R

Remarks: M: Maize, B: Beans, V: Vegetables, F: Fruits, R: Rice, Ct: Cotton, Cf: Coffee, T: Tobacco, Hc: Horticulture

The location of the schemes is shown in Figure 4.3.

(2) Small scale irrigation schemes

The proposed schemes include 140 projects having a total area of approximately 7,000 ha. The schemes are scatter over 30 Districts. The approximate location is shown in a water resources development map attached at the end of this report.

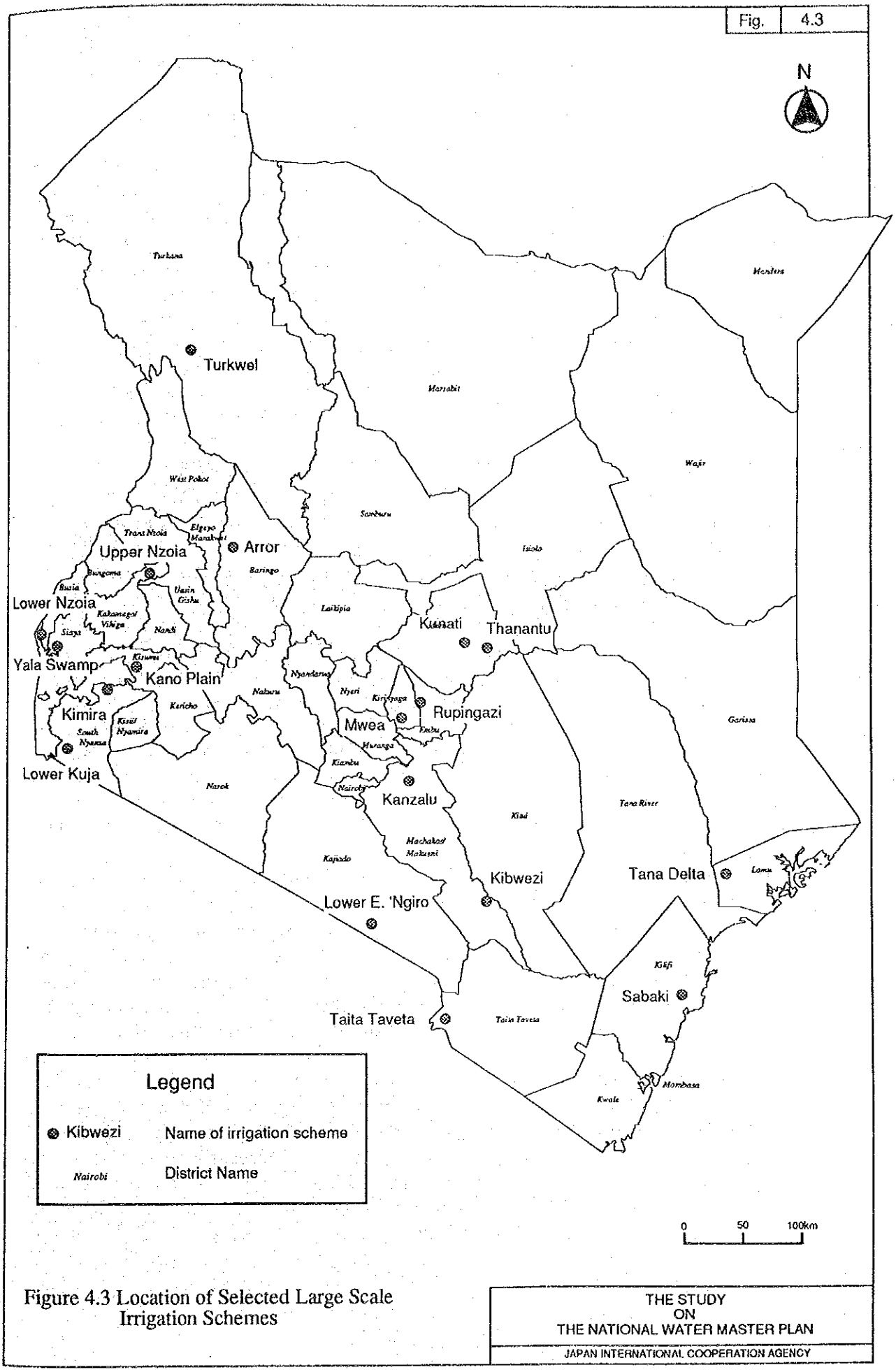

Figure 4.3 Location of Selected Large Scale Irrigation Schemes

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4.4 Livestock, Wildlife, and Inland Fisheries

4.4.1 Livestock water development

(1) Water sources for livestock

Water for livestock is supplied by surface water, groundwater, or rainwater harvesting. The water is provided at water source points in principle. Water exploitation by type of source has been planned as summarized below and also shown in Figure 4.2 presented earlier.

Table 4.4 Livestock Water Supply - Source Development Plan

Source Development	Water Exploitation (m^3/day)	(%)	No. of Facilities*
Surface water	248,489	44.5	-
Borehole	133,675	23.8	4,582 holes
Shallow well	151,320	27.1	27,030 holes
Small dam	14,404	2.6	688 no.
Subsurface dam	3,473	0.6	527 no.
Sand dam	4,256	0.8	608 no.
Existing pipeline	3,114	0.6	-
Total	558,731	100.0	

Remarks: * Based on a typical design assumed for each source development plan
- Not estimated. Subject to detail planning on each local basis.

In arid areas, some of the livestock water demand was planned to be met by a piped point supply system once the piped supply system is established for domestic demand in rural areas. This demand was assumed to be 20% of the total livestock water demand in the mid-potential area and 50% in the low-potential area. Its facility cost is included in the construction costs for domestic water supply schemes.

(2) Promotion of ASAL pastoral development

To promote ASAL development, a watering point will be provided in every 25 km square in pastoral land which has been classified herein as bushland and grassland on the vegetation map. According to a rough estimate, 560 points for boreholes or shallow wells are proposed for the country. For preliminary estimate of the cost, the current study assumed, tentatively, that the installation of boreholes/wells would be the watering facility. However, this should be supplemented by small dams or water pans once the potential site is found.

This attempt is somewhat of a controversial issue and hence requires a careful step-wise approach as follows; (i) firstly a survey of wet season pasture availability, (ii) secondly the environmental evaluation of the appropriateness for provision of watering points which may, in some cases, cause over-grazing, devastating the dry land ecology, and then (iii) provision of watering points. Taking into account that this is an experimental attempt, it is assumed that only 30% of the contemplated work would be implemented by the year 2000.

4.4.2 Wildlife watering

(1) Water source conservation

The current study does not propose any structural measures for wildlife due, chiefly, to the lack of relevant information. The following suggestions have been tentatively proposed:

- Conservation of the dry season flow of rivers in the national parks and game reserve areas. In areas where no information of the ecological balance of wildlife in terms of water is defined, water transfer from the rivers upstream of the parks and reserve areas should not be introduced in principle.
- Rehabilitation of existing watering facilities.

(2) Future Development

Of the 31 national parks and game reserves for which data are available, 13 of them have some manmade facilities such as waterholes, boreholes, or dams for wildlife. A further 12 consider that additional water facilities should be installed in the future. Although this study does not propose any facilities for wildlife, the concept of watering facilities proposed for livestock (Subsection 4.4.1 above) might be applied to wildlife animals as well. The proposed facilities would vary by District.

4.4.3 Inland fisheries (Fishpond)

The current study does not propose any structural measures for fishponds. The fishponds consume a relatively small quantity of water compared to the total water use. In most cases, water for fishponds is taken from sources during rainy season and flood stage. Thus, water demand from this sector seems to have little influence on the water balance during the dry season.

4.5 Hydropower

In KPC's power development plan, the following six hydropower projects are envisaged as promising projects. They are proposed to be commissioned towards 2010. The location of the respective schemes is indicated in Figure 4.4.

Table 4.5 Hydropower Projects to be Implemented by 2010

Project	River	Capacity(MW)	Completion Year	Remark
Sondu/Miriu No. 1	Sondu	60	1997	Multi purpose (Irrigation)
No. 2*		20.6	1998	Additional power station
Low Grand Falls**	Tana	120	2000	Single purpose
Oldorko	Ewaso N'giro	72	2002	Multi purpose (Irrigation, Water supply)
Magwagwa*	Sondu	120	2003	Multi purpose (Irrigation)
Gitaru #3 (Extension)	Tana	72.5	2003	Single purpose
Mutonga **	Tana	60	2005	Single purpose
	Total	525.1		

Remark: * Evaluated to be feasible in the recent feasibility study.
** High Grand Falls project is considered as the alternative, which should be examined further

4.6 River and Flood Control Works

(1) Flood control project

Presented in Table 4.6 are five projects which are economically viable and will be implemented by the target year 2010. Figure 4.5 shows their locations and affected area by flood.

Table 4.6 Flood Control Projects to be Implemented by 2010

Project	River	Design Flood (1st Stage)	Land Use Condition	Completion Target Year
Kano Plain	Nyando	25-year	Agricultural land	2000
Nairobi City	Nairobi, etc.	25-year	Urban area	2000
Yala Swamp	Yala/Nzoia	25-year	Agricultural land	2010
Kuja Rivermouth	Kuja	25-year	Agricultural land	2010
Lumi Rivermouth	Lumi	25-year	Agricultural land	2010

(2) Other Projects related to River Improvement

(a) Urban drainage schemes: urban drainage schemes should be introduced in 47 selected major towns (41 are District headquarters under the District structure, and the other six are major towns having an estimated population of more than 100,000 in 2010) in succession by 2010. The towns are listed in Table 4.7. The necessity for an other six District headquarters, recently established, will be subject to further study depending on the growth of the towns.

(b) Minor river improvement: there will arise the need for river improvement works for the improvement of people's well-being, particularly in urban areas, to which the appropriate budget should be applied. The schemes should be proposed through identification of the problems in each river.

