THE REPUBLIC OF KENYA
MINISTRY OF ENVIRONMENT,
WATER AND NATURAL RESOURCES
WATER RESOURCES MANAGEMENT
AUTHORITY

THE REPUBLIC OF KENYA

THE PROJECT
ON
THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

FINAL REPORT
VOLUME - Ⅱ MAIN REPORT (1/2)

OCTOBER 2013

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.

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FINAL REPORT

List of Reports

VOLUME - I EXECUTIVE SUMMARY

VOLUME - II MAIN REPORT (1/2)
- Part A : Overall Concepts and Frameworks
- Part B : Lake Victoria North Catchment Area
- Part C : Lake Victoria South Catchment Area
- Part D : Rift Valley Catchment Area

VOLUME - III MAIN REPORT (2/2)
- Part E : Athi Catchment Area
- Part F : Tana Catchment Area
- Part G : Ewaso Ng'iro North Catchment Area
- Part H : Action Plan for WRMA Regional Offices toward 2022

VOLUME - IV SECTORAL REPORT (1/3)
- A : Socio-economy
- B : Meteorology and Hydrology
- C : Water Supply
- D : Sanitation

VOLUME - V SECTORAL REPORT (2/3)
- E : Agriculture and Irrigation
- F : Hydropower
- G : Water Resources Development
- H : Water Resources Management
- J : Flood and Drought Disaster Management

VOLUME - VI SECTORAL REPORT (3/3)
- K : Environmental and Social Considerations
- L : Institution
- M : Database and GIS
- N : Pilot Activities

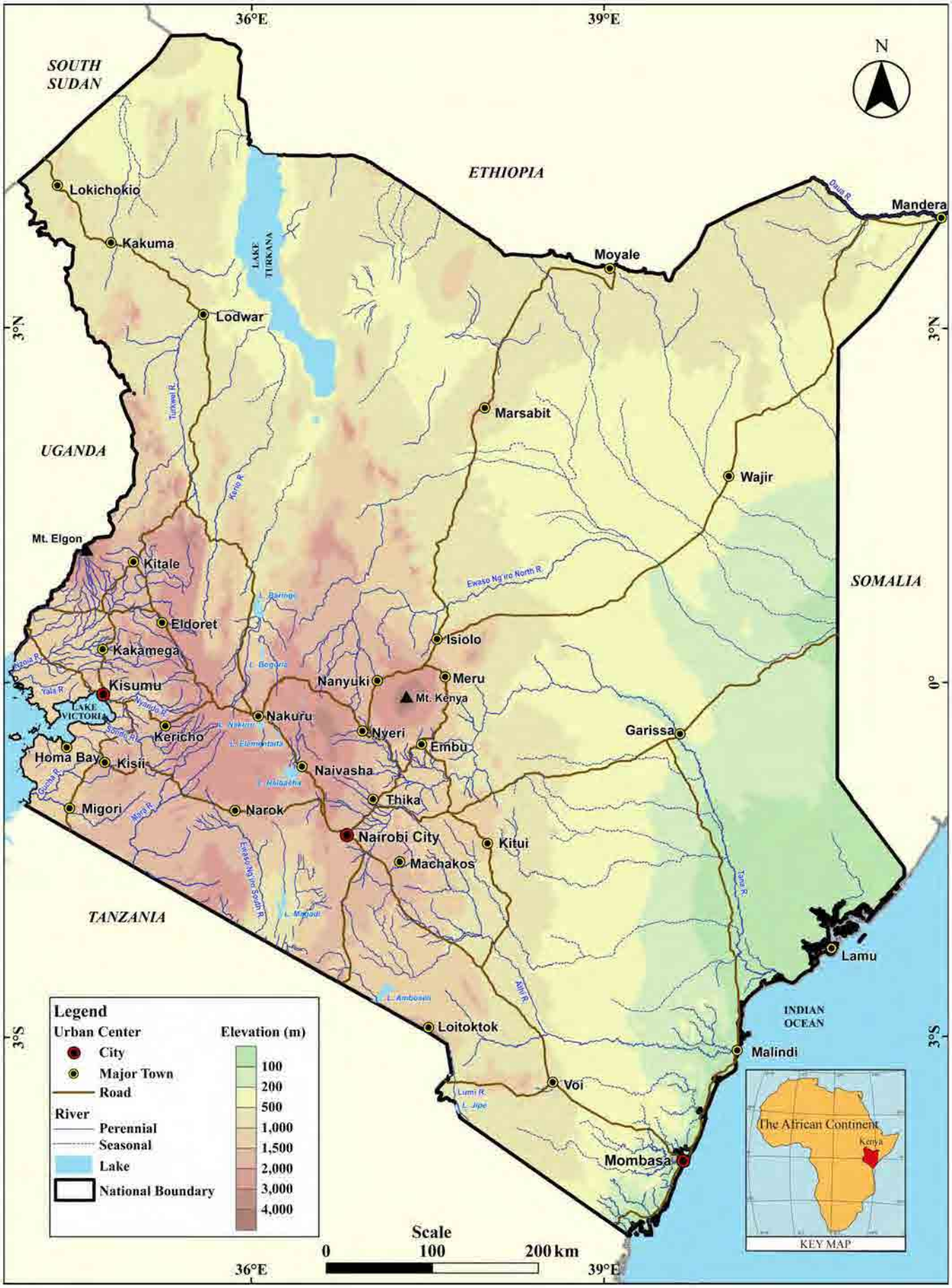
VOLUME - VII DATA BOOK
- Part A : Meteorological and Hydrological Data
- Part B : Irrigation Inventory
- Part C : Subletting Works

EXCHANGE RATE

US$1.00 = KSh 85.24 = ¥79.98

as of November 1, 2012

Part A
Overall Concepts and Frameworks



Location Map

THE PROJECT
ON
THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030
IN
THE REPUBLIC OF KENYA

FINAL REPORT
VOLUME - II MAIN REPORT (1/2)

PART A: OVERALL CONCEPTS AND FRAMEWORKS

Location Map
Abbreviation

Table of Contents

Page

List of Tables

Page

List of Figures

Page

List of Abbreviations and Acronyms

AIA	:	Actual Irrigated Area
ALRMP	:	Arid Land Resources Management Project
ASAL	:	Arid and Semi-arid Land
BOD	:	Biochemical Oxygen Demand
BPS	:	Budget Policy Statement
BWRB	:	Basin Water Resources Board
CAAC	:	Catchment Areas Advisory Committee
CBDM	:	Community-based disaster management
CBS	:	Central Bureau of Statistics
CMIP3	:	Phase 3 of Coupled Model Intercomparison Project
COD	:	Chemical Oxygen Demand
CoK	:	Constitution of Kenya
CRC	:	Crisis Response Centre
DDMC	:	District Disaster Management Committee
DIO	:	District Irrigation Office
DO	:	Dissolved oxygen
DRSRS	:	Department of Resource Surveys and Remote Sensing
EIA	:	Environmental Impact Assessment
EMCA	:	Environmental Management and Coordination Act
ENN	:	Ewaso Ng'iro North
ENSO	:	El-Niño/Southern Oscillation
ESP	:	Economic Stimulus Programme
FAO	:	Food and Agriculture Organization
FMU	:	Flood Management Unit
GCM	:	General Circulation Model
GDP	:	Gross Domestic Product
GOB	:	Gross Operating Balance
GOK	:	Government of Kenya
GW	:	Groundwater
ICPAC	:	IGAD Climate Prediction and Application Centre
IDD	:	Irrigation and Drainage Department
ITCZ	:	Inter Tropical Convergence Zone
IWRM	:	Integrated Water Resources Management
IWUA	:	Irrigation Water users Association
JICA	:	Japan International Cooperation Agency
JMP	:	Joint Monitoring Programme
KenGen	:	Kenya Electric Generating Company
KEWI	:	Kenya Water Institute
KFS	:	Kenya Forest Service
KFSSG	:	Kenya Food Security Steering Group
KMD	:	Kenya Meteorological Department
KNBS	:	Kenya National Bureau of Statistics
KWS	:	Kenya Wildlife Service
LCPDP	:	Least Cost Power Development Plan

LSRWSS	:	Large Scale Rural Water Supply System
LVN	:	Lake Victoria North
LVS	:	Lake Victoria South
MDNKOAL	:	Ministry of State for Development of Northern Kenya and Other Arid Lands
MOE	:	Ministry of Environment
MOFD	:	Ministry of Fisheries Development
MOLD	:	Ministry of Livestock Development
MOWD	:	Ministry of Water Development
MWI	:	Ministry of Water and Irrigation
NCPC	:	National Conservation and Pipeline Corporation
NDOC	:	National Disaster Operation Centre
NEMA	:	National Environment Management Authority
NET	:	National Environment Tribunal
NGO	:	Non-Governmental Organization
NIB	:	National Irrigation Board
NRW	:	Non-Revenue Water
NWCPC	:	National Water Conservation and Pipeline Corporation
NWMP	:	National Water Master Plan
NWP	:	National Policy on Water Resources Management and Development
NWRDP	:	National Policy on Water Resources Management and Development
NWRMS	:	National Water Resources Management Strategy
PIO	:	Provincial Irrigation Office
QBO	:	Quasi-biennial Oscillations
RBO	:	Community-based disaster management
RV	:	Rift Valley
SHER	:	Similar Hydrologic Element Response
SS	:	Suspended Solids
SSRWSS	:	Small Scale Rural Water Supply System
SW	:	Surface Water
TC	:	Tropical Cyclones
T-N	:	Total Nitrogen
T-P	:	Total Phosphorus
UN	:	United Nations
UNICEF	:	United Nations Children's Fund
UWSS	:	Urban Water Supply System
WAB	:	Water Appeal Board
WASREB	:	Water Services Regulatory Board
WHO	:	World Health Organization
WRM	:	Water Resources Management
WRMA	:	Water Resources Management Authority
WRRA	:	Water Resources Regulatory Authority
WRUA	:	Water Resources Users Association
WSB	:	Water Service Board
WSP	:	Water Service Provider
WSRB	:	Water Service Regulatory Board
WSTF	:	Water Services Trust Fund

Abbreviations of Measures

Length

mm	=	millimeter
cm	=	centimeter
m	=	meter
km	=	kilometer

Area

ha	=	hectare
m^2	=	square meter
km^2	=	square kilometer

Volume

L, lit	=	liter
m^3	=	cubic meter
m^3/s, cms	=	cubic meter per second
CM	=	cubic meter
MCM	=	million cubic meter
BCM	=	billion cubic meter
m^3/d, cmd	=	cubic meter per day
BBL	=	Barrel

Weight

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

Time

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

Money

KSh	=	Kenya shilling
US$	=	U.S. dollar

Energy

kcal	=	Kilocalorie
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
L/p/d	=	litter per person per day

NOTE

1. The National Water Master Plan 2030 was prepared based on the material and data provided from Kenyan Government and its relevant organisations during field surveys in Kenya carried out until November 2012. The sources etc. of the material and data utilised for the study are described in the relevant part of the reports.