Fig. 4.4

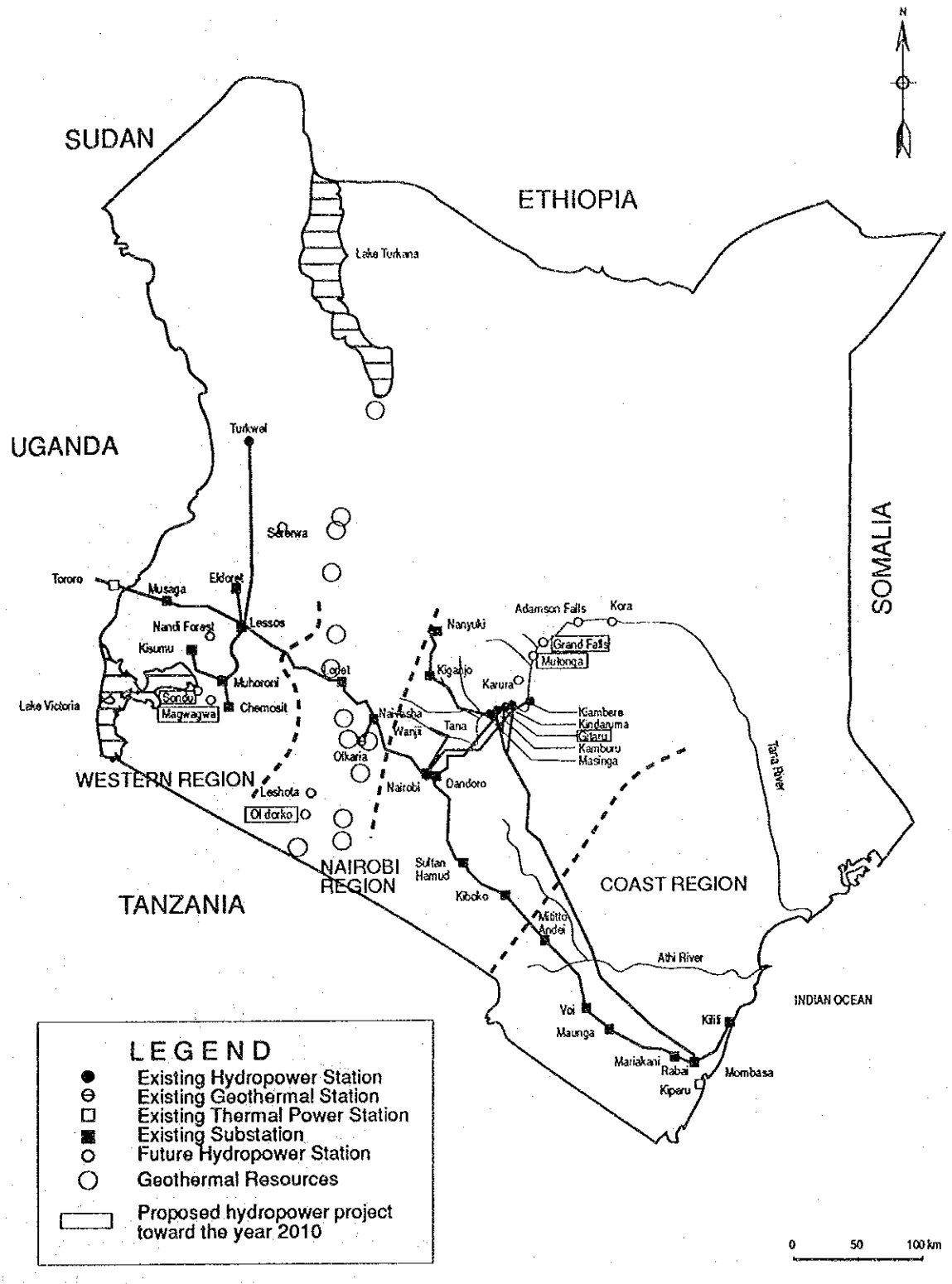

Figure 4.4 National Power Grid Map

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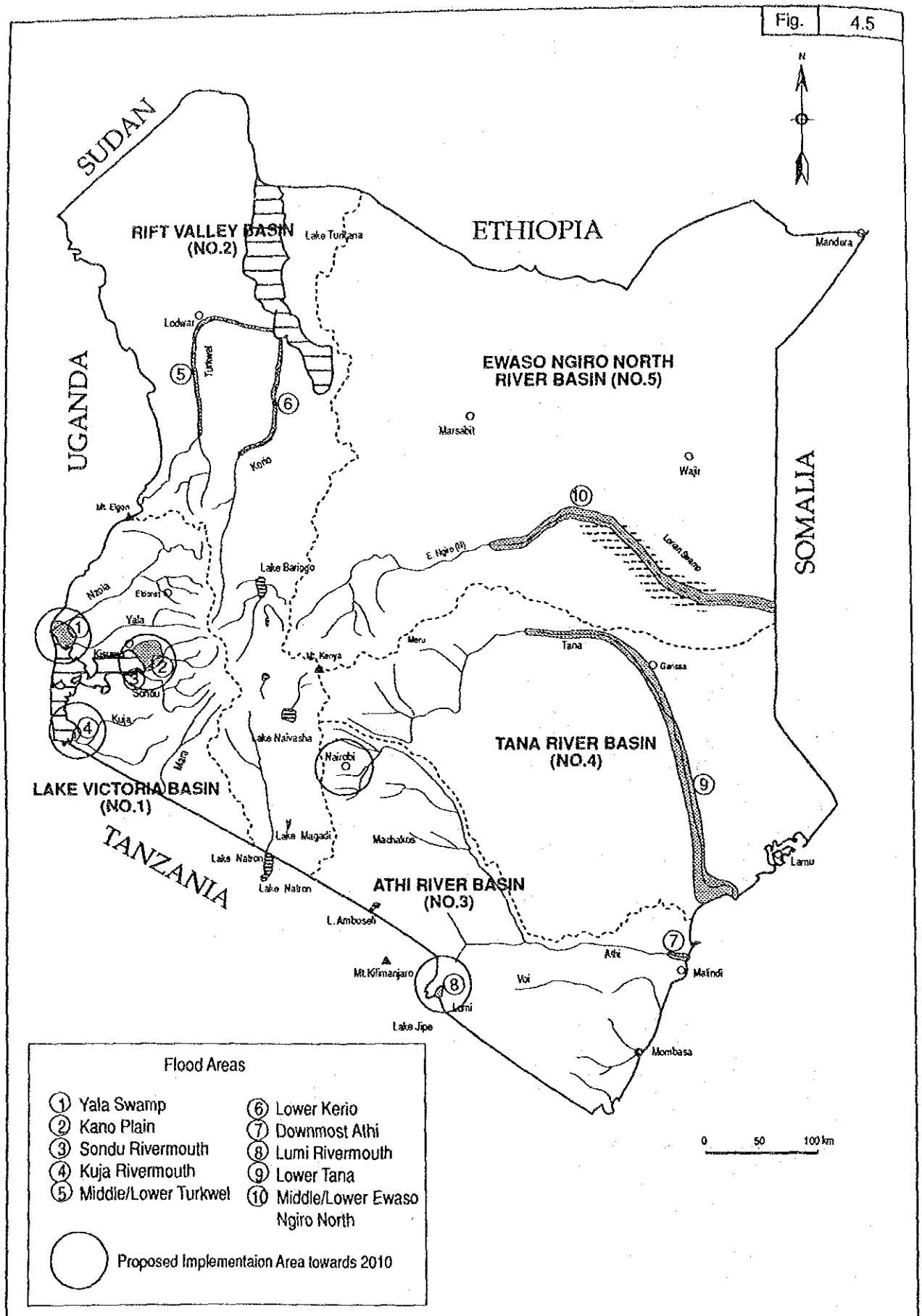

Figure 4.5 Flood Areas in the Country

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Table 4.7 List of Proposed Urban Drainage Schemes

	Town Name	Location of Town Centre				Town Area (km2)	Estimated Const.Cost (1000 $)	Remarks
			District		Location Name			
1	Nairobi	110	Nairobi			90.00	360,000	*1
2	Kiambu	210	Kiambu	211.4	Kiambu Municipality	1.62	12,920	
3	Thika	210	Kiambu	214.4	Thika Municipality	1.85	14,800	*1
4	Kerugoya	220	Kirinyaga	222.3	Inoi	0.96	7,680	
5	Murang'a	230	Murang'a	234.3	Mbiri	5.25	31,500	
6	OlKalou	240	Nyandarua	241.3	OlKalou	0.75	5,980	
7	Nyeri	250	Nyeri	257.0	Nyeri Municipality	1.64	13,120	*1
8	Kilifi	310	Kilifi	313.2	Tezo	0.62	4,940	
9	Malindi	310	Kilifi	314.4	Malindi	0.95	7,600	*1
10	Kwale	320	Kwale	321.1	Shimba North	0.90	7,200	
11	Lamu	330	Lamu	333.2	Lamu Town	0.88	7,000	
12	Mombasa	340	Mombasa	340.0	Mombasa	11.64	46,550	*1
13	Voi	350	Taita Taveta	352.4	Voi	1.15	9,200	
14	Wundanyi	350	Taita Taveta	353.2	Werugha	0.28	2,240	
15	Hola	360	Tana River	363.3	Zabaki	0.93	7,400	
16	Embu	410	Embu	413.7	Embu Municipality	0.95	7,600	
17	Isiolo	420	Isiolo	421.1	Central	0.45	3,600	
18	Kitui	430	Kitui	431.4	Changwithya	0.46	3,640	
19	Machakos	440	Machakos	441.1	Muvuti	2.76	22,080	*1
20	Mitaboni	440	Machakos	441.2	Mutituni	0.20	1,600	*1
21	Marsabit	450	Marsabit	454.1	Mountain	0.11	840	
22	Meru	460	Meru	461.4	Ntima	0.34	2,700	*1
23	Garissa	510	Garissa	519.1	Sankuri	0.80	6,400	*1
24	Mandera	520	Mandera	521.1	Mandera	0.06	500	
25	Wajir	530	Wajir	532.4	Wajir Township	0.19	1,540	
26	Kiii	610	Kisii	615.0	Kisii Municipality	2.64	21,080	*1
27	Kisumu	620	Kisumu	622.2	Central Kisumu	5.58	33,480	
28	Siaya	630	Siaya	634.1	East Alego	0.12	960	
29	Homa Bay	640	South Nyanza	641.1	Kanyada West	1.15	9,180	
30	Kajiado	710	Kajiado	713.1	Ildamat	1.16	9,240	
31	Kericho	720	Kericho	725.5	Kericho Township	1.17	9,360	*1
32	Nanyuki	730	Laikipia	731.5	Nanyuki	1.96	15,640	*1
33	Naivasha	740	Nakuru	744.1	Naivasha	0.90	7,200	*1
34	Nakuru	740	Nakuru	749.0	Nakuru Municpality	12.95	51,800	*1
35	Narok	750	Narok	752.1	Lower Melili	0.81	6,440	
36	Kitale	760	Trans Nzoia	762.3	Kitale	4.20	25,200	*1
37	Eldoret	770	Uasin Gishu	772.5	Eldoret Municipality	8.58	34,320	*1
38	Kabarnet	810	Baringo	812.5	Kabarnet Mosop	0.16	1,280	
39	Iten	820	Elgeyo-Marakwet	822.4	Kiptuilong	0.33	2,640	
40	Kapsabet+Baraton	830	Nandi	832.2	Chemundu	1.64	13,120	
41	Maralal	840	Samburu	841.4	Maralal Urban	0.70	5,600	
42	Lodwar	850	Turukana	853.5	Lodwar	0.22	1,760	
43	Kapenguria/Makutano	860	West Pokot	861.1	Kapenguria	0.35	2,800	
44	Bungoma	910	Bungoma	912.4	Kanduyi	1.87	14,960	*1
45	Webuye	910	Bungoma	914.2	Webuye	0.23	1,840	*1
46	Busia	920	Busia	921.5	South Teso	0.11	900	
47	Kakamega	930	Kakamega	935.4	Kakamega Municipality	2.07	16,560	*1
	Total cost						873,990	

Notes: Town area was obtained from the maps of 1: 50,000 scale.
*1 Projected population in 2010 is more than 100,000 people.