2. The names of ministries and related organisations of Kenyan Government are as of November 2012.

3. Information to be updated

   The following information which is given in the report is needed to be updated properly:

   (1) Information on the proposed development projects

   The features and implementation schedules of the proposed development projects may be changed toward implementation of the project. After the subject projects were clearly featured for implementation, the project features and implementation schedules in this report should be updated.

   (2) Information on the water demand

   The water demand projected in this master plan should be revised when the large scale development plans, other than the projects proposed in this master plan, were formulated, as they will significantly affect to the water resources development and management.

4. Exchange rate for cost estimate

   The costs of the proposed development and management plans were estimated by applying the following exchange rate as of November 1, 2012.

EXCHANGE RATE
US$1.00 = KSh 85.24 = ¥79.98
as of November 1, 2012

CHAPTER 1 INTRODUCTION

1.1 Background of the Project

Aiming to ensure proper development and management of water resources in the country, the Government of Kenya (GOK) had formulated the National Water Master Plan in 1992 (NWMP (1992)) under technical assistance of the Japan International Cooperation Agency (JICA). Since then, the GOK has been implementing the projects proposed in the NWMP (1992).

After the enactment of the Water Act 2002, the GOK has been implementing water sector reform. In the water resources management subsector, the Water Resources Management Authority (WRMA) was established in 2003 as a lead agency in national water resources management. The water resources management system was changed from administrative basis to catchment basis.

Kenya Vision 2030 was prepared in 2007 and in it a new development blueprint for the country was presented. Water was defined as essential resources to support the development activities planned in Kenya Vision 2030. In order to achieve the objectives set forth in Kenya Vision 2030, a proper implementation system and the planning of water resources management are essential to cope with the increasing water demands of domestic, irrigation, industries, etc. while conserving the catchments sustainably.

Global climate change is becoming a great challenge in Kenya. Recently, drought and flood risks are considered to be increasing. In this regard, the GOK has prepared the National Climate Change Response Strategy. As the water sector is one of the most important sectors to support the development of the country, adaptation measures should be carefully considered.

The situation of the water sector has much changed as mentioned above. This makes the renewal of the NWMP (1992) necessary.

In response to the official request from the GOK in July 2008, the Government of Japan decided to conduct technical cooperation (development study program) for the Project for the Development of the National Water Master Plan 2030 in the Republic of Kenya (the Project) in accordance with the relevant laws and regulations in force in Japan.

Accordingly, JICA, the official agency of the Government of Japan which is responsible for the implementation of official development assistance (ODA), was entrusted to undertake the Project jointly with the Ministry of Water and Irrigation (MWI) and in close cooperation with the authorities concerned.

1.2 Objectives of the Project

The objectives of the Project are as follows:

a) To assess and evaluate availability and vulnerability of the country's water resources up to around 2050 taking into consideration the climate change,
b) To formulate the National Water Master Plan toward the year 2030 for sustainable water resources development and management for six catchment areas,

c) To prepare the action plan for activities of the WRMA's regional offices up to the year 2022 in order to strengthen their water resources management capability, and

d) To transfer technology on water resources development and management through implementation of the Project.

1.3 Outline of the Project

1.3.1 Project Area and Target Year

The Project covers the entire area of Kenya. The Project area consists of the following six catchments designated by the National Water Resources Management Strategies (2007-2009), as shown in Figure 1.3.1:

a) Lake Victoria North Catchment Area (LVNCA: 18,374 km^2)

b) Lake Victoria South Catchment Area (LVSCA: 31,734 km^2)

c) Rift Valley Catchment Area (RVCA: 130,452 km^2)

d) Athi Catchment Area (ACA: 58,639 km^2)

e) Tana Catchment Area (TCA: 126,026 km^2)

f) Ewaso Ng'iro North Catchment Area (ENNCA: 210,226 km^2)

The figures of the catchment areas mentioned above are those presented in the Catchment Management Strategies of the six catchments of WRMA.

The target year for planning is 2030 according to the objectives of the Project mentioned in Section 1.2.

1.3.2 Phasing and Contents of the Project

The Project was carried out in two phases as follows:

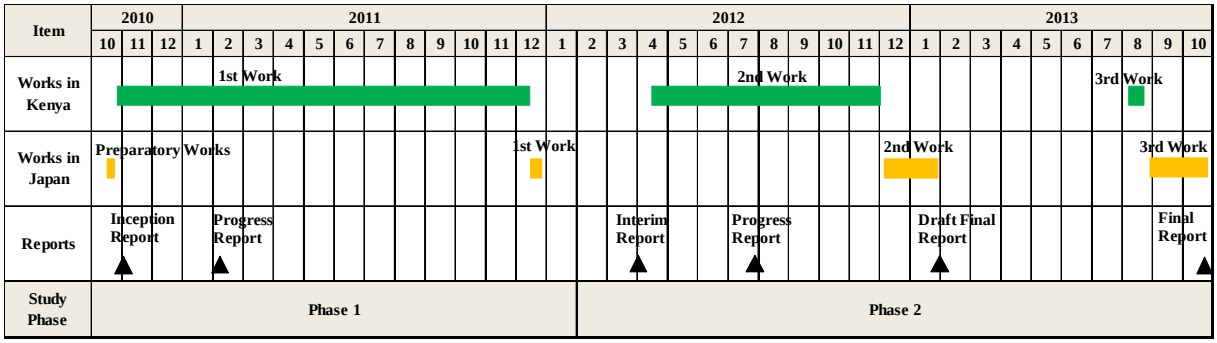
Phase 1: Basic Study

- Preparation of inception report,
- Collection and review of basic information and data on present legal and institutional systems, existing policies, strategies and plans, current conditions of subsectors of the water sector, natural conditions, socioeconomic conditions, etc. relevant to the National Water Master Plan 2030 (NWMP 2030) formulation,
- Field surveys on water use, flood and drought damages and groundwater,
- River cross survey near Garissa and rehabilitation of 24 river gauging stations,
- Hydrometeorological analysis including climate change analysis,
- Projection of future water demands,
- Evaluation of water resources in the future,
- Pilot activities in the Tana Catchment Area (TCA) regarding catchment forum, hydrometeorological information management, water permit database management and flood and drought information management, and
- Preparation of progress reports and interim report.

Phase 2: Formulation of Master Plan

- Formulation of concept and frameworks for water resources development and management,
- Formulation of the NWMP 2030 including cost estimate, economic evaluation and implementation program,
- Preparation of an action plan for the WRMA regional offices up to the year 2022 in order to strengthen their water resource management capability, and
- Preparation of progress reports, draft final report and final report.

The Project was carried out in accordance with the schedule shown in the figure below. The total period of the Project was 37 months. Phase 1 covers the period from October 2010 to December 2012, and Phase 2 covers the period from February 2012 to October 2013.



Source: JICA Study Team

Overall Schedule of the Project

1.3.3 Outputs of the Project

The Project was carried out in two phases, i.e. Phase 1: Basic Study and Phase 2: Formulation of Master Plan.

The outputs of the Project were compiled into the following seven volumes. Respective titles are also presented after the cover page of this report:

Volume - I	Executive Summary
Volume - II	Main Report (1/2)
Volume - III	Main Report (2/2)
Volume - IV	Sectoral Report (1/3)
Volume - V	Sectoral Report (2/3)
Volume - VI	Sectoral Report (3/3)
Volume - VII	Data Book

The Main Reports present the water master plan for each catchment area of WRMA, and the Sectoral Reports present the study results of the subsectors related to water resources. The Data Book presents data used during the course of this study and outputs of sublet works.

The Executive Summary is a summary of the Main Reports.

CHAPTER 2 PHYSICAL CONDITIONS

2.1 Land, Topography and Physiography

Kenya is located on the east coast of Africa, with the equator running almost straight along the middle of the country as shown in the location map. Kenya lies approximately between latitudes 5°20'N and 4°40'S and between longitudes 33°50'E and 41°45'E, as shown in the location map, and has a territorial area of 582,646 km^2 according to the Ministry of Lands.

The territorial area of Kenya is divided into water area of 11,230 km^2 and land area of 571,416 km^2. The major part of the inland water surface area is covered by a portion of Lake Victoria and Lake Turkana. Of the land area, approximately 490,000 km^2 (more than 80% of the land area) is classified as arid and semi-arid land (ASAL), which has few soil or water resources but supports almost 30% of the human population and 70% of the livestock production in the country at present. The remaining area of about 81,000 km^2 is classified as profitably usable lands, which sustain a substantial portion of Kenya's economy and human population.

Kenya is characterised by tremendous topographical diversity, ranging from glaciated mountains to a true desert landscape. The elevation varies greatly from sea level at the Indian Ocean to 5,199 m at the Batian Peak of Mount Kenya, which is the second highest mountain on the African continent.

Kenya borders with Somalia, Ethiopia and South Sudan in the north, Uganda in the west, Tanzania in the south and the Indian Ocean in the east.

2.2 General Geology

2.2.1 Overview

Four major geological series, Precambrian, Paleozoic, Mesozoic and Cenozoic represent the complex geologic formation of Kenya. The Precambrian series, the lower portion of the geologic formation, is represented by volcanic rocks as well as igneous and metamorphic rocks. The Paleozoic series is represented by the sedimentary rocks known as Karoo Series which is distributed in the south eastern part. The Mesozoic series is well developed in the north-east and the south-east and represented by sedimentary rocks. The Cenozoic series is probably the best developed and most important in terms of surface coverage and is represented by sedimentary and volcanic rocks of Tertiary and Quaternary deposition. Geological map of Kenya is shown in Figure 2.2.1.

2.2.2 Geology of Each Series

(1) Precambrian Series

The Precambrian series are distributed in south western and central part of Kenya. The Precambrian series are consists of four geological series: Basement, Nyanzian, Kavirondian and Bukoban. Detailed description of each series is summarised as follows;

- The Basement series is composed of sedimentary rocks (grits, sandstones, shale, limestone) and volcanic rocks metamorphosed by heat, pressure and hydro thermal fluids

- The Nyanzian series is composed of volcanic rocks (rhyolite, andesite, basalt and greywackes).
- The Kavirondian Series is composed of sedimentary rocks (alternating bands of grits, sandstones and shale which are only slightly metamorphosed).
- The Bukoban series is composed of volcanic rocks (quartzite and volcanic product).