Construction cost of drainage works above was estimated based on the following assumption.

Civil works per km2 of drainage area:

Improvement and new construction of drainage channels without concrete/masonry slope protection works.

Type I :	bottom width=4 m, height= 2 m, slope 1:2.0	200 m long each
Type II :	bottom width=10 m, height= 2 m, slope 1:2.0	200 m long each
Closed channel (culvert):	3m wide and 2.5 m high	100 m long
Lateral (concrete pipe):	0.6 m dia.	1,000 m long

Unit Price:

Area = 1 km2 class	US $ 8,000,000
Area = 5 km2 class	US $ 6,000,000
Area = 10 km2 class	US $ 4,000,000

c) Tana river channel stabilization project: this project is proposed as a pilot scheme for the long-term channel improvement work which would be one of the essential programmes for the development of land and water resources in the Lower Tana river basin. The main work components of the pilot work will be the rectification of meandering and the protection of bank erosion.

4.7 Water Source Development Plan

Taking into account the development needs and plans of the respective sectors, the water balance study was conducted in every river basin, for surface water, and in every location, for groundwater. In addition, water transfer plans were proposed for water deficit areas. As a result, the water sources development plan was summarized as follows:

(1) Dam schemes for water supply, large-scale irrigation, and hydropower

The current study proposes 28 dam schemes which are to be implemented by the target year 2010. Table 4.8 briefly outlines them and Figure 4.6 illustrates their location. The proposed schemes comprise 19 dams for water supply, 2 dams for irrigation, 2 dams for hydropower, and 5 dams for multipurpose development.

Since some dam schemes have the other alternatives, further comparative study would be required prior to their implementation.

(2) Groundwater for urban water supply

There are 22 urban centres, out of the total 158 centres in the country, which do not have enough surface water sources (see Appendix 6.3 for the list of 22 urban centres). Their water supply systems will depend, to a large extent, on groundwater sources.

A problem foreseen is that, if the water demand is to be met only by the ordinary extent of safe groundwater yield (30-80 m^3/day), the area required for groundwater development would be unpractical, of the order of several ten km in radius for the most of the towns. Therefore, the agencies concerned should survey potential groundwater resources to find high yield aquifers, since maximum groundwater development is necessary to meet the water requirement. A further description of the proposed survey is given in Subsection 5.2.1(3).

There may be a possibility that the availability of groundwater resources will not meet the demand. Assuming this case, the Study examined a very preliminary alternative source development plan (mostly a water transfer scheme) for some of the towns, which is described in the Sectoral Report D.

Table 4.8 List of Proposed Dam Schemes

Item No.	Prospective Site proposed in the Study: Damsite	Sub-basin	Purpose	Water Supply: Service Urban Centre	Irrigation: Large Irri. Scheme	Hydropower: Hydropower Scheme	Remarks
L.Victoria Drainage Area							
1 *1	(Moiben)	1BA	W*2	Eldoret/Iten	–	–	detailed design stage
2	Mukulusi	1EA	W	Kakamega	–	–	small dam
3	Londiani	1GC	W	Londiani	–	–	
4	Kibos	1HA	W	Kisumu/Maseno	–	–	
5	Itare	1JA	W	Nakuru/Molo/Njoro /Elburugon/Rongai /Mogotio	–	–	
6 *1	(Sondu/Miriu)	1JG	P, I	–	(Kano Plain)	Sondu/Miriu	run-of-river type weir detailed design stage
7	Magwagwa	1JG	P, I	–	Kano Plain	Magwagwa	multipurpose
8	Bunyunyu	1KB	W	Kisii	–	–	
Rift Valley Drainage Area							
9 *1	(Chemususu)	2ED	W	Eldama Ravine	–	–	detailed design stage
10 *1	(Kirandich)	2EH	W	Kabarnet	–	–	detailed design stage
11	Malewa	2GB	W	Nakuru/Gilgil/ Naivasha	–	–	
12	Upper Narok	2KA	W	Narok	–	–	
13	Oldorko	2KB	P, I, W	Magadi	Lower E.Ngiro	Oldorko	multipurpose
Athi River Drainage Area							
14	Upper Athi	3AA	W	Athi River	–	–	
15 *1	(Ruaka (Kiambaa))	3BA	W	Rural Centres	–	–	centres near damsite
16	Ruiru- A	3BC	W	Nairobi	–	–	
17	Kikuyu	3BA	W	Kikuyu	–	–	
18	Ndarugu	3CB	W, I	Nairobi, Ruiru, Kiambu	Kanzalu	–	multipurpose
19	Yatta	3FB	I	–	Kibwezi Ext.	–	
20	Rare	3LA	W	Malindi	–	–	off-stream reservoir
21	Mwachi	3MB	W	Mombasa	–	–	
22	Pemba	3HC	W	Mombasa	–	–	run-off-river type weir
Tana River Drainage Area							
23	Chania- B	4CD	W, I	Nairobi	(small irri.)	–	multipurpose
24	Thiba	4DA	I	–	Mwea EXt.	–	
25	Mutonga	4FA	P	–	–	Mutonga	
26	Low Grand Falls	4FB	P	–	–	L. Grand Falls	
Ewaso Nigro North River Drainage Area							
27	Rumuruti	5AA	W	Rumuruti	–	–	
28	Nyuhururu	5AA	W	Nyuhururu	–	–	small dam

Note: *1 shows a dam scheme in detailed design stage.
*2 W : Water supply I : Irrigation P : Hydropower

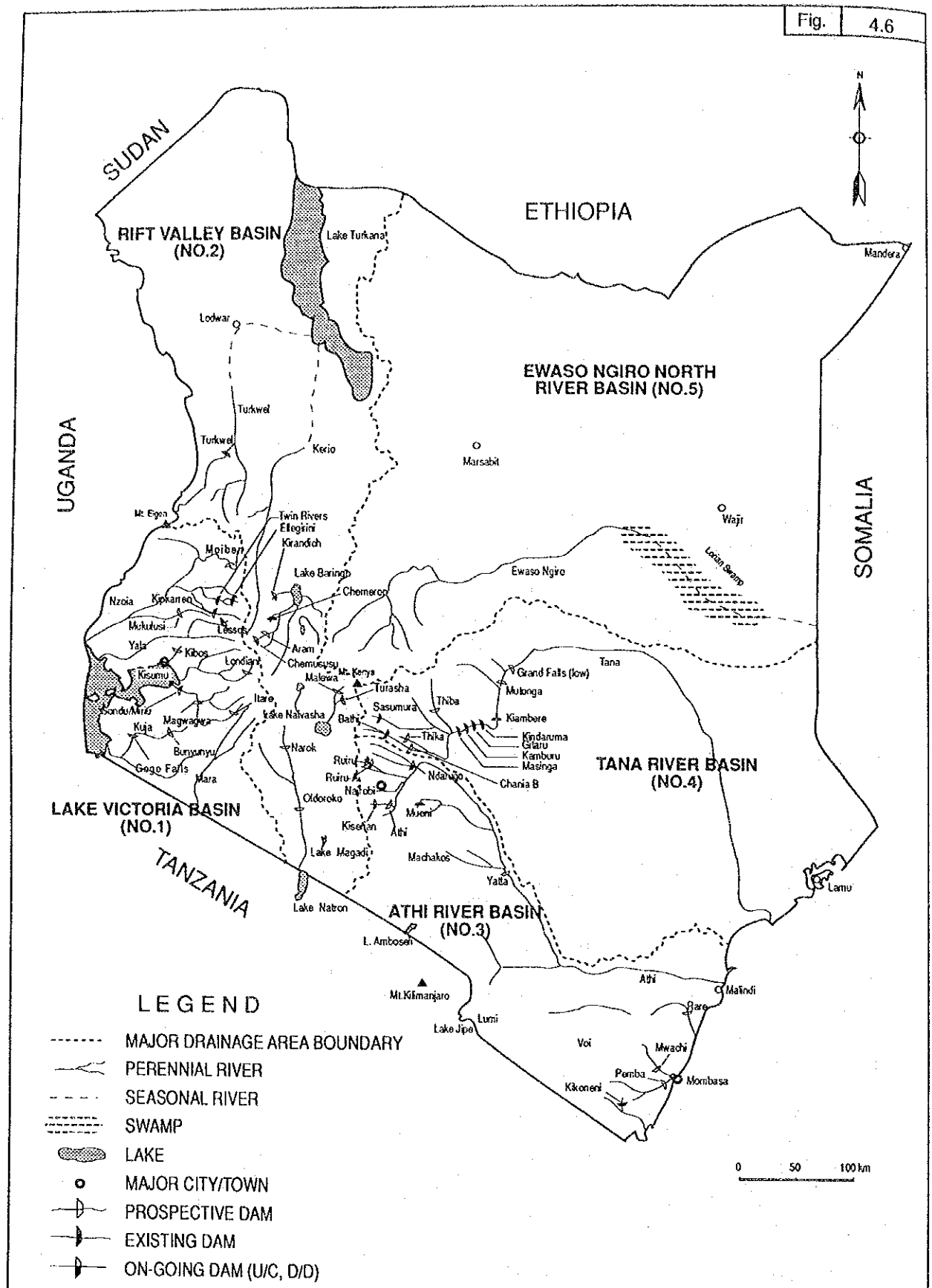

Figure 4.6 Location of Prospective Dams

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(3) Water sources for rural water supply and livestock water supply

Water resources development plans for rural, domestic, and livestock demands were devised, location by location for all 976 Locations (based on 1986 administrative units). The proposed water sources are mostly small facilities as presented in Sections 4.1 and 4.4.

(4) Water transfer schemes

Water transfer schemes were examined to ascerntain whether they could be introduced into urban areas as sources of urban water supply. Water transfer schemes include (i) inter-basin water transfer and (ii) intra-basin water transfer. If the scheme, particularly (i) above, exerts an unfavourable influence upon downstream areas, sufficient environment research should be carried out before implementation. The water transfer schemes proposed in this study are shown in Tables 4.9 and 4.10 and Figure 4.7.

Table 4.9 List of Inter-basin Water Transfer Schemes

No.	Intra-basin Water Transfer				Yield for D & I Water (m3/day)	Remarks
	Sub-Drainage Area	Water Source	Sub-Drainage Area	Demand Center		
1	1BA	Moiben Dam	2CB	Iten & Tambach	2,538\	
2	1FF	Edzawa River	1HB	Maseno	17,407\	
3	1JA	Itare Dam	2EC	El burgon	9,664\	
			2EG1	Molo	8,715\	
			2FC	Njoro	7,049\	
			2FC	Nakuru	86,400\	
4	2GB	Malewa Dam	2FC	Nakuru	17,951\	
5	2EH	Kirandich Dam	2CB	Kabarnet	4,147\	
6	2KB	Oloibortoto River*	2H	Magadi	2,328\	
7	3AA	Kiserian Dam	3FA	Kajiado	5,377\	
8	3G	Second Mzima*	3LA	Voi	5,235\	
			3MD2	Mombasa	25,920\	
9	3HC	Sabaki Extension*	3MD2	Mombasa	25,920\	Alternative for Mwachi Dam
			3LB	Malindi	18,005\	Alternative for Rare Dam
10	4CA	Chania B Dam	3BA	Nairobi	65,664\	
11	4CA	Komu transfer*	3CB	Ndarugu Dam	691,200\	
12	4CA	Komu transfer*	3DA	Munyu Dam	691,200\	Alternative for Ndarugu Dam
13	4CB	Thika Dam System	3AA	Nairobi	224,640\	
14	4DE	Masinga Dam**	4HA	Kitui	5,470\	
15	4GF	Tana River*	3KB	Lamu	5,719\	
16	5ED	Ewaso Ngiro	5EA	Wajir	6,235\	

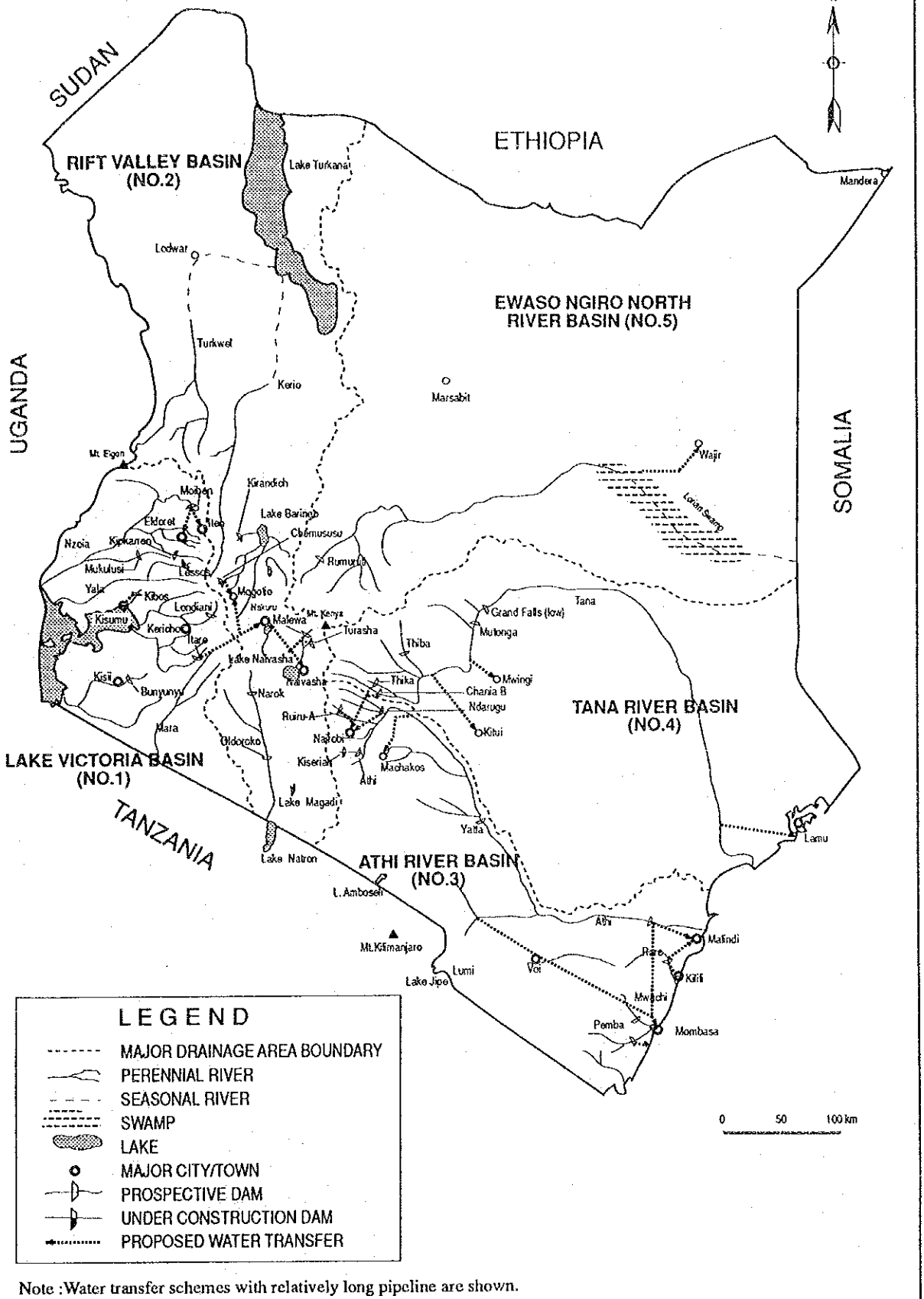
Note: Marked "*" means inter-basin water transfer scheme without dam.
Marked "**" means existing dam.
"Inter-basin water transfer" is defined here to be transfer of water from a river basin to another river basin.

Table 4.10 List of Intra-basin Water Transfer Schemes

No.	Intra-basin Water Transfer				Yield for D & I Water (m3/day)	Remarks
	Sub-Drainage Area	Water Source	Sub-Drainage Area	Demand Center		
1	1AG	Sio River*	1AH	Busia	8,928\	
2	1BA	Moiben Dam	1CB	Eldoret	51,000\	
3	1EA	Mukulusi Dam	1EB	Kakamega	27,027\	
4	1GC	Londiani Dam	1GC	Londiani	1,663\	
5	1HA	Kibos Dam	1HA	Kisumu	72,432\	
6	1KB	Bunyunyu Dam	1KA	Kisii	20,153\	
			1KB	Keroka	1,376\	
7	2ED	Chemususu Dam	2EF	Eldama Ravine	5,596\	
			2EF	Mogotio	1,209\	
8	2GB	Malewa Dam	2GC	Gilgil	11,096\	
			2GD	Naivasha	29,336\	
9	2KA	Upper Narok Dam	2KA	Narok	13,248\	
10	3AA	Upper Athi Dam	3AA	Athi River	11,002\	
11	3BA	Kikuyu Dam	3BA	Kikuyu	9,239\	
12	3BA	Kiambaa Dam	3BA	Karuri	7,431\	
			3BA	Kiambu	4,209\	
13	3BC	Ruiru A Dam	3AA	Nairobi	25,920\	
14	3CB	Ndarugu Dam	3BA	Nairobi	299,163\	
15	3AC	Munyu Dam	3BA	Nairobi	299,163\	Alternative for Ndarugu Dam
16	3DA	Athi River*	3EA	Machakos	53,078\	
17	3DA	Athi River*	3EA	Kangundo	6,619\	
18	3DA	Athi River*	3EA	Tala	1,872\	
19	3FA	Athi River*	3FC	Mtito Andei	2,015\	
20	3MC	Pemba Dam	3MD2	Mombasa	2,592\	
21	3MB	Mwachi Dam	3MD1	Mombasa	103,445\	
22	3LA	Rare Dam	3LB	Malindi	9,768\	Alternative for Sabaki P/L
23	5AA	Nyahururu Dam	5AA	Nyahururu	8,415\	
24	5AA	Rumuruti Dam	5AA	Rumuruti	1,539\	

Note : Marked "*" means intra-basin water transfer scheme without dam.
"Intra-basin water transfer" is defined here to be transfer of water from a sub-basin to other sub-basin (s) within a river basin.

Fig. 4.7



Note :Water transfer schemes with relatively long pipeline are shown.

Figure 4.7 Water Transfer Scheme

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4.8 Financial Requirement

The total costs of water resources development schemes are enumerated in the following Table 4.11. These development plans have been established to meet basic human needs for domestic/industrial water and of livestock farming and to satisfy national economic development needs for irrigation, hydropower, and flood control/river improvement by the target year 2010.

Table 4.11 Construction Costs of Water Resources Development Schemes

Development Sector	Development Cost US$.Million Equivalent	Development Cost K£ Million Equivalent
1. Domestic/Industrial Water Supply		
(a) Urban water supply (incl. industrial water)	4,949	6,236
(b) Rural water supply	2,627	3,310
Sub-total	7,576	9,546
2. Sewerage Development	705	888
3. Irrigation Development		
(a) Major irrigation schemes	963	1,213
(b) Small irrigation schemes	10	13
Sub-total	973	1,226
4. Livestock Water Development		
(a) Source development	670	844
(b) Provision of water points in nomadic pasturage area	85	107
Sub-total	755	951
5. Hydropower Development	1,034	1,304
6. River and Flood Control Works		
(a) Major flood control projects	63	79
(b) Urban drainage works	874	1,101
(c) Minor river improvement	90	113
(d) Lower Tana channel stabilization	40	50
Sub-total	1,067	1,343
Total	12,110	15,258

Remarks: Cost of dams and water transfer facilities is included in respective sectors

4.9 Economic Evaluation

For the four main sectors - water supply, irrigation, hydropower and flood control projects - the overall economic evaluation was preliminarily conducted at a master plan level. The results are shown in the following table.