(2) The Paleozoic series

The Paleozoic series is distributed in south eastern part of Kenya.The Paleozoic series is mainly represented by the Toru Grits, a monotonous series of grits, sandstones, shales and traces of coal.

(3) Mesozoic Series

The Mesozoic series is distributed in north and south eastern part of Kenya.The Mesozoic series are divided into three ages: Triassic, Jurassic and Cretaceous.Triassic age is consists of upper unit series and lower unit series.

The Upper unit series is represented by the Mazeras Sandstone and Shiiaba Grits overlain by the Mariakani Sandstones. The lower unit series is represented by sandstone. The Jurassic age series is composed of shales, sandstones in the south-east, whereas in the north-east it is chiefly limestone. The Cretaceous age series occurs in north- eastern Kenya, where a lower series of siltstones and flaggy, fine-grained sandstones are overlain by a thick formation of cross-bedded sandstones, both of which are together known as Marihan Series.

(4) Cenozoic series

The Cenozoic series is distributed in central and eastern part of Kenya. The Cenozoic series are divided into two ages. Tertiary and Quaternary. The Tertiary age series is composed of volcanic rocks (basalt and trachyte) in the western part and sedimentary rocks (sandstone and limestone) in the eastern part. The Quaternary age series is composed of volcanic rocks (basalt, pyroclastics and trachyte) and alluvial and colluvial deposits in the western part, and sedimentary rocks (sandstone and limestone) and alluvial and colluvial deposits in the eastern part.

2.2.3 Tectonics

Mountain building, chiefly folding and faulting, began during the Precambrian or early Cambrian and continued until Tertiary times, with varying degrees of intensity. Movements consisted mainly of uplifts with long periods of almost continued denudation, leading to peneplanation of much of Kenya in later Jurassic times. During Cretaceous and early Tertiary, vertical and tilting movements were dominant and their effects are most readily evident along the coast as well as the Rift Valleys.

2.3 Climate and Meteorology

2.3.1 General

The climate in Kenya is primarily controlled by the movement of the Inter Tropical Convergence Zone (ITCZ) and by topographic relief, especially elevation. The rainfall in Kenya is affected by large

water bodies like Lake Victoria, the complex topography of the Great Rift Valley, and high mountains such as Mt. Kenya and Mt. Elgon. Furthermore, local influences such as land-sea breezes and vegetation complicate the rainfall distribution.

A relatively wet and narrow tropical belt lies along the coast of the Indian Ocean. Behind the coastline are large areas of semi-arid and arid lands. The land then rises steeply to a highland plateau through which the Rift Valley runs. Kenya generally experiences two seasonal rainfall peaks (bimodal) in most places. However, some stations in the western and central parts of the Rift Valley experience a trimodal rainfall pattern.

2.3.2 Climatic Zone

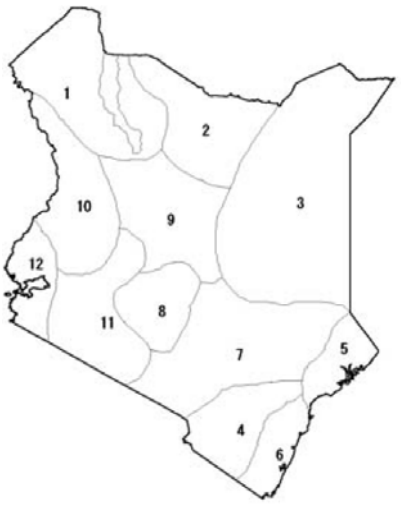
The main synoptic scale systems affecting rainfall in Kenya are the following:

- The position and strength of subtropical high pressure systems in the Southwest Indian Ocean (Mascarene High), Southeast Atlantic Ocean (St. Helena High), North Atlantic Ocean (Azores/Saharan High), and the Arabian High to the northeast.
- The position and intensity of the ITCZ.
- The position and intensity of tropical cyclones (TCs).
- El Niño/Southern Oscillation (ENSO).
- The Congo air mass.
- Inter-seasonal annual waves: the quasi-biennial oscillations (QBO).

The bimodal nature of rainfall corresponds with the northward and southward migration of the ITCZ. The first peak or season termed as the “long rains” in the East African region occurs from March to May, while the second season termed as the “short rains” is observed from October to December.

The climatic zones of Kenya with moisture availability (ratio of rainfall and potential evaporation) are illustrated in Figure 2.3.1. The moisture availability zones are classified from I to VII: (I) >80 Humid, (II) 65-80 Sub-humid, (III) 50-65 Semi-humid, (IV) 40-50 Semi-humid to Semi-arid, (V) 25-40 Semi-arid, (VI) 15-25 Arid, and (VII) <15 Very arid. The temperature zones are classified from 1 to 9: (1) 24-30, (2) 22-24, (3) 20-22, (4) 18-20, (5) 16-18, (6) 14-16, (7) 12-14, (8) 10-12, and (9) Less than 10.

Similar to the agro-climatic zones of Kenya, the Kenya Meteorological Department (KMD) defines the climatic zones in Kenya into 12 zones as described in the following table and figure on the right.



Climatic Zone of Kenya

Climatic Zones of Kenya Defined by KMD

Area	Climatic Zone	Representative Station
01) North Western Kenya	Arid (VI) to Very Arid (VII)	Lodwar
02) Northern Kenya	Arid (VI) to Very Arid (VII)	Marsabit, Moyale
03) North Eastern Kenya	Arid (VI) to Very Arid (VII)	Mandera, Wajir, Garissa
04) Southern Lowlands	Semi-arid (V) to Arid (VI)	Voi
05) Northern Coast Strip	Semi-humid (III) to Semi-arid (V)	Lamu
06) Southern Coast Strip	Semi-humid (III) to Semi-arid (V)	Mombasa, Mtwapa, Malindi, Msabaha
07) South Eastern Lowlands	Semi-arid (V) to Arid (VI)	Machakos, Makindu
08) Central highlands including Nairobi	Humid (I) to Semi-humid (III)	Nairobi, Nyeri, Meru, Embu
09) Highlands North	Sub-humid (II) to Arid (VI)	Isiolo
10) Highlands West of the Rift Valley	Humid (I) to Semi-humid (III)	Kericho, Eldret, Kitale, Kakamega
11) Central Rift Valley	Semi-humid (III) to Semi-arid (IV)	Narok, Nakuru, Nyahururu, Laikipia Air Base
12) Lake Victoria Basin	Humid (I) to Sub-humid (II)	Kisii, Kisumu

Source: KMD

2.3.3 Meteorology

(1) Temperature

Kenya has a wide variety of temperatures, ranging from below the freezing point on the snow-capped Mt. Kenya (minimum) to over 40 °C in the north and northeast arid and semi-arid areas (maximum). The average daily temperature in the coastal town of Mombasa (altitude 17 m) varies from 22.4 °C to 30.3 °C; the capital city of Nairobi (altitude of 1,661 m) from 13.6 °C to 25.2 °C; Eldoret (altitude of 2,085 m) in the western part from 9.5 °C to 23.6 °C; and Lodwar (altitude of 506 m) in the Rift Valley and the drier north plain lands from 23.7 °C to 34.8 °C.

(2) Evaporation and Relative Humidity

The annual mean evaporation depth varies from 1,215 mm at the Kimakia forest station to 3,945 mm observed at Lokori in South Turkana using Class “A” evaporation pan.

The highest annual mean maximum and minimum relative humidities were both recorded at Mombasa station at approximately 90% and 82%, respectively. On the other hand, the lowest annual mean maximum and minimum humidities were both recorded at the Lodwar station at approximately 60% and 34%, respectively. The relative humidity in Kenya is generally highest at 6 a.m. and lowest at 3 p.m..

(3) Rainfall

An isohyetal map of the mean annual rainfall for the period of 1981-2010 is shown in Figure 2.3.2. The mean annual rainfall over the country is approximately 680 mm. It varies from about 200 mm in the ASAL zones, such as Garissa, Isiolo, Mandera, Marsabit, Moyale and Turkana, to about 1,800 mm in the humid zones, such as Nyeri, Meru, Nyandarua and Mt.Elgon.

Humid zones, which receive more than 1,000 mm of annual rainfall, occupy less than 20% of the productive agricultural land and carry approximately 50% of the country’s population. Semi-humid zones receive 700-1,000 mm of rainfall annually, occupy between 30% and 35% of the country’s land

area, and contain about 30% of the country's population. ASALs, which receive 200-700 mm of rainfall annually, cover over 80% of the country's land area.

2.4 Rivers, Lakes and Springs

(1) Rivers

The major rivers in Kenya are shown in Figure 2.4.1. Kenya's river system is relatively simple. All the main rivers are consequent on the great dome formed by the Central Highlands.

Kenya has five "water towers", namely, Mt.Kenya (199,558 ha), Aberdares Range (103,315 ha), Cherangani Hills (128,000 ha), Mt.Elgon (73,089 ha), and Mau Forest Complex (400,000 ha). These water towers form the upper catchments of all the main perennial rivers in Kenya. On the other hand, the rivers in ASALs run out seasonally when heavy storm rainfall occurs.

Kenya has limited natural renewable water resources estimated at 42.1 BCM/year, which consists of 20.6 BCM/year of surface water and 21.5 BCM/year of groundwater recharge as mentioned in Section 5.2. The per capita renewable water resources (precipitation – evapotranspiration) was currently estimated at 1,093 m^3 per capita per year for the country's population of 38.53 million in 2010. Assuming that the sustainable groundwater yield is 10% of the groundwater recharge, the available water resources was estimated at 22.6 BCM/year as mentioned in Section 5.2.3 and the per capita available water resources comes to 586 m^3 per capita per year in 2010.

Kenya is delineated into six catchment areas as designated by National Water Resources Management Strategy. The major rivers of each catchment area are listed in the table below.

Major Rivers of Six Catchment Areas

Catchment Area	Area (km^2)	Major Rivers
Lake Victoria North	18,374	Nzoia R., Yala R.
Lake Victoria South	31,734	Nyando R., Sondu R., Kuja (Gucha) R., Mara R.
Rift Valley	130,452	Turkwel R., Kerio R., Ewaso Ng'iro South R.
Athi	58,639	Athi R., Lumi R.
Tana	126,026	Tana R.
Ewaso Ng'iro North	210,226	Ewaso Ng'iro North R., Daua R.
Total	575,451	

Source: WRMA Catchment Management Strategies

(2) Lakes

Kenya has nine major lakes as listed in the table below and shown in Figure 2.4.1.