Table 4.12 Overall Economic Efficiency by Sector

Sector	Internal Rate of Return (%)
(l) Water Supply Schemes	
- Urban water supply	Very small*
- Rural water supply	Very small*
(2) Irrigation (18 large-scale projects)	9.6
(3) Hydropower (Five projects)**	14.1
(4) Flood Control (Five projects)	10.1

* Average of all schemes shows a negative value. A positive value was evaluated for 42 urban water supply schemes.

** Excl. Gitaru#3 Extension

As seen in the above table, the water supply sector had a extremely low efficiency from an economic point of view. However, this sector should be promoted from the point of basic human needs. In time people's willingness to pay for potable water will rise in accordance with an increase of household income and the water supply business will be managed independently on the basis of reasonable water charges. However, the government must initially support these undertakings by grant or other countermeasures.

4.10 Environmental Conservation

(1) Dam schemes

The construction of dam and reservoir works brings various general social and environmental problems, however, the 28 dams proposed in Section 4.7.(1) might not create serious influences on the social and environmental conditions around the selected site. During the time of implementation, however, it is important to minimize the adverse effects of the schemes as much as possible. The potential issues needing due attention are;

(a) Compensation for submerged lands and resettlement of people: Magwagwa and Ndarugu dams
(b) Submergence and deforestation in forest areas: Itare, Mukulusi, and Upper Narok dams
(c) Water quality and sanitation problems: Oldorko, Mwachi, Pemba, and Rare dams
(d) Consideration of water utilization downstream: Oldorko and Malewa dams

(2) Irrigation

In irrigation schemes generally, common environmental problems prevail rather than specific problems isolated to an individual scheme. Nevertheless, specific issues needing attention in respective schemes will be;

(a) Problems for public health:
Kano, Kanzalu, Kimira, Ewaso N'giro, Mwea, and Tana Delta schemes,
(b) Problems for water utilization in downstream areas:
Ewaso N'giro and Turkwel schemes,
(c) Water quality problems in downstream areas:
Kano, Kimira, Kuja, and Tana Delta schemes,
(d) Influence on vegetation in ASAL areas:
Ewaso N'giro and Turkwel schemes

Of the 18 irrigation schemes, Ewaso N'giro and Turkwel schemes have noticeable problems such as in the (b) and (d) above. Although these problems may not be serious enough to exclude the two schemes from the proposed list, careful consideration should be made before implementing them.

(3) Flood control schemes

Social and environmental problems that would be brought about by the five flood control schemes proposed in Section 4.6.(1) are considered to be relatively insignificant, as their construction takes place in the existing river courses or, the construction itself, is a repair of the existing river dykes. Even in the case of new dykes, the problems should not influence the surrounding areas because there are few inhabitants along the rivers.

(4) Water transfer schemes

(a) General problems

Environmental problems from water transfer schemes are classified into the following two aspects.

(i) Decreased river flow downstream from source rivers
(ii) Change of the water environment (quality and quantity) in receiving rivers and lakes from transferred water

These problems occur frequently within a closed basin. In this Study, therefore, the following points were taken into consideration.

(i) The source rivers for water transfer are restricted into rivers which have affluent water flow and little difficulty of water shortage in downstream areas such as Nzoia, Yala, Nyando, Sondu, and Tana rivers.

(ii) Water must not be transferred from closed basins in principle, although water from Malewa River is an exception (discussed later). This point is quite important for rivers which are functioning as water resources for key production areas in ASAL regions, such as Turkwel, Kerio, Ewaso N'giro North, and Ewaso N'giro South rivers. Also, the Mara River is added as the river has the same characteristics, though its basin is not closed.

(iii) Water transfer into closed basins is, in some instances, necessary from the point of view of satisfying the basic human needs in water deficit areas. The potential problem is that the transferred water may contaminate the water catchment areas, i.e., lakes and marshes, and become a secondary water pollution problem. However, this problem should not always deny the introduction of a water transfer plan. On condition that the maximum volume of transferred water is considered in regard to the ecological balance, water transfer plans should be carefully introduced in water shortage areas.

(b) Water transfer schemes for closed basin
(For example the Nakuru water transfer scheme)

The Nakuru water transfer plan (Phase II) is under planning as an urgent scheme to solve the water shortage problem in Nakuru city. Phase I of the scheme is not foreseen to involve any significant environmental issues, however, the proposed Phase II water transfer plan involves some controversial issues, and it is imperative to promote a countermeasure for the environmental deterioration problem of Lake Nakuru from transferred

water. The following countermeasures are proposed for environmental conservation of the lake:

(i) Total regulation of water utilization
(Non-structural measure)

- Regulation of regional development within Nakuru basin by enforcing a local act.
- Diversification of development activities in outlying areas of Nakuru basin.
- Introduction of a special water tariff in Nakuru basin primarily to encourage the saving of water use and secondly to procure the funds for the structural countermeasures proposed below.

(ii) Structural measures

- To furnish an urban sewerage system to prevent water pollution (Improvement of the existing sewage plant is an urgent work to be undertaken)
- To pump treated sewerage water to outlying areas of Nakuru basin and then use the water for irrigation (though this is a relatively costly proposal).
- To divert or retain the runoff during the rainy season and to transfer it outside the Nakuru basin. For this purpose, it will be necessary to provide diversion drainage facilities and flood retention dams. The water will be used for irrigation in outlying areas.

To establish these programmes, a "regional water use study" should be carried out urgently. An important element in the proposed study is to formulate an integrated regional development plan aimed at diversification of development activities to the outlying areas of the Nakuru basin. The study area shall cover three lake basins; Nakuru, Elementeita, and Naivasha.

Provisions set forth in the Ramsar Rules (convention on wetlands of international importance especially waterfowl habitats) is another aspect to be taken into account in the formulation of the Lake Nakuru conservation plan.

5. ACTION PLAN TOWARDS YEAR 2000 and 2010

5.1 Implementation of Development Plans

5.1.1 Implementation of water master plan - proposed development programme

All the schemes listed in Sections 4.1 through 4.8 have to be implemented to meet the water demand estimated in Section 2.2 and to satisfy the national water development policy mentioned in Chapter 3. The capital investment schedule of the schemes is enumerated in Table 5.1 assuming that the plans are implemented over 18 years from 1993 to 2010.

Table 5.1 Development Cost - Disbursement Schedule

(Unit: US$ Million, K£ Million)

Development Sector		Cumulative Development Cost		Disbursement Schedule (Period Total)			
		1993 - 2000	1993 - 2010	1993 - 1995	1996 - 2000	2001 - 2005	2006 - 2010
1. Domestic/Industrial Water Supply	US$	3,470	7,576	1,517	1,953	2,069	2,037
	K£	4,372	9,546	1,911	2,461	2,607	2,567
2. Sewerage Development	US$	420	705	242	178	128	157
	K£	529	888	305	224	161	198
3. Irrigation Development	US$	201	973	77	124	300	472
	K£	253	1,226	97	156	378	595
4. Livestock Water Development	US$	252	755	94	158	251	252
	K£	318	951	118	200	316	317
5. Hydropower Development	US$	542	1,034	99	443	492	-
	K£	683	1,304	125	558	621	-
6. River and Flood Control Works	US$	624	1,067	110	514	217	226
	K£	785	1,343	139	646	273	285
Total	US$	5,509	12,110	2,139	3,370	3,457	3,144
	K£	6,940	15,258	2,695	4,245	4,356	3,962

According to this estimate annual investment is roughly US$690million (equivalent to K£870 million) in the 1993-2000 period and US$660 million (equivalent to K£830 million) in the 2001-2010 period.

The detailed implementation programme of the proposed development schemes is contained in Appendix 2.

5.1.2 Development scenarios in accordance with availability of financial resources

(1) Estimate of available financial resources

The table below compares the necessary capital costs estimated in the previous section and the projected available financial resources. The available resources were estimated at US$6,309 million or K£7,951 million as the accumulation until the year 2010. The process of estimating financial sources is explained in Table 5.3, it assumes that the present budgetary resources would be increased in proportion to the projected GDP growth.

Table 5.2 Comparison between Required Development Costs and Available Financial Resources

(Unit: Million)

Development Sector	(A) Required Development Cost		(B) Estimated Available Resources (*)		(B)/(A)
	US$ Equiv.	K£ Equiv.	US$ Equiv.	K£ Equiv.	%
1. Domestic/Industrial Water Supply	7,576	9,546	2,596	3,271	34.3
2. Sewerage Development	705	888	220	278	31.3
3. Irrigation Development	973	1,226	604	761	62.1
4. Livestock Water Development	755	951	-	-	-
5. Hydropower Development	1,034	1,304	2,875	3,623	278.0
6. River and Flood Control Works	1,067	1,343	14	18	1.3
Total	12,110	15,258	6,309	7,951	52.1

Remark : The development costs represent the necessary costs covering only the projects proposed in this Study, while the available resources should cover other expenditures for projects not included in the Study. The comparison should take into account this aspect.

(2) Reduced budgetary scenarios

As seen in the table, the financial sources are extremely insufficient in all sectors except for hydropower. Taking this situation into account, the following two alternative scenarios were examined:

Scenario "A" : Available budget to be about 50% of the total requirement (which represents a case that the availability of funds for the water sectors would be similar to the present level; 52% in the above table)

Scenario "B" : Available budget to be about 75% of the total requirement (which represents a case that the availability of budget would be in between those of the Full Development Scenario (Subsection 5.1.1) and Alternative Scenario "A")

The capital investment costs and accomplishment rates of the respective scenarios by the year 2010 are shown in Table 5.4. The details of the selected projects for the respective scenarios are presented in Appendixes 3 and 4 for Scenarios "A" and "B", respectively.

(3) Reduced development scenario of domestic/industrial water supply schemes

A great unfavourableness noted in the domestic/industrial water supply development programme proposed in (2) above is that the development be restricted to a limited number of projects and badly distributed, geographically. This would not be fair and equitable to the districts and people who would not be benefitted.