Major Lakes in Kenya

Lakes	Elevation (m)	Area (km^2)	Type of Water
Victoria (Kenyan part)	1,133	3,755	Fresh
Turkana	375	6,405	Saline
Naivasha	1,884	210	Fresh
Baringo	975	129	Fresh
Bogoria	991	34	Saline
Nakuru	1,758	52	Saline
Elementaita	1,776	21	Saline
Jipe	701	39	Fresh
Magadi	579	104	Saline
Total	-	10,749	-

Source: Statistical Abstract, 2009, Kenya National Bureau of Statistics.

Of the nine lakes listed above, only Lake Victoria has an outlet, while the other lakes have none. Lake Bogoria, Lake Baringo, Lake Naivasha, Lake Elementaita and Lake Nakuru were registered in the Ramsar Convention in 2001, 2002, 2004, 2005 and 2006, respectively.

(3) Springs

It was said that there are a number of springs in the country. These springs are important sources of water supply for various sectors. According to the "Welfare Monitoring Survey II, 1994, Basic Report, CBS" (the Welfare Monitority Survey II), springs sustain 15% of the total households in Kenya in terms of safe water supply. Unfortunately, there are no data presenting the exact the locations and discharges of these springs. Major springs include the Mzima, Njoro Kubwa, Noltresh, and Kikuyu springs, as shown in Figure 2.4.1.

CHAPTER 3 SOCIO-ECONOMY

3.1 Administrative Division

Previously, the administrative division has been comprised of provinces, districts, divisions, locations and sublocations. However, with the New Constitution promulgated in 2010, the administrative division of Kenya now consists of counties, districts, divisions, locations and sublocations. The number of counties established under the New Constitution was 47. The county governments shall generate revenue and deliver public services such as water and sanitation services to citizens. Figure 3.1.1 shows the new county boundaries.

According to the Kenya National Bureau of Statistics (KNBS), all cities, municipalities, town councils, urban councils, district headquarters and town and trading centres, with a minimum population of 2,000, were defined as urban areas. This definition applied to the 1989, 1999, and 2009 Censuses. With the New Constitution, the Urban Areas and Cities Bill 2011 was enacted, and it categorises urban areas into two: i) an urban area that includes a municipality and a town, and ii) cities. An urban area with a population of at least 500,000 residents is classified as a city, while a population of more than 250,000 is classified as a municipality, and a population of more than 10,000 is classified as a town. This new classification has not been fully applied yet and in a transition period. Since Kenya Vision 2030 used the previous definition of urban areas by the KNBS, this study adopts the previous definition of urban areas.

3.2 Population

(1) Present Population

The number of persons in Kenya according to the 2009 Population and Housing Census was 38,610,097. Such figure represented an increase of 35% from the population in the 1999 Census at an average growth rate of 3.0% annually. At the national level the growth rate increased marginally from 2.9 to 3.0% annually in the past ten years. In the 1999-2009 period, growth rates have reduced in all provinces except the Rift Valley. The average population density in Kenya was calculated at 68 population/km^2.

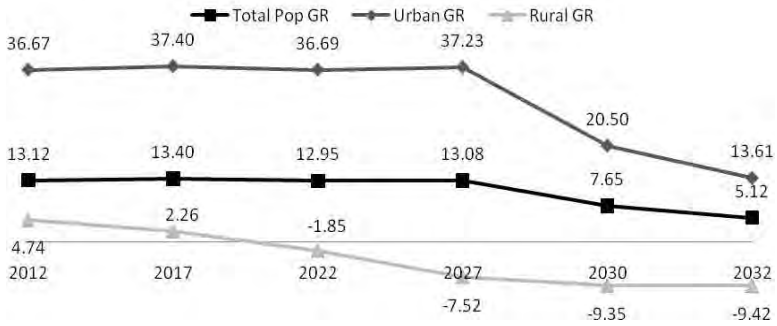
Majority of the population still resides in the rural areas. As of 2009, 67.7% (26,122,722) of the population were living in rural areas and 32.3% (12,487,375) in urban centres. As for the population in urban centres within urban and peri-urban areas in 2009, the urban population was estimated at 11,546,351 people. Out of the 215 urban centres, 137 urban centres, each with a population greater than 10,000, were selected as the target of urban water supply projects. In addition, 95 urban centres were selected for urban sewerage projects.

Table 3.2.1 shows the population of 47 counties in the 2009 Population and Housing Census.

(2) Population Projection

The planning scope of this study is until 2030, but the year 2050 was adopted to evaluate future water resources in Kenya. Therefore, the population projection was made for both 2030 and 2050.

Kenya Vision 2030 presents the future population up to 2032 using the 1999 Census results as the base. This study adopted the 2009 Census data as the base. The average population growth rates according to Kenya Vision 2030 are presented below.



Source: Kenyan Vision 2030

Average Population Growth Rates in Kenya Vision 2030

Since projections beyond 2032 are not available in Kenya, this study adopted the United Nations' projection of Kenya's population in 2050, which is 96.89 million. The average annual growth rate from 2030 to 2050 is 1.94% indicative of a more developed country with a decrease in birth rate and a reduction in internal migration rate from rural to urban. The ratio of urban to rural populations in 2050 was assumed to be the same as in 2030. The table below summarises the national population as projected based on the procedure mentioned above.

Projected Population

(Unit: million persons)

Year	2009 (Census)*		2010		2030		2050	
Area	No.	%	No.	%	No.	%	No.	%
Urban	12.29	32.8	13.08	33.9	46.02	67.8	65.69	67.8
Rural	25.21	67.2	25.45	66.1	21.82	32.2	31.20	32.2
Total	37.50	100.0	38.53	100.0	67.84	100.0	96.89**	100.0

Note: * 2009 Census Population adjusted for eight anomalous Districts
** UN World Urbanisation Prospects: The 2011 Revision
Source: JICA Study Team based on Kenya Vision 2030 and UN projection

The table below shows the population projection[1] by catchment area.

Population Forecast in each Catchment Area

(Unit: million persons)

Catchment Area	2010			2030			2050		
	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total
Lake Victoria North	1.53	5.43	6.96	7.71	4.65	12.36	11.00	6.66	17.66
Lake Victoria South	1.85	5.52	7.37	7.99	4.73	12.72	11.41	6.76	18.17
Rift Valley	1.41	3.45	4.86	4.49	2.96	7.45	6.41	4.23	10.64
Athi	6.51	3.28	9.79	17.73	2.81	20.54	25.31	4.02	29.33
Tana	1.04	4.69	5.73	6.34	4.03	10.37	9.05	5.76	14.81
Ewaso Ng'iro North	0.74	3.08	3.82	1.76	2.64	4.40	2.51	3.77	6.28
Total	13.08	25.45	38.53	46.02	21.82	67.84	65.69	31.20	96.89

Source: JICA Study Team (Ref. Sectoral Report (C), Section 3.2.3)

Figures 3.2.1 and 3.2.2 show the population densities in 2010 and 2030, respectively.

[1] The calculation method is described in Section 3.2.3 at Sectoral Report (C)

3.3 Macro Economy

3.3.1 Present Economic Performance

The economy of Kenya has been largely dependent on agriculture and tourism in the past. According to the 2012 Economic Survey, Kenya continues to recover steadily from the multiple shocks that the country suffered since 2008, despite the recent high oil and food prices and unfavourable weather conditions. The World Bank's Kenya Economic Update for June 2012 projects a gross domestic product (GDP) growth rate of 5.0% for 2012, while the government had estimated at the same level of 5.2%. The major economic indices are as shown in the table below.

Economic Statistics

Indices	2007	2008	2009	2010	2011*
GDP (current price- KSh billion)	1,834	2,108	2,367	2,550	2,671
GDP growth (annual %)	7.0	1.5	2.7	5.8	4.4
Inflation, GDP deflator (annual %)	4.3	16.2	10.5	4.1	14.0
Agriculture, value added (% of GDP)	21.7	22.3	23.5	21.4	24.0
Manufacturing (% of GDP)	10.4	10.8	9.9	9.9	9.4
Electricity and water supply	1.5	2.1	1.9	1.4	0.9
Electricity (% of GDP)	0.8	1.5	1.2	0.7	0.2
Water supply (% of GDP)	0.6	0.6	0.6	0.7	0.7
Transport and communications (% of GDP)	10.6	10.3	9.9	10.0	9.7
Growing of crops and horticulture (growth rate %)	2.7	-7.2	-5	7.5	0.0
Electricity (growth rate %)	11.8	6.1	5.2	11.9	-4.5
Water supply (growth rate %)	1.8	2.9	3.6	3.5	3.2
GDP per capita (US$)	719	774	738	760	774
Balance of trade (KSh billion)	-330	-426	-443	-537	-805

Note: * Provisional
Source: 2012 Economic Survey; Kenya Economic Update June 2012, World Bank

East Africa is the second highest growing region in the world and Kenya is taking advantage of its location. Trade with East African countries has been rapidly growing in the past five years (annual growth rate of 19% in export). The development of the Northern Corridor and the Lamu Port-Southern Sudan- Ethiopia Transport project (LAPSET), which would connect Lamu Port and Southern Sudan and Ethiopia, is expected to enhance the growth in the transport sector and trade among countries. In the water sector, a water supply project transferring water from the High Grand Falls to the Lamu area, and an energy generation project from the same falls have been planned as part of the LAPSET.

3.3.2 GDP Projection

The 2011 Budget Outlook Paper (BOPA) provides the basis of the GDP projection for the medium-term projection. In addition, the overall target of Kenya Vision 2030 to achieve 10% of GDP growth annually by 2017 will be considered for the long-term GDP projection. The BOPA expects a moderate rate of 6.1% in 2012 with a weaker global economy and tighter domestic macroeconomic conditions, but in the medium term the economy is expected to grow up to 7% to accelerate towards Kenya Vision 2030's target.

Kenya Vision 2030 projects a 10% of high growth rate starting from 2016 and would be sustained up to 2023. Given the growth prospect of BOPA in the medium term and the recent growth trend in East Africa, the target of high economic growth envisaged in Kenya Vision 2030 is expected to be achieved

thereafter when key infrastructure development and oil export from Kenya are undertaken. The high growth rate would sustain, as Kenya Vision 2030 projected, and then decline gradually as the economy becomes mature thereafter. It is projected that Kenya will gradually achieve the high growth by approximately 2016, provided the global economy constant and infrastructure development and oil export on track. The projected GDP values are shown in the table below.