Table 5.3 Trend of Projected Public Expenditure for Development up to 2010

(Unit : K.Pound Million)

Item	1989 Provisional	1990 1990/91	1995 1995/96	2000 2000/01	2005 2005/06	2010 2010/11
1. GDP at 1989 Constant Prices *1 (at Factor Cost)	7,330.5	7,762.8	10,351.5	13,832.1	16,805.0	20,435.8
2. Total Expend. by the National Government	3,522.7	3,700.4	4,742.8	6,100.0	7,411.0	9,012.2
1) Recurrent Expenditure	2,516.2	2,653.8	3,463.4	4,520.1	5,491.6	6,678.0
2) Development Expenditure	1,006.5	1,046.5	1,279.4	1,579.9	1,919.5	2,334.2
a) Appropriations-in-Aid	548.9	560.2	620.5	687.3	835.0	1,015.4
b) Net Expenditure	457.7	486.3	658.9	892.6	1,084.5	1,318.8
3. Capital Expenditure	665.9	678.3	743.6	815.2	990.4	1,204.4
a) Gross Fixed Capital Formation	603.4	613.5	666.3	723.6	879.1	1,069.0
4. Expenditure for Projects Related to Water Development	225.4	232.8	273.7	322.3	391.6	476.2
a) Expenditure by MOWD	75.2	78.5	96.9	119.6	145.3	176.7
b) Expend. by the Agencies Concerned	150.1	154.3	176.9	202.7	246.3	299.5
5. Accumulation of Expenditure for Projects Related to Water Development after 1992	-	-	1,284.0	2,795.0	4,608.9	6,813.9
a) Expenditure by MOWD	-	-	446.0	996.5	1,669.5	2,487.6
b) Expend. by the Agencies Concerned	-	-	838.0	1,798.5	2,939.4	4,326.4
Equivalent in US$ (US$ Million) *2						
Total Expenditure Accumulation	-	-	1,188.8	2,587.8	4,267.3	6,308.9
1) Expenditure by the Ministry						
a) Expenditure by MOWD	-	-	412.9	922.7	1,545.8	2,303.2
b) Expend. by the Agencies Concerned	-	-	775.9	1,665.2	2,721.5	4,005.7
2) Expenditure by Sector*3						
a) Water Supply	-	-	489.1	1,064.8	1,755.8	2,595.9
b) Sewerage	-	-	41.6	90.5	149.2	220.5
c) Irrigation	-	-	113.8	247.6	408.4	603.7
d) Livestock	-	-	0.0	0.0	0.0	0.0
e) Hydropower	-	-	541.7	1,179.3	1,944.6	2,874.9
f) Flood Control	-	-	2.6	5.7	9.4	13.8

Source : A.01, A.13 and A.24 (Sectoral Report A)

Remark : *1 Refer to Table A5.1. (Sectoral Report A)

*2 Foreign exchange rate : KShs21.6/US$ (as of December, 1989)

*3 Distribution(1) in Table A2-48 is applied.

Table 5.4 Development Cost and Accomplishment Rates under Reduced Budgetary Scenarios

Description		Full Development Scenario (Chapter 4) 2000	2010	Alternative Scenario A 2000	2010	Alternative Scenario B 2000	2010
Development Cost							
Domestic/Industrial Water Supply:							
– US$	million	3,470	7,576	2,081	4,330	2,606	5,685
– K£	million	4,372	9,546	2,622	5,456	3,284	7,163
Sewerage Development:							
– US$	million	420	705	353	588	371	620
– K£	million	529	888	445	741	467	781
Irrigation Development:							
– US$	million	201	973	201	486	200	598
– K£	million	253	1,226	253	613	252	754
Livestock Water Development:							
– US$	million	252	775	128	371	192	566
– K£	million	318	951	161	475	242	713
Hydropower Development							
– US$	million	542	1,034	542	1,034	542	1,034
– K£	million	683	1,304	683	1,304	683	1,304
River/Flood Control Works:							
– US$	million	624	1,067	235	504	462	798
– K£	million	785	1,343	296	635	582	1,005
Total							
– US$	million	5,509	12,110	3,540	7,319	4,373	9,301
– K£	million	6,940	15,258	4,460	9,224	5,510	11,720
Achievement of Development							
Domestic/Industrial Water Supply:							
(a) Urban water supply							
– No. of cities/towns		151	158	42	42	65	66
– No. of beneficiaries	(million)	8	13	6	10	8	13
	(%)	100	100	77	77	100	100
(b) Rural water supply							
– No. of beneficiaries	(million)	10	28	9	18	14	28
	(%)	100	100	39	65	61	100
Sewerage Development:							
– No. of cities/towns		151	158	42	42	66	66
– No. of beneficiaries	(million)	8	13	6	10	8	13
	(%)	100	100	77	77	100	100
Irrigation Development:							
(a) Large scale irrigation							
– Irrigation area	(thousand ha)	15	111	15	58	15	83
	(%)	100	100	100	52	100	75
(a) Small scale irrigation							
– Irrigation area	(ha)	3,506	7,012	3,506	7,012	3,506	7,012
	(%)	100	100	100	100	100	100
Livestock Water Development:							
(a) Livestock water supply							
– Livestock served	(mill. Lu)	3.8	11.2	1.9	5.6	2.9	8.4
	(%)	100	100	50	50	75	75
(b) Water points in nomadic area							
– No. of water points	(No)	171	559	0	0	0	0
	(%)	100	100	0	0	0	0
Hydropower Development							
– No. of water points	(No)	2	6	2	6	2	6
	(%)	100	100	100	100	100	100
River/Flood Control Works:							
(a) Major flood control projects							
– No. of schemes	(No)	2	5	1	2	1	3
	(%)	100	100	50	40	50	60
(b) Urban drainage work							
– No. of cities/towns	(No)	5	46	0	2	1	13
	(%)	100	100	0	4	20	28
(c) Minor river improvement works							
	(%)	100	100	50	50	75	75
(d) Improvement of Lower Tana river							
	(%)	100	100	50	50	75	75

(%) : % to the case of Full Development Scenario

An alternative solution may be to select a reduced development scenario where each scheme is proposed at a reduced development scale, while the development would cover as many schemes as possible. On this basis, the Study examined an alternative case that the development meets the demand in the year 2000 and would be effected towards the year 2010. This implies that water demand after the year 2000 level cannot be met and rationing of water supply would be inevitable. This criterion was applied to all schemes including the schemes for major urban centres such as Nairobi and Mombasa.

The estimated cost and accomplishment rates for development of this programme are summarized below. The implementation programme under this development scenario is presented in Appendix 5.

Table 5.5 Development Cost and Accomplishment Rates of Domestic/Industrial Water Supply under a Reduced Development Scenario

Description		Alternative Budgetary Scenarios A 2000	A 2010	B 2000	B 2010
Development Cost:					
Domestic/Industrial Water Supply					
– US$ million		1,904	3,837	3,032	5,788
– K£ million		2,399	4,835	3,821	7,293
Sewerage Development					
– US$ million		203	407	310	563
– K£ million		256	513	390	709
Achievement of Development:					
Domestic/Industrial Water Supply					
(a) Urban water supply					
– No. of cities/towns		81	87	143	151
– No. of beneficiaries	(million)	7	11	8	13
	(%)	88	88	100	100
(b) Rural water supply					
– No. of beneficiaries	(million)	14	28	14	28
	(%)	88	88	61	100
Sewerage Development					
– No. of cities/towns		88	88	152	158
– No. of beneficiaries	(million)	7	11	8	13
	(%)	88	88	100	100

Notes: Water supply only meets the demand at year 2000 level

5.1.3 Proposals for financial procurement

It is beyond the scope of the Study to recommend which of the above development scenarios is the best for the future conditions in Kenya. Nevertheless, the Study recommends that all possible arrangement should be made to achieve the proposed Master Action Plan (Full Development Plan proposed in Subsection 5.1.1) and that Kenya Government should distribute as much of the budget as possible to the water sector. Without financial back up, the national water development policy set forth in Chapter 3 can not be achieved.

The development budget will be procured from the following financial resources:

Table 5.6 Availability of Financial Resources

	Financial Source	Urban Water Supply	Rural Water Supply	Sewerage Development (Urban)	Irrigation Development	Livestock Water Development	Hydro-power Development	River Flood Control Works
(a)	Grant							
	Government Subsidy	o	o	o	o	o	o	o
	External Donor	o	o	o	o	o	o	-
	NGO	-	o	-	o	o	-	-
(b)	Loan							
	Internal Lender	o	o*1	o*1	o	o	o	o
	External Lender	o	-	o	o	-	o	o
(c)	Fund							
	Revolving Fund	-	o	-	o	o	-	-
	Co-operative Society*2	-	o	-	o	o	-	-
	Private Entity*3	o	o	o	-	o	-	-
	Contribution of Beneficiary*4	o	o	o	-	o	-	-
(d)	Others							
	Voluntary Service*5	o	o	o	o	o	o	o

Remarks:
- *1 Low interest personal loans for individual connection, rainwater harvesting facilities, septic tank, etc.
- *2 In case of an existing community or a newly organized society which is concerned in the scheme, it could provide or procure some financial resources for capital investment.
- *3 A local leading entity could provide a water supply system for the people within the surrounding area of the entity.
- *4 Some beneficiaries in the service area of the water supply systems could afford to contribute to part of capital costs of the systems.
- *5 The labour force of beneficial people could be available (semi-)voluntarily, which might be effective for construction works of water systems.
- \- Deemed to be not major source, but there may be the case of financing from these sources.

Constraint from financial resources is foreseen to be most critical in the water supply sector. To increase the investment funds, core agencies concerned with water supply systems such as MOWD and NWCPC should positively exert themselves to propose viable projects for facilitating the acquisition of the necessary budget. In addition, they should strive to raise the funds by improving the cost recovery of water supply undertakings through improvement of revenue collection and revision of water tariffs and by reducing the government recurrent expenditure for supplementation of new water undertakings. It is essential that these funds are added to the investment funds.

Other agencies such as MOLG and local authorities should also exercise similar effort in collaboration with MOWD/NWCPC. Contribution of efforts from cooperative societies and NGOs will also be helpful to lessen the financial burden of the sector.

5.2 Recommendation on Further Study Programmes

5.2.1 Further studies proposed

(1) Study and design of the proposed individual projects

Implementation of the projects usually requires preinvestment studies and detailed design thereof on an individual project basis. These studies/design will be carried out for all the proposed schemes in Chapter 4. The proposed study programmes are presented in Appendix 6.1.

(2) Integrated water resources development study by drainage basin (River Basin Study)

Regional water development master plans by major drainage basin should be formulated to utilize the water resources consistently and effectively on various industrial fields in the basin. One of the important objectives of the river basin study is to examine the potential of multipurpose projects through formulation of optimum water uses and the need/possibility of major water transfer schemes through water balance assessment of the basin. This master plan would be a prerequisite to effectively exploit such a large quantity of water as corresponding to 28% of the potential water resources in the country (explained in Section 2.3.1). LBDA, KVDA, and TARDA have already formulated this kind of master plan. The plans should be reviewed every ten years and considered as rolling plans in pursuance of the up-to-date manner. The study is proposed for 9 river basins as illustrated in Appendix 6.2. The leading agency in this exercise will be the river basin development authorities, while MOWD should provide proper coordination in the light of its roles as river administrator (see Subsection 6.2.7 hereinafter).

(3) Groundwater resources study for urban water supply

Twenty two (22) urban centres in arid land have to rely on groundwater sources for their water supply as described in Subsection 4.7.(2) , where, however, the available groundwater resources would presumably be critical compared with the water exploitation requirement. To find productive aquifers, an intensive groundwater potential study is proposed for 20 urban centres as presented in Appendix 6.3.

(4) District water resources study

The Water Resources Assessment and Planning (WRAP) by MOWD with assistance of the Government of Netherlands has produced satisfactory results in water resources development in some Districts. Entire Districts should be covered by the same kind of programme in succession. Afterwards, this current master plan should be reviewed and upgraded on the basis of the results of these programmes. The proposed programme is illustrated in Appendix 6.4.

(5) Programmes for data collection and water management

A pertinent plan is essential to develop a scheme effectively and efficiently. A prerequisite to this is the accumulation of accurate and proper data and information. The same could be said for attaining proper water management. Although the agencies concerned have exerted themselves to do so, some additional data and research, listed in Appendix 6.5, would be required to be accumulated systematically in the future.

The proposed programmes include the data collection and management activities relevant to (i) surface water management, (ii) groundwater management, (iii) water quality and pollution control and (iv) various supporting measures to facilitate the development and water management activities.

(6) Environmental studies

Programmes specifically proposed under this article include the following two items:

(a) Preparation of environmental impact assessment and management guidelines

(b) Regional environmental study for Mara river basin, Lake Jipe (including Lake Chala), and Lake Turkana, which would not be covered by the river basin studies proposed in (2) above.

The proposed study programme is presented in Appendix 6.6. Other environmental issues will be examined in the river basin studies, District water resources studies, and individual project studies.

(7) Estimate of Study Costs

The financial cost required to achieve the study programmes proposed from (1) to (6) above, amounts to US$1,225 million or K£1,543 million. The estimated cost is summarized by study item as follows:

Table 5.7 Further Study Programme - Estimated Cost

Study Programme	Estimated Cost	
	US$ million Equivalent	K£ million Equivalent
(1) Studies and design of individual projects	751.9	947.4
(2) River basin study	25.5	32.1
(3) Groundwater resources study for urban water supply schemes	51.0	64.3
(4) District water resources study	59.0	74.3
(5) Data collection and water management	47.0	59.2
(6) Environmental studies*	7.5	9.5
(7) Other miscellaneous studies**	282.6	356.1
Total	1,224.5	1,542.9

Note : * Specific studies on project, river basin and District basis are not included.
** 30% of the total of (1) thru (6)

It is noted that the study programmes listed in this Subsection cover the major items, but presumably not all items. There would be other miscellaneous studies which may become necessary in the course of the proposed implementation programmes. Item (7) of the above table was listed to cover those expenditures. A very preliminary budgetary schedule is shown in Appendix 6.7.

5.2.2 Major source development schemes for further consideration

There are many other source development schemes other than the schemes proposed as objectives to be implemented within the target year 2010. Further study is proposed for verifying the viability of those other schemes.

(1) Multipurpose dam plans

The following dam schemes are prospective for multipurpose development in the future:

Table 5.8 List of Multipurpose Dam Schemes (Potential Scheme in Future)

Project	River Basin	Objective of Development*	Remark
Nyando Dam	Nyando	D.I.P.F.	Also proposed in Greater Rift Water Transfer Plan
Nandi Forest Dam	Yala	D.I.P	Water transfer to Kano plain irrigation
Kimwarer Dam	Kerio	D.I.P	One of Kerio Valley Development Plans
Sererwa Dam	Arror	D.I.P	One of Kerio Valley Development Plans
Munyu Dam	Athi	D.I.P	The alternative of Ndarugu dam
High Grand Falls Dam	Tana	D.I.F	The alternative of Low grand Falls and Mutonga Dams
Adamson's Falls Dam	Tana	P.I.F	To contribute to downstream basin development of Tana River
Kora Dam	Tana	P.I.F	To contribute to downstream basin development of Tana River

Remark: * D:Domestic water supply; I:Irrigation; P:Hydropower; F:Flood control

(2) Dams for improvement of the hydrological regime (flow augmentation)

Dam plans to supplement and to maintain minimum flow in downstream of in rivers might be necessary in some water deficit areas. The details of this situation, refer to Section 6.3.1(5), are mentioned later. The possible dams are listed below.

Table 5.9 Dams for Improvement of the Hydrological Regime (Flow Augmentation) (Potential Schemes in the Future)

River Basin	Potential Dam	Remark
Kerio	Kamukuny Dam	Alternatively, to be developed as a subsurface dam
Athi	Yatta Dam	To improve the hydrological regime downstream of the river in addition to irrigation purposes
Ewaso N'giro North	Kihoto Dam	Irrigation, hydropower, and hydrological regime improvement
	Archer'sPost Dam	

(3) Potential dam schemes other than the proposed 28 schemes

Table 5.10 shows various dam schemes other than the 28 dam schemes proposed for implementation towards year 2010. Some of the dams may be worthy of further consideration as alternatives to the proposed 28 or for development additionally.

For urban water supply schemes, 19 dams were enumerated for implementation towards 2010. On top of those, another 19 dams are listed in Table 5.10. These schemes shall also be subject to further study as alternative or additional dams.

(4) Large-scale water transfer schemes

There are several large-scale water transfer schemes which have been proposed in previous studies (see Table 5.11). Not only do these schemes need a huge capital investment, but they also contain socio-environmental difficulties and/or are in trade-off conflict with beneficiaries downstream. Thus, the implementation of these schemes requires in-depth pre-investment studies.

Table 5.10 Potential Dam Schemes as Alternative Scheme or for Additional Development (1/2)

Item No.	Prospective Site proposed in the Study		Alternative Site Future Dev't Potentials		Purpose	Water Supply	Irrigation	Hydropower	Remarks
	Damsite	Sub-basin	Damsite	Sub-basin		Service Urban Centre	Large Irri. Scheme	Hydropower Scheme	
L.Victoria Drainage Area									
1 *1	Moiben	1BA			W	Eldoret/Iten	–	–	
2			Moi's Bridge	1BE	P, I, W		–	Moi's Bridge	inter-basin/transfer
3			Hemsted Brg.	1BD	W, I, P	Great Rift W/S	Upper Nzoia	Hemsted Brg.	inter-basin/transfer
4			Kibolo	1CE	W	–	–		
5			Webuye Falls	1DA	P	–	–	Webuye Falls	
6			Teremi	1DB	P	–	–	Teremi	rural hydro-electricity
7	Mukulusi	1EA			W	Kakamega	–	–	small dam
8			Kimondi	1FC	W, I	Great Rift W/S	–	–	inter-basin/transfer
9			Nandi Forest	1FD	I, P, W	–	Yala Swamp/ Kano Plain	Nandi Forest	multipurpose
10			Mushangumbo	1FE	P	–	–	Mushangumbo	
11	Londiani	1GC			W	Londiani	–	–	
12			Nyando	1GD1	W, I, F	Great Rift W/S	Kano Plain	–	inter-basin w/transfer
13	Kibos	1HA			W	Kisumu/Maseno	–	–	
14	Itare	1JA			W	Nakuru/Molo/Njoro /Elburugon/Rongai /Mogotio	–	–	
15			Timbilil	1JC	W	Kericho	–	–	
16			Sisei	1JF	W	–	–	–	
17 *1	(Sondu/Miriu)	1JG			P, I	–	(Kano Plain)	Sondu/Miriu	run-of-river type weir detailed design stage
18	Magwagwa	1JG			P, I	–	Kano Plain	Magwagwa	multipurpose
19	Bunyunyu	1KB			W	Kisii	–	–	
20			Katieno	1KB	W	–	–	–	
21			Namba Kodero	1KC	W, P	–	–	Namba Kodero	
22			Amala	1LB1	W	Nakuru	–	–	
Rift Valley Drainage Area									
23			Kimwarer	2CB	W, P, I	–	Kimwarer	Kimwarer	multipurpose
24			Kipsang	2CB	W	–	–	–	
25			Arror	2CC	W	–	–	–	
26			Sererwa	2CC	P, I, W	–	Arror	Arror	multipurpose
27			Waseges	2CC	W	–	–	–	
28			Kamukuny	2CC	W, I	–	–	–	flow augment,
29 *1	(Chemususu)	2ED			W	Eldama Ravine	–	–	detailed design stage
30			Aram	2EE	W	–	–	–	run-of-river type weir
31			Ratat	2EE	W	–	–	–	
32 *1	(Kirandich)	2EH			W	Kabarnet	–	–	detailed design stage
33	Malewa	2GB			W	Nakuru/Gilgil/ Naivasha	–	–	
34	Upper Narok	2KA			W	Narok	–	–	
35	Oldorko	2KB			P, I, W	Magadi	Lower E.Ngiro	Oldorko	multipurpose
36			Leshota	2KB	P, W	–	–	Leshota	
Athi River Drainage Area									
37	Upper Athi	3AA			W	Athi River	–	–	
38	Ruiru- A	3BC			W	Nairobi	–	–	
39	Kikuyu	3BA			W	Kikuyu	–	–	
40	Ndarugu	3CB			W, I	Nairobi, Ruiru, Kiambu	Kanzalu	–	multipurpose
41			Munyu	3DA	W, I, P	Nairobi	–	Munyu	multipurpose
42			Mbuuni	3EA	W	Machakos	–	–	
43			Kiteta	3EB	W	rural	–	–	
44			Thwake	3FA	I, W	–	–	–	
45	Yatta	3FB			I	–	Kibwezi Ext.	–	
46			Tsavo	3G	W	Tsavo	–	–	
47			Bar-icho	3HD	W	–	–	–	
48	Rare	3LA			W	Malindi	–	–	off-stream reservoir
49	Mwachi	3MB			W	Mombasa	–	–	
50	Pemba	3HC			W	Mombasa	–	–	run-off-river type weir