Projected Annual GDP Growth Rate up to 2030

Year	%	Year	%	Year	%	Year	%
2010	4	2016	10	2021	10	2026	9
2011	5	2017	10	2022	10	2027	9
2012	6	2018	10	2023	10	2028	8
2013	7	2019	10	2024	9	2029	8
2014	8	2020	10	2025	9	2030	8
2015	9						

Source: Budget Outlook Paper 2011, Projection by Kenya Vision 2030

It is not possible to carry out projections for the next 20 years in a similar way as above due to the lack of long-term data and the unpredictable nature of relevant parameters. For this study it was assumed that following the implementation of Kenya Vision 2030, the Kenyan economy would have reached a level of relative maturity; and with reference to the current GDP rates of stable economies, a GDP rate of 4% per year is applied.

3.4 Public Finance

According to the 2012 Economic Survey, the central government's revenue is expected to record a 15.1% increase, accounting for KSh766.2 billion in 2011/12. The central government's expenditure is expected to record a 35.2% increase, accounting for KSh909.9 billion in 2011/12.

A summary of the government operations from financial year 2007/08 to financial year 2011/12 is provided in the table below.

Statement of Government Operations 2007/08-2011/12

(Unit: KSh million)

Item	2007/08	2008/09	2009/10	2010/11*	2011/12+
GDP at Market Price	1,833,511	2,107,589	2,366,984	2,549,825	3,024,782
1 Revenue[1]	468,243	498,895	574,135	665,462	766,176
Increase of Revenue	20.8%	6.5%	15.1%	15.9%	15.1%
% of GDP	25.5%	23.7%	24.3%	26.1%	25.3%
2 Expenses (2.1+2.2)	448,762	492,669	574,253	673,215	909,911
% of GDP	24.5%	23.4%	24.3%	26.4%	30.1%
2.1 Current Expenditure	417,381	465,970	525,671	621,493	740,975
2.2 Capital Transfers	31,380	26,699	48,581	51,721	168,936
3 Gross Operating Balance (GOB) (1-2)	19,481	6,226	-117	-7,753	-143,735
4 Acquisition of Non-Financial Assets (net)	74,386	113,198	114,823	125,401	156,649
5 Net lending/Borrowing (3-4)	-54,904	-106,972	-114,941	-133,154	-300,384
6 Net Acquisition of Financial Assets (6.1+6.2)	46,244	-9,126	5,659	6,316	5,795
7 Net Incurrence of Liabilities (7.1+7.2)	-7,566	92,549	162,625	143,566	137,317
8 Public Debt Redemption (8.1+8.2)	92,269	75,361	91,714	124,543	89,225

Note: * Provisional, + Revised estimates, [1] includes grants and A-I-A
Acquisition of Non-financial assets (net) = Acquisition of Non-financial assets - Disposal of Non-financial assets
Source: Economic Survey 2012

The form in which the government accounts are kept and published is determined by the administrative structure and the requirements of financial control. The total government spending has increased double since 2007/08 – in particular, a rapid increase in capital expenditure by more than four times of the 2007/08 level. The rise in spending has largely been classified under the development budget. The development expenditure increased from 1.7% of GDP in 2003/04 to 5.6% of GDP in 2011/12.

The government grant given to the water sector remains below 3% of the government's total budget, and less than 1% of GDP, although both aspects are on an upward trend, with the 2012/13 fiscal year recording the highest levels in both (estimated at KSh20.4 billion for development grant). The following table shows the revenue and expenditure in the water sector under the MWI.

Current and Future Projected Revenue and Expenditure in the Water Sector 2012/13-2015/16

(Unit: KSh billion)

Item		Actual	Projected		
		2012/13	2013/14	2014/15	2015/16
Total Revenue	(a: b+c+d)	50.3	54.1	57.3	58.9
Internally Generated	(b)	1.8	2.1	2.1	2.1
Government Grants	(c)	24.8	25.9	27.8	29.4
% of Government's Budget		3.0%	2.9%	2.9%	2.8%
Recurrent Grants	(d)	4.4	4.4	4.7	4.7
Development Grants	(e)	20.4	22.0	23.7	25.4
External Resources	(f)	23.7	26.1	27.4	27.4
Total Expenditure for Development (Including External Resources)	(h: f+i)	44.1	47.6	50.5	52.1
Estimated Development Expenditure by Government Grant	(i: j+k+l+m+n)	20.4	22.0	23.7	25.4
Water Supply	(j)	6.1	6.8	7.3	8.0
Sewerage and Sanitation	(k)	0.7	0.7	0.8	0.8
Irrigation	(l)	8.0	8.4	9.0	9.9
Water Resource Development (Storage)	(m)	5.2	5.6	5.9	6.0
Water Resource Management	(n)	0.4	0.5	0.6	0.7

Source: Ministry of Water and Irrigation, National Irrigation Board, Estimated by the JICA Study Team

There are 15 semi-autonomous government agencies (SAGAs) in the water and irrigation subsectors. SAGAs that implement development projects, such as the National Irrigation Board (NIB) and the National Water Conservation and Pipeline Corporation (NWCPC), have higher resources requirements, and there is deficiency of investment funds seen in such agencies. These two SAGAs have received the most resources from the central government, while the Water Service Boards (WSBs) generally rely on external resources for their capital expenses. In 2012/13, the NIB was allocated a total of KSh6,102 million.

Resource Allocation and Requirements 2011/12-2012/13
(SAGAs in Water and Irrigation)

(Unit: KSh million)

SAGA	Allocation 2011/12	Requirements (1) 2012/13	Allocation (2) 2012/13	Variance (1)- (2)
Water Appeal Board	15.00	20.00	15.00	-5.00
Water Services Regulatory Board	20.00	131.00	20.00	-111.00
Water Resources Management Authority	100.00	1,918.00	100.00	-1,818.00
Water Services Trust Fund	2,182.00	2,576.00	2,302.00	-274.00
Athi Water Services Board	4,322.00	3,224.00	4,322.00	1,098.00
Tana Water Services Board	3,293.00	3,293.00	3,293.00	-
Tanathi Water Services Board	3,770.00	6,387.00	3,640.00	-2,747.00
Rift Valley Water Services	428.00	2,500.00	428.00	-2,072.00
Lake Victoria North Water Services Board	2,998.00	3,008.00	2,998.00	-10.00
Lake Victoria South Water Services Board	2,921.00	2,931.00	2,921.00	-10.00
Northern Water Services Board	1,431.00	2,060.00	1,431.00	-629.00
Coast Water Services Board	3,947.00	4,000.00	3,947.00	-53.00
National Water Conservation and Pipeline Corporation	5,588.00	16,969.00	5,598.00	-11,371.00
National Irrigation Board	6,402.00	12,294.00	6,102.00	-6,192.00
Kenya Water Institute	120.00	130.00	120.00	-10.00
Sub-Total Water and Irrigation	37,267.00	63,441.00	37,237.00	-26,204.00

Source: Environmental Protection, Water & Housing Sector Report: MTEF 2012/13-2014/15

3.5 Household Welfare and Poverty

(1) Household Welfare

It is commonly said that household welfare can be measured by household or individual expenditure rather than income per capita in developing countries such as Kenya, partly because there are many individuals who are self-employed or are engaged in informal economy. The Kenya Integrated Household Budget Survey (KIHBS) 2005/06 provides the most recent available data on household expenditure in Kenya. On average, the monthly expenditure per adult in Kenya accounts for KSh3,432 in 2005/06. There is a huge difference between the urban and rural areas in terms of expenditure per adult. Adults in urban areas spend KSh6,673 per month, while the expenditure of adults in rural areas was estimated at KSh2,331 per month, which is around one-third the expenditure of the urban population

Based on the above data, the monthly expenditure per adult in 2012 was calculated by taking into account the growth rate of real GDP and inflation rate. The annual expenditure per adult in 2012 was estimated at around KSh175,000 in urban areas, and at around KSh61,000 in rural areas.

Half of urban households have access to electricity, as compared to only 5% of households in rural areas. According to the KIHBS, around half of urban households have access to piped water in their

compounds or dwellings, or get water from public taps, while only 12.8% of the rural population have access to piped water. The Western Province is particularly deficient in piped water services, with only 4.6% of its population having access to piped water. About 70% of Kenyan households are located within 15 minutes of their drinking water supply.

(2) Poverty

The reduction of poverty was cited as one of the major objectives in Kenya Vision 2030. On average, around 47% of the population in Kenya was below the poverty line in 2005/06. The poorest districts were concentrated in arid and semi-arid areas such as Turkana District (94.3% of its people are poor), Marsabit District (91.7%), and Mandera District (87.8%). Kenya Vision 2030 gives special attention to poor districts in arid and semi-arid areas for future investments. This study also considers this spatial dimension of poverty for future water resources development.

CHAPTER 4 NATIONAL WATER POLICY AND DEVELOPMENT TARGETS

4.1 National Water Policy

The National Water Policy of Kenya was developed in 1999 as the National Policy on Water Resources Management and Development (NWP 1999). Although it is effective at present, it is currently in the process of revision to align with the new Constitution of Kenya to be the National Water Policy 2012. Based on the NWP 1999, the Water Act was established in 2002.

The NWP 1999 aims to achieve sustainable development and management of the water sector by providing a framework in which the desired targets/goals are set, outlining the necessary measures to guide the entire range of actions and to synchronise all water related activities and actors.

The NWP 1999 set the following specific policy objectives covering four basic areas of water resources management, water supply and sewerage development, institutional arrangement and financing of water sector:

a) Preserve, conserve and protect available water resources and allocate it in a sustainable, rational and economical way.
b) Supply of water of good quality and in quantities that are sufficient to meet the various water needs including poverty alleviation, while ensuring safe disposal of wastewater and environmental protection.
c) Establish an efficient and effective institutional framework to achieve systematic development and management of the water sector.
d) Develop a sound and sustainable financing system for effective water resources management, water supply and sanitation development.

The NWMP 2030 will be formulated in line with the NWP 1999.

4.2 National Development Targets

The GOK published Kenya Vision 2030 in 2007, which is the country's new development blueprint covering the period from 2008 to 2030. Kenya Vision 2030 was aimed at transforming Kenya into a newly industrialising, middle-income country providing a high quality of life to all its citizens by the year 2030.

Kenya Vision 2030 was based on three pillars – the economic, the social and the political. The economic pillar aims to achieve an average gross domestic product (GDP) growth rate of 10% per annum beginning in 2012. The social pillar seeks to build a just and cohesive society with social equity in a clean and secure environment. The political pillar aims to realise a democratic political system, and protects the rights and freedoms of every individual in Kenyan society.

The national development targets on the water sector in Kenya Vision 2030 are as follows:

a) Water and sanitation; to ensure that improved water and sanitation are available and accessible to all by 2030,

b) Agriculture; to increase the area under irrigation to 1.2 million ha by 2030 for increase of agricultural production,

c) Environment; to be a nation that has a clean, secure and sustainable environment by 2030, and

d) Energy; to generate more energy and increase efficiency in the energy sector.

Under Kenya Vision 2030, more concrete targets were proposed as flagship projects[2] on water and sanitation for the period of 2008-2012, which will be taken into account in this study.

[2] Projects such as High Grand Falls Multipurpose Reservoir and Extension of Mzima Pipeline are proposed.

CHAPTER 5 WATER RESOURCES OF KENYA

5.1 Projection of Future Climates

The future water resources situation of Kenya was evaluated considering the potential effects of climate change. The projection of future climates is described in detail in Sectral Report (B). The emission scenario selected for the climate change analysis was A1B scenario because it is physically plausible and consistent, and the potential range of future regional climate change is realistic. In addition, there are a sufficient number of variables on a spatial and temporal scale that allows for impact assessment. A flowchart for projection on effects of future climate change and formulation of water resources development plan is as shown in Figure 5.1.1.

The future climate change was projected based on the outputs of the general circulation models (GCMs) of Phase 3 of the Coupled Model Intercomparison Project (CMIP3) for the period from 2045 to 2065 (2050 climate), which were obtained through the Data Integration and Analysis System under the cooperation of the University of Tokyo's Earth Observation and Fusion Research Initiative and JICA. Considering data availability for the adopted emission scenario A1B and evaluation of the reproducibility of Kenya's climate characteristics, 11 out of 17 GCMs obtained were used for the future projection of 2030 and 2050 climates. The climate of 2030 was interpolated using the climates of 1990 and bias corrected 2050.

According to the multi-model ensemble analysis of 11 GCMs, an increase in surface air temperature seems to be unavoidable in the future. The surface air temperature will increase around 1 ºC by 2030 and 2 ºC by 2050 uniformly for the current climate.

As for estimation of the potential evapotranspiration[3], Hamon method which requires only temperature data for estimation was adopted taking into account insufficiency of available meteorological data. Further, it was tried to roughly estimate the potential evapotranspiration adjusted by FAO Penman-Monteith method based on monthly statistical meteorological data such as atomospheric pressure, temperature, psycrometer, relative humidity, daylight hours, radiation, etc. The estimation method is detailed in Sectoral Report (B).

The estimated mean annual rainfall and mean annual acutual evapotranspiration for the whole country in 2010, 2030 and 2050 are summarised below. Both are predicted to increase toward 2050.

[3] Ref. Sectoral Report (B), Sections 4.1 to 4.5.

Projection of Mean Annual Rainfall and Actual Evapotranspiration

(Unit: mm/year)

Item	2010	2030	2050
Mean Annual Rainfall	679	750	801
Mean Annual Actual Evapotranspiration based on Hamon Method	549	613	659
Mean Annual Actual Evapotranspiration based on FAO Penman-Monteith Method	608	675	723

Note: Figures are ensemble means of 11 GCMs.
Source: JICA Study Team (Ref. Sectoral Report (B), Section 5.4 and 5.5)

The temporal and spacial distributions of the mean annual rainfalls in 2030 and 2050 are similar to the current climate of 2010. In the long rainy season (March to May), the rainfall may increase in the western highland areas and may be unchanged or decrease in the coastal areas. In the dry season (June to August), rainfall may be almost unchanged throughout the country and slightly decrease in the coastal areas.

From the viewpoint of water resources, the western part of Kenya is expected to be wetter, while the eastern part is anticipated to be drier due to the increase of potential evapotranspiration.

5.2 Water Resources

5.2.1 Renewable Water Resources

Renewable water resources are defined to be the theoretically available maximum amount of water resources. It can be estimated by multiplying the value of annual precipitation minus actual annual evapotranspiration by the subject area. Renewable water resources include surface runoff and groundwater recharge, which can be obtained through rainfall-runoff analysis. In this study, the Similar Hydrologic Element Response (SHER) model, which can simulate basin-scale hydrological cycle including river flow, infiltration, groundwater recharge and interflow, was applied for the rainfall-runoff analysis. The future renewable water resources were estimated using the said SHER model with future climate conditions for 2030 and 2050. The rainfall-runoff analysis is detailed in Sectoral Report (B).

Based on the analysis for the potential evapotranspirations estimated by two methods mentioned in the previous Section 4.1, the annual renewable water resources consisting of surface water runoff and groundwater recharge for 2010, 2030 and 2050 were estimated as shown in the table below.

Annual Renewable Water Resources

(Unit: MCM/year)

Evapotranspiration Estimation	Item	2010	2030	2050
Hamon's Method	Renewable Water Resources	76,610	80,474	83,583
	Surface Water Runoff	20,637	24,894	26,709
	Groundwater Recharge	55,973	55,580	56,874
FAO Penman-Monteith Method	Renewable Water Resources	42,107	44,301	45,996
	Surface Water Runoff	20,637	24,894	26,709
	Groundwater Recharge	21,470	19,407	19,287

Source: JICA Study Team (Ref. Sectoral Report (B), Section 5.5 and 5.6)

As seen in the table above, the renewable water resources for the evapotranspiration adjusted by FAO Penman-Monteith method is much less than those for the evapotranspiration estimated by Hamon's method due to larger evapotranspiration. As the surface water runoff remain unchanged since it was calibrated by the observed river discharge, the groundwater recharge is consequently decreased with decrease of the renewable water resources. However, it cannot be concluded which method is reasonable at this moment since no data to properly estimate the evapotranspiration is available.

From the viewpoint of water resources development planning, less groundwater recharge should be employed for planning to avoid the excessive groundwater development. This study finally adopted the renewable water resources and groundwater recharge for the evapotranspiration adjusted by FAO Penman-Monteith method.

The estimated annual surface water runoff (renewable surface water resources) of six catchment areas are summarised in the table below.

Annual Surface Water Runoff by Catchment Area

(Unit: MCM/year)

Catchment Area	Area (km^2)	2010	2030	2050
Lake Victoria North	18,374	4,626	4,969	5,455
Lake Victoria South	31,734	4,773	5,749	7,005
Rift Valley	130,452	2,457	3,045	3,794
Athi	58,639	1,198	1,334	1,711
Tana	126,026	5,858	7,261	7,383
Ewaso Ng'iro North*	210,226	1,725	2,536	1,361
Total	575,451	20,637	24,894	26,709

Note: * The decrease of annual surface water runoff in ENNCA is supposed to be largely affected by the regional climate characteristics that 90% of the total precipitation evapotranspirates. Detailed explanation is given in Sectoral Report (B), Sub-section 5.4.1.
The potential evapotranspiration estimated by Hamon method was applied for surface water runoff estimation.
Source: JICA Study Team (Ref. Sectoral Report (B), Section 5.4)

As shown in the table above, the annual surface water runoff in all catchment areas except the Ewaso Ng'iro North Catchment Area are expected to increase. The annual surface water runoff in Ewaso Ng'iro North Catchment Area has a trend to increase toward 2030, but would then decrease toward 2050 due to the increase of the potential evapotranspiration. This contradicting trend is observed due to the sensitive balance of rainfall increase and evaporation increase. Figure 5.2.1 shows the distribution of surface water runoff.

The estimated annual groundwater recharges (renewable groundwater resources) of six catchment areas are shown in the table below.

Annual Groundwater Recharges by Catchment Area

(Unit: MCM/year)

Catchment Area	Area (km^2)	2010	2030	2050
Lake Victoria North	18,374	1,326	1,251	1,612
Lake Victoria South	31,734	2,294	2,111	2,126
Rift Valley	130,452	1,126	1,126	1,209
Athi	58,639	3,345	3,303	3,649
Tana	126,026	7,719	6,520	5,840
Ewaso Ng'iro North	210,226	5,660	5,095	4,851
Total	575,451	21,470	19,407	19,287

Note: The potential evapotarnspiration adjusted by FAO Penman-Monteith method was applied for groundwater recharge estimation.
Source: JICA Study Team (Ref. Sectoral Report (B), Section 5.5)

The annual groundwater recharge is given by subtracting the annual surface water runoff from the annual renewable water resources (Precipitation – Evapotranspiration) as an annual water budget. Seeing the table above from the long term span, Tana and Ewaso Ng'iro North catchment areas show the clear decrease trend compared with other catchment areas. Figure 5.2.2 shows the distribution of groundwater recharge.

5.2.2 Sustainable Groundwater Yield

The estimated renewable groundwater recharges are not fully usable. It is quite difficult to estimate the sustainable yield of groundwater. According to the study researches of Ponce (2008) and U.S. Geological Survey Circulars 1186 and 1200 (1998, 1999), sustainable groundwater yield may reasonably be around 10% of groundwater recharge taking into consideration the aspects of hydrology, ecology, socio-economy, culture, etc. This study also adopted 10% of groundwater recharge as sustainable yield, but the river and riparian areas with 1 km wide were excluded from the expected groundwater abstraction areas as the groundwater abstraction in such areas should be restricted. As for the depth of groundwater, the deepest existing boreholes for water use purpose are at around 400 to 500 m at maximum. Therefore, this depth was regarded as the maximum for exploitation in the study. It was decided not to consider water use deeper than this, such as geothermal water.

Accordingly, the sustainable yields of groundwater by catchment area were estimated as given in the table below. Figure 5.2.3 shows the distribution of sustainable groundwater yields.

Estimated Sustainable Yield of Groundwater by Catchment Area

(Unit: MCM/year)

Catchment Area	Area (km^2)	2010	2030	2050
Lake Victoria North	18,374	116	108	140
Lake Victoria South	31,734	203	188	190
Rift Valley	130,452	102	102	109
Athi	58,639	305	300	332
Tana	126,026	675	567	508
Ewaso Ng'iro North	210,226	526	475	449
Total	575,451	1,927	1,740	1,728

Source: JICA Study Team (Ref. Sectoral Report (B), Section 7.7)

Although the 10% value was tentatively used for this study to estimate the above sustainable yield of groundwater, such value should be carefully determined based on a more detailed study.

5.2.3 Available Water Resources

The available water resources is defined as a total of annual surface water runoff and sustainable yield of groundwater resources mentioned above. It is the maximum available water resources for development. The available water resources of six catchment areas are given in the table below.

Available Water Resources by Catchment Area

(Unit: MCM/year)

Catchment Area	Area (km^2)	2010	2030	2050
Lake Victoria North	18,374	4,742	5,077	5,595
Lake Victoria South	31,734	4,976	5,937	7,195
Rift Valley	130,452	2,559	3,147	3,903
Athi	58,639	1,503	1,634	2,043
Tana	126,026	6,533	7,828	7,891
Ewaso Ng'iro North	210,226	2,251	3,011	1,810
Total	575,451	22,564	26,634	28,437

Source: JICA Study Team

5.2.4 Per Capita Water Resources

Based on the renewable water resources estimated and projected in the previous sections, per capita water resources was calculated by catchment area and for 2010, 2030 and 2050 by applying the population estimated and projected in Chapter 3. The results of calculation are shown in the table below.

Per Capita Renewable Water Resources

Catchment Area	2010		2030		2050	
	Population (million)	Per Capita (m^3/c/year)	Population (million)	Per Capita (m^3/c/year)	Population (million)	Per Capita (m^3/c/year)
Lake Victoria North	6.96	855	12.36	503	17.66	400
Lake Victoria South	7.37	959	12.72	618	18.17	503
Rift Valley	4.86	737	7.45	560	10.64	470
Athi	9.79	464	20.54	226	29.33	183
Tana	5.73	2,369	10.37	1,329	14.81	893
Ewaso Ng'iro North	3.82	1,933	4.40	1,735	6.28	989
Whole Country	38.53	1,093	67.84	653	96.89	475

Source: JICA Study Team

In addition, per capita available water resources was calculated by using the renewable surface water resources and sustainable groundwater yield. The results of calculation are shown in the table below.

Per Capita Available Water Resources

Catchment Area	2010		2030		2050	
	Population (million)	Per Capita (m^3/c/year)	Population (million)	Per Capita (m^3/c/year)	Population (million)	Per Capita (m^3/c/year)
Lake Victoria North	6.96	681	12.36	411	17.66	317
Lake Victoria South	7.37	675	12.72	467	18.17	396
Rift Valley	4.86	527	7.45	422	10.64	367
Athi	9.79	154	20.54	80	29.33	70
Tana	5.73	1,142	10.37	758	14.81	534
Ewaso Ng'iro North	3.82	589	4.40	684	6.28	288
Whole Country	38.53	586	67.84	393	96.89	294

Source: JICA Study Team

As shown in the above tables, the per capita renewable and available water resources have much decreased toward 2030, which is the planning target year.

It should be noted that the per capita water resources of 2050 were obtained under uncertainty of the climate change effects, and also the water demand was very roughly projected due to absence of a national development plan. The per capita water resources of 2050 should be for reference only.

CHAPTER 6 PRESENT WATER USE AND FUTURE WATER DEMANDS

6.1 General

The present water use estimation and future water demand projection were made for the categories of domestic, industrial, irrigation, livestock, wildlife and inland fisheries uses for subsequent water resources development and management planning.

As for present water use, actual water use data were not sufficiently available for estimation; therefore, the present water demand was estimated instead of the present water use.

The future water demands were projected based on the socioeconomic frameworks set in Kenya Vision 2030, which is a national development plan of Kenya toward 2030.

The water demands were estimated for the year 2010 and projected for the years 2030 and 2050. The projection for 2030 was intended to formulate the NWMP 2030, while the projection for 2050 was intended to assess the vulnerability of water resources in the future considering the effects of climate change. The estimation for 2010 was intended to grasp the current situation.

6.2 Basic Conditions for Projection

(1) Population

The populations in 2010 and 2030 were estimated and projected as presented below, based on Kenya Vision 2030's projection and the 2009 Census as mentioned previously in Chapter 3. The population in 2050 depended on the projection made by the United Nations in 2011 because population projection beyond 2032 was not available in Kenya and very difficult to predict. The ratio of urban to rural populations in 2050 was assumed to be the same as in 2030.

Projected Population

(Unit: million persons)

Year	2009 (Census)*		2010		2030		2050	
Area	Population	%	Population	%	Population	%	Population	%
Urban	12.29	32.8	13.08	33.9	46.02	67.8	65.69	67.8
Rural	25.21	67.2	25.45	66.1	21.82	32.2	31.20	32.2
Total	37.50	100.0	38.53	100.0	67.84	100.0	96.89**	100.0

Note: * Census 2009 Population adjusted for eight anomalous Districts

** UN World Urbanisation Prospects: The 2011 Revision

Source: JICA Study Team based on Kenya Vision 2030 and UN projection

(2) GDP Growth Rate

The annual growth rates of GDP up to 2030 were projected by the office of Kenya Vision 2030 as mentioned in Chapter 3. The projected growth rates are provided in the table below. The annual growth rate of GDP up to 2050 was set at 4% assuming that the Kenyan economy would have reached a level of relative maturity following the implementation of Kenya Vision 2030.

Projected Annual GDP Growth Rates

Year	Growth Rate (%)	Year	Growth Rate (%)	Year	Growth Rate (%)	Year	Growth Rate (%)
2010	4	2016	10	2021	10	2026	9
2011	5	2017	10	2022	10	2027	9
2012	6	2018	10	2023	10	2028	8
2013	7	2019	10	2024	9	2029	8
2014	8	2020	10	2025	9	2030	8
2015	9						

Source: Kenya Vision 2030

6.3 Domestic Water Demand

6.3.1 Present Domestic Water Demand

Domestic water demand comprises residential, institutional and commercial demands. The water demand calculations were carried out using data on population projection, design unit water consumption ratio, ratio of institutional/commercial water use, non-revenue water (NRW) ratio, and percentage of satisfaction. The conditions for estimation are as follows:

a) The current population was estimated based on the 2009 Census.
b) In line with common international practices and bearing in mind the fundamental lack of raw data, the institutional demand was calculated based on 10% of residential demand, and commercial demand was calculated based on 15% of urban demand and 10% of rural demand.
c) An NRW ratio of 45% was adopted. This NRW ratio was the national average in 2010.
d) The design water consumption rates were taken from the MWI Design Manual as shown on the table below.
e) It was assumed that the current water supply system could satisfy only 61% of the design water consumption amount, according to results of the water use survey in this study.

Design Water Consumption Rates

(Unit: L/p/d)

Consumer	Urban Population			Rural Population		
	High Class Housing	Medium Class Housing	Low Class Housing	High Potential	Medium Potential	Low Potential
People with individual connections	250	150	75	60	50	40
People without connections	-	-	20	20	15	10

Source: MWI Design Manual for Water Supply in Kenya

The current domestic water demand based on the design manual was estimated, as shown below.

Estimated Present Domestic Water Demand

(Unit: MCM/year)

Year	2010
Domestic Water Demand	1,186

Source: JICA Study Team (Ref. Sectoral Report (C), Sub-section 3.4.2)

6.3.2 Future Domestic Water Demand

The future domestic water demand was projected by the methodology set out in the MWI Design Manual for Water Supply in Kenya, October 2005. The basic conditions for the projection were as follows:

(1) Target Coverage Ratio

To achieve the target level of water supply, a water supply system shall be developed. The current conditions and target levels of coverage of the water supply system are shown in the table below.

Current Conditions and Target Levels of Coverage of Water Supply Systems

(Unit: million persons)

Year	Area	Piped by WSPs	Spring/Well/Borehole	Water Vendor	Stream, Lake, Pond, Others
2010	Urban	7.1 (54%)	3.1 (24%)	1.7 (13%)	1.2 (9%)
	Rural	4.1 (16%)	10.9 (43%)	0.5 (2%)	9.9 (39%)
	Total	11.2 (28%)	14.0 (37%)	2.2 (6%)	11.1 (29%)
2030	Urban	46.0 (100%)	0.0 (0%)	0.0 (0%)	0.0 (0%)
	Rural	4.7 (22%)	17.1 (78%)	0%	0%
	Total	50.7 (75%)	17.1 (25%)	0%	0%

Source: JICA Study Team based on Census 2009 data, Kenya Vision 2030 and Water Service Strategic Plan 2009

(2) Unit Water Demand of Domestic Water Use

The domestic water demand includes residential water demand, institutional water demand, commercial water demand and water loss (Hereinafter, the NRW ratio is used also as an approximation of ratio of water loss). For water demand calculation, first of all, a unit water demand for residential use was assumed, based on standard values in the Guidelines for Water Allocation, 2010. In the draft of the new Water Act 2012, the minimum requirement of unit residential water demand was set at 25 L/person/day, though some of the standard values are less than 25 L/person/day in the guideline. In the water demand projection, the unit residential water demand was proposed not less than 25 L/person/day. The table below shows the standard values and proposed unit water demands for residential use.

Standard Value and Proposed Value of Unit Residential Water Demand

(Unit: L/p/d)

Category		Standard Value (including allowance for water loss)	Standard Value (excluding allowance for water loss)	Proposed Value (excluding allowance for water loss)
Urban Population	High Class Housing	250	200	200
	Middle Class Housing	150	120	120
	Low Class Housing			
	Individual Connection	75	60	60
	Non-individual Connection	-	20	30
Rural Population	Individual connection	High: 60 Medium: 50 Low: 40	High: 48 Medium: 40 Low: 40	High: 60 Medium: - Low: 40
	Non-individual connection	High: 20 Medium: 15 Low: 10	High: 20 Medium: 15 Low: 10	High: 30 Medium: - Low: 25

Source: JICA Study Team, based on Guidelines for Water Allocation, 2010 (WRMA)

According to the guideline, the water demands are estimated for each categories of water users in urban and rural population separately. However, there is no enough information on percentage of future water users by category, such as high, middle and low class housing, and individual and non-individual connections. The percentages of water users by category were assumed and the unit residential water demands was estimated by target area, as shown in the table below.

Assumed Unit Residential Water Demand by Target Area

Category		Unit Residential Water Demand for Each Category (L/p/d)	Percentage of Water Users in Each Target Area				
			1)	2)	3)	4)	5)
Urban Population	High Class Housing	200	6%	5%	-	-	-
	Middle Class Housing	120	50%	30%	-	-	-
	Low Class Housing						
	Individual Connection	60	22%	30%	-	-	-
	Non-individual Connection	30	22%	35%	-	-	-
Rural Population	Individual Connection						
	High Potential	60	-		65%	20%	
	Low Potential	40	-				20%
	Non-individual Connection						
	High Potential	30			35%	80%	
	Low Potential	25					80%
Estimate of Unit Residential Water Demand for Each Target Area (L/p/d)			92	75	50	36	28

Note: The target areas are 1) urban water supply for Nairobi, Mombasa and Kisumu, 2) urban water supply for other urban areas, 3) large scale rural water supply, 4) small scale rural water supply in non-arid areas, and 5) small scale rural water supply in arid areas.
The percentages of water users in the target area 1) were estimated based on the conditions of the Draft Feasibility Study and Master Plan for developing New Water Sources for Nairobi and Satellite Towns.
The percentages of water users in other target areas were estimated based on current situation.
The arid area is categorised as low potential, and other areas are categorised as high potential.

Source: JICA Study Team based on Guidelines for Water Allocation, 2010(WRMA)

In addition to the unit water demand for residential use, institutional water demand, commercial water demand and NRW were determined for projection of future domestic water demand of each urban centre and area, as shown in the table below.

Proposed Unit Water Supply Amount

Target Area	(a) Unit Water Supply Amount for Residential Water Use (L/p/d)	(b) Planning Ratio of Institutional & Commercial Water Use	(c) NRW Ratio	(d) Unit Water Supply Amount for Domestic Water Use (L/p/d)
1) Urban Water Supply for Nairobi, Mombasa and Kisumu	92	27%	20%	146
2) Urban Water Supply in Other Urban Areas	75	27%	20%	119
3) Large Scale Rural Water Supply	50	22%	20%	76
4) Small Scale Rural Water Supply in Non Arid Areas	36	22%	20%	55
5) Small Scale Rural Water Supply in Arid Areas	28	20%	20%	42

Note: (a) Unit Water Supply Amount for Residential Water Use is to meet "Estimate of Unit Residential Water Demand for Each Target Area".
(b) Planning Ratio of Institutional and Commercial Water Use was assumed considering current situation and existing water supply development plans.
(c) NRW Ratio is target in Water Service Strategic Plan 2009.
(d) Unit Water Supply Amount for Domestic Water Use is given by (a) x (1 +(b))/(1-(c)).

Source: JICA Study Team based on Kenya Vision 2030 and Water Service Strategic Plan in 2009

(3) Future Domestic Water Demand

The future domestic water demand, as shown below, was projected based on the abovementioned conditions.

Projected Future Domestic Water Demand

(Unit: MCM/year)

Year	2030	2050
Industrial Water Demand	2,561	3,657

Source: JICA Study Team (Ref. Sectoral Report(C), Sub-section 3.4.3)

6.4 Industrial Water Demand

6.4.1 Present Industrial Water Demand

Sufficient data relevant to industrial activities to carry out the present and future water demand estimation are not available. In this study the industrial activity level was assumed to be represented by the ratio of number of firms per district and the total number of registered firms in the country.

It is safe to assume that districts with high industrial activity will have a higher industrial water usage as a % of the population water demand. Based roughly on the methodology adopted in the Aftercare Study (1998) and the industrial activity analysis, 158 districts were classified as high, medium, low or non activity levels, and grouped based on the following criteria. List of districts by each industrial activity are described in Table 3.5.1 of Sectoral Report (C).

Criteria of Industrial Activity Level

Industrial Activity	Criteria (% of Firms per District)	Area
High	>3%	11 districts
Medium	1% - 3%	16 districts
Low	0% - 1%	104 districts
Non	0%	27 districts

Source: JICA Study Team, based on Aftercare Study(1998)

For each group, the following consumption rates as a percentage of urban water demand were applied in this study. It is noted that the percentages were adjusted from the Aftercare Study (1998) to account for the different approach in the industrial activity grouping of the districts and the separation of commercial activities included under domestic demand.

Water Consumption Rate by Industrial Group

Industrial Group	% of Urban Water Demand
High Activity Group	25%
Medium Activity Group	15%
Low Activity Group	5%
Non Activity Group	0%

Source: JICA Study Team, based on Aftercare Study(1998)

The present industrial water demand was calculated by multiplying the above rates with urban domestic water demand.

Estimated Present Industrial Water Demand

(Unit: MCM/year)

Year	2010
Industrial Water Demand	125

Source: JICA Study Team (Ref. Sectoral Report(C), Sub-section 3.4.3)

6.4.2 Future Industrial Water Demand

The future industrial water demand in 2030 was projected based on the premise that industrial water use will increase in line with the growth of urban water demand. Industrial water demand up to 2030 was calculated using the same method for present water demand calculation. The water demand in 2050 was estimated assuming that the economy would have matured sufficiently and an average GDP value of 4% was applied. The projected industrial water demand is shown below.

Projected Future Industrial Water Demand

(Unit: MCM/year)

Year	2030	2050
Industrial Water Demand	280	613

Source: JICA Study Team (Ref. Sectoral Report(C), Sub-section 3.5.3)

6.5 Irrigation Water Demand

6.5.1 Present Irrigation Water Demand

(1) General

The irrigation water demands in 2010 under present conditions were estimated for 204 hydrological sub-basins on a monthly basis under probable five year drought conditions. Because of the limitation of available data such as meteorological data, cropping pattern, irrigation efficiencies and exact locations of irrigation schemes, the present irrigation water demands were estimated based on several assumptions. Monthly irrigation water demands were calculated by multiplying irrigation area, monthly unit water requirement, monthly cropping intensity, and irrigation efficiency.

(2) Estimation of Present Irrigation Area

The irrigation area at present conditions by type in 2010 was estimated under the following conditions:

a) Large-scale scheme: Reported areas by the NIB and listed areas based on water permits of the WRMA

b) Small-scale scheme: Identified by DIOs offices under Irrigation and Drainage Department of MWI

c) Private scheme: Identified by the regional offices of the WRMA and estimated area based on water permits granted by the WRMA

The existing irrigation areas by county and by type in 2010 are listed in Table 6.5.1. These figures were summarised by catchment area, as shown in the table below.

Existing Irrigation Area by Type and by Catchment Area in 2010

(Unit: ha)

Catchment Area	Existing Irrigation Area in 2010			
	Total	Large Scale	Small Scale	Private
Lake Victoria North	1,876	363	1,327	186
Lake Victoria South	13,218	1,800	10,225	1,193
Rift Valley	9,587	774	5,791	3,022
Athi	44,898	0	13,524	31,374
Tana	64,425	11,200	14,823	38,402
Ewaso Ng'iro North	7,896	0	6,233	1,663
Total	141,900	14,137	51,923	75,840

Source: JICA Study Team based on the Inventory Survey conducted from Jan.-Mar. 2011 in this study.

(3) Unit Water Requirements by Sub-basin

To estimate unit water requirement by sub-basin, the report prepared by the Irrigation Section of the Ministry of Water Development in 1985, which were used in the NWMP (1992), were applied in this study, because this report has been reliable and still usable though no updating has been done yet. The estimated values for green grass cover under an irrigation efficiency of 60% were applied as the basic requirement, and such values were adjusted using assumed cropping patterns and cropping intensity. The iso-annual irrigation water requirement is presented in Figure 6.5.1. Following the unit water requirement in the book by region, the monthly unit water requirement (m^3/s/1,000 ha) by sub-basin under 60% irrigation efficiency were estimated as shown in Tables 6.5.2. An average of the unit water requirement by location is summarised below for reference.

Unit Irrigation Water Requirement by Climate Zone

(Unit:m^3/s/1000 ha)

Climate Zone	Elevation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Humid	> 1,500 m	0.83	0.73	0.59	0.05	0.00	0.00	0.34	0.32	0.70	0.37	0.32	0.54
Semi Humid	1000-1500	1.00	0.96	0.62	0.14	0.21	0.62	0.73	0.73	0.91	0.60	0.56	0.74
Semi Arid	500-1000	1.07	1.07	1.04	0.76	1.04	0.91	0.98	0.98	1.08	0.88	0.81	0.84
Arid	< 500 m	1.21	1.27	1.24	0.85	1.06	1.15	1.12	1.18	1.26	0.95	0.99	1.14

Source: JICA Study Team, based on Water Requirement for irrigation in Kenya (MWD, 1995)

The estimated monthly unit water requirements by sub-basin are shown in Tables 6.5.2.

(4) Assumed Cropping Pattern and Cropping Intensity

Based on information provided by WRMA on water permit for rainy and dry seasons and by referring to the rainfall patterns in the county, etc., it was assumed that most of irrigation areas could be irrigated at 80% of the registered irrigation area during the long rainy season (March to May) and 60% in the short rainy season (October to December), considering less water management and lack of proper management. Low water demands may occur in June to September during the dry season. The assumed cropping pattern and cropping intensity for the six catchment areas are shown in the table below. The annual cropping intensity was assumed at 140% (long rainy season 80%+ short rainy season 60%).

Assumed Present Cropping Pattern and Cropping Intensity

(Unit: %)

Catchment Area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lake Victoria North	*60*	*60*	*80*	*80*	*80*	*80*	*40*		*40*	*60*	*60*	*60*
Lake Victoria South	*60*	*60*	*80*	*80*	*80*	*80*	*40*		*40*	*60*	*60*	*60*
Rift Valley			*40*	*80*	*80*	*80*	*80*	*40*	*40*	*60*	*60*	*60*
Athi		*40*	*80*	*80*	*80*	*40*			*40*	*60*	*60*	*60*
Tana		*40*	*80*	*80*	*80*	*40*			*40*	*60*	*60*	*60*
Ewaso Ng'iro North		*40*	*80*	*80*	*80*	*40*			*40*	*60*	*60*	*60*

Note: Assumed cropping season based on information from WRMA
Source: JICA Study Team based on information by WRMA on water permit for irrigation

(5) Present Irrigation Water Demand

The present irrigation water demand of existing irrigation areas in 2010, as shown in the table below, was estimated based on the conditions mentioned above.

Estimated Present Irrigation Water Demand in 2010

(Unit: MCM/year)

Type of Scheme	LVNCA	LVSCA	RVCA	ACA	TCA	ENNCA	Total
Large-scale Scheme	4	22	12	0	130	0	168
Small-scale Scheme	13	121	90	164	173	74	635
Private Scheme	1	12	41	334	393	18	799
Total	18	155	143	498	696	92	1,602

Source: JICA Study Team (ref. Sectoral Report(E), Section 3.3)

The annual total irrigation water demand for existing irrigation area of 141,900 ha in 2010 was estimated at 1,602 MCM/year, or an overall average of 11,290 m^3/ha, assuming 140% annual cropping intensity and 60% irrigation efficiency.

6.5.2 Future Irrigation Water Demands

(1) Method and Assumptions for Estimation of Future Irrigation Demands

Future cropping pattern is one of the key factors that will much affect irrigation water demand. Based on rainfall pattern by basin, the availability of river water in the short rainy season by basin, and the type of irrigation, future cropping pattern and cropping intensity were assumed from a viewpoint of maximising the irrigation area under full use of available water resources.

Regarding diversion of river water for weir irrigation projects, the cropping pattern and cropping intensity were assumed such that the irrigation area could be 100% of the project area in the long rainy season (March to May) and 60% in the short rainy season (October to December). The assumed cropping patterns and cropping intensity for the case of 160% annual cropping intensity (long rainy season 100%+ short rainy season 60%) are shown below.

Standard Future Cropping Pattern and Cropping Intensity for Weir Irrigation in 2030

(Unit: %)

Catchment Area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lake Victoria North	*60*	