..... continued

Table 5.10 Potential Dam Schemes as Alternative Scheme or for Additional Development (2/2)

Item No.	Prospective Site proposed in the Study: Damsite	Prospective Site proposed in the Study: Sub-basin	Alternative Site Future Dev't Potentials: Damsite	Alternative Site Future Dev't Potentials: Sub-basin	Purpose	Water Supply: Service Urban Centre	Irrigation: Large Irri. Scheme	Hydropower: Hydropower Scheme	Remarks
Tana River Drainage Area									
51			Maragua	4BE	W	–			
52	Chania- B	4CA			W, I	Nairobi	(small iri.)	–	multipurpose
53			Ndiara	4CA	W	–	–	–	
54	Thiba	4DA			I, W	–	Mwea Ext.	–	
55	Mutonga	4FA			P	–	–	Mutonga	
56	Low Grand Falls	4FB			P	–	–	L.Grand Falls	
57			High Grand Falls	4FB	P, W, I	–	–	H.Grand Falls	multipurpose
58			Adamson Falls	4GA	P, W, I	–	–	Adamson Falls	multipurpose
59			Kora	4GB	P, W, I	–	–	Kora	multipurpose
60			Umaa	4HA	W	–	–	–	
61			Mutuni	4HA	W	–	–	–	
62			Kitimui	4HA	W	–	–	–	
Ewaso Nigro North River Drainage Area									
63	Rumuruti	5AA			W	Rumuruti	–	–	
64	Nyuhururu	5AA			W	Nyuhururu	–	–	small dam
65			Archers Post	5DA	W, I, P	–	–	–	flow augment.
66			Crocodile Jaw	5DC	P, W, I	–	–	Crocodile Jaw	flow augment.
			Kirium	5DC	P	–	–	Kirium	
67			Kihoto	5BC	W, I	–	–	–	flow augment.
68			Nundoto	5CA	W	Maralal	–	–	small dam
69			Lag-Bor	5EA	W	–	–	–	*2
70			Buna	5EA	W	Buna	–	–	*2
71			Habaswein	5EC	W	Habaswein	–	–	*2
72			Meri	5EC	W	Meri	–		*2
73			Modogashe	5FA	W	–	–	–	*2
74			Dadab	5FA	W	–	–	Oldorko	*2
75			Kutulo-Elwak	5GA	W	–	–	Leshota	*2
76			Takaba	5GA	W	–	–		*2
77			Mandera	5GB	W	Mandera	–		*2
78			Neboi-Mandera	5GB	W	–	–		*2
79			Rham Mandera	5GB	W	–	–		*2
80			Arabic	5GB	W	–	–		*2
81			Fino	5GB	W	–	–		*2
82			Kalatiyo	5H	W	–	–		*2
83			Markamari	5H	W	–	–		*2

Note: *1 shows a dam scheme in detailed design stage.
*2 potential sites proposed by MOWD. No detailed information available.

Table5.11 Large-scale Water Transfer Schemes
(Potential Schemes in Future)

Project	Source River	Target River Basin	Objective of the Development
Greater Rift Water Transfer Plan	Nyando or Nzoia	Rift Valley Area	Domestic and industrial water and Irrigation (at reconnaissance survey stage)
Nzoia-Kerio/Suam Double Water Transrer Plan	Nzoia	Kerio and Suam	Hydropower and Irrigation (at reconnaissance survey stage)
Amala Diversion Water Transfer Plan	Amala	Ewaso N'giro South	Hydropower and Irrigation (at a stage of a tentative plan)
Mbalambala Diversion Water Transfer Plan	Tana	Ewaso N'giro North	Regional development in downstream areas of Ewaso N'giro North River (at a conception stage)

Of these plans, the study on Nzoia-Kerio/Suam Double Water Transfer Plan should precede all others in view of its relative attractiveness revealed in a previous study.

5.3 Recommendation for Implementation of Projects

(1) Executing agencies

Implementation programmes contained in Appendixes 2 through 6 show the proposed executing agencies of respective projects/studies which would be most appropriate under the present organizational set-up. Since the existing organizations are functioning well, as a whole, the study is of the opinion that there would be no specific need to reform the present organizations. However, since there are many implementing agencies involved in the respective sectors, proper allotment on the implementation and co-operation among them must be contrived carefully. This point is discussed in more detail in Chapter 6.

(2) Selection of priority projects

The major problems on implementation in the respective sectors are (a) lack of budget; (b) lack of well-trained personnel; and (c) lack of physical facilities such as vehicles, equipment, etc. Among these points, the inadequacy of funds is the most fundamental problem with regards to the executing agencies.

Since the inadequacy of funds is not a problem that can be solved in a short time, the existing financial resources must be used in the most effective way. In other words, the competent agencies select the priority projects and/or the priority public affairs and implement them in that order. It would give more satisfactory results to implement 10 projects of two years by installment in five serial terms rather than to implement 50 projects for ten years in parallel.

(3) Buildup of personnel required

The Government aims at reforming itself into a small organization, so it should be promoted with prudence to increase personnel required for implementation. The Study presumes that most undertakings, excluding some special works which would be managed by MOWD and NWCPC directly, would be handled by positive private sectors (consultants/contractors), henceforward, reducing the number of the agencies' own forces. This issue would apply to every agency concerned.

Yet, as mentioned in Section 5.1, the number of undertakings will increase drastically in the future, so it would be a prerequisite to increase some supervisory/ management staff for implementation. The Study examined a draft plan of the staff reinforcement required for achieving the implementation of the proposed development programmes, which is presented in Vol. 2 of the Main Report.

6. RECOMMENDATION ON LEGAL AND INSTITUTIONAL ASPECTS

The general framework of laws and administration related to water development in Kenya has no significant problems on the whole, as mentioned in several references (for example WHO research 1973). The problems are not in the framework of laws but on implementation of laws and on management of water resources and use. Therefore, the current study recommends the improvement of implementation and management in these aspects; particularly those regarding formulation and implementation of projects proposed in this National Water Master Plan.

In view of the importance of these legal/institutional issues, most of the descriptions in the Main Report Volume II are quoted in this Summary Report.

6.1 Laws Related to Water

6.1.1 Issues of existing laws

(1) Water Act

The Water Act, the supreme law on water, is now being revised by MOWD. The draft version of the Act was reviewed through discussion with the Attorney General Chamber and is now at Cabinet level. The proposed revision appears to be reasonable, in general. This revision would improve the implementation and management of water issues in the future.

(2) Tana and Athi Rivers Development Authority (TARDA) Act

In the present Act, TARDA is assigned as the agency of "advice and coordination". It would be revised so that TARDA functions as the implementing agency as LBDA and KVDA are so enpowered.

(3) Water (Water Undertakers) Rules

These rules should be applied to all existing water undertakers including non-gazetted water undertakers and local authority water undertakers, on a uniform basis and without exceptions.

(4) Lakes and Rivers Act

In view of the increasing need for the protection and management of river courses, the regulations regarding management issues on rivers and lakes should be added to the Act. In this case, MOWD will be closely related to the Act, although the Act is presently administered by Ministry of Transport and Communication.

(5) Local Government Act

The Act gives power to undertake sewerage, drainage, and water supply works to local authorities such as city commission and municipal, town, urban, and

county councils. At the same time, the authorities should take up the duties appointed under the Water Act as water undertakers. Form this point of view, the two Acts should keep consistency in legal power and obligation.

(6) Establishment of environmental assessment and management guidelines

There are no comprehensive environmental guidelines in Kenya, other than a guideline included in the Environmental Management Report (NES, 1978). The preparation of comprehensive guidelines will be prerequisite. The guidelines should be legislated in the future.

6.1.2 Implementation of laws

The active and strict implementation and enforcement of the law are essential to manage water development and use pertinently. As mentioned before, the problems encountered arise from a low level of enforcement from the agencies concerned, so the active and strict prosecution of their duties is recommended as the most essential issue.

To prosecute efficiently, the following three improvements are required: (i) decentralization of implementation responsibilities, to the district offices in particular; (ii) training of the officials in charge of implementation and enforcement; and (iii) wider use of existing powers (rather than making new regulations in vain).

6.2 Issues Related to Planning and Implementation of Undertakings

6.2.1 Domestic and industrial water supply

(1) Implementing agencies

The various implementation agencies are related to water schemes. The active utilization of present existing institutions would basically be sufficient to promote the future projects. In the long run, it would be better to apportion responsibilities between them as follows:

MOWD:	It must function as a comprehensive policy formulating agency with regard to water resource development, water use, and river management of the country, including the administration of water supply, sewerage, drainage, and water quality control.
NWCPC:	It must take over major implementing functions of MOWD as a practical implementing agency covering the whole country. It also keeps the important function as a bulk water supplier to water undertakers.
Other Ministries and Agencies related to water supply schemes:	The respective ministries and agencies should carry on development of water schemes, because they are most familiar with the needs of the development of

(MOLG, MOTC, MOTW, MOLD, MOCSS, MOLH and MORDASAW)	the relevant sectors. However, engineering aspects (planning and designing) of water schemes should actively rely on MOWD and NWCPC.
River Basin Development Authorities	They should facilitate water supply development through formulation of multi-purpose development schemes, where MOWD and NWCPC would be actively involved for coordination
Local Authorities:	Operation and maintenance of water supply systems is the major duty for them. They should also expand the service areas and proceed to develop water resources in their territories. It would be efficient for them to rely on NWCPC regarding large-scale water resources development.
NGOs:	Their efforts contribute a lot to the development of the water supply sector in the country, particularly in rural areas. They should rely on MOWD for further technical and administrative co-operation.

(2) Operation and maintenance (O&M) of water supply works

Water supply systems are operated and maintained presently by various organizations, such as MOWD, NWCPC, local authorities, local communities, and NGOs, as mentioned above. In the long run, however, O&M should preferably be handled by local authorities representing the beneficiaries, which is the county council in case of rural water supply schemes. Bulk water supply should be operated and maintained by NWCPC continuously.

(3) Improvement of cost recovery

The following three measures are recommended for improving the cost recovery of the water supply works:

(i) Extension of individual connections and metering measurement
(ii) Reduction of water leakage from the piping networks, e.g. establishment of a leakage inspection team for each major system.
(iii) Introduction of an ascending water tariff system

(4) Diversification of water demands

The current study has revealed that the balance between water demand and potential available water will be more and more critical in many areas. The following are particular areas which would need specific attention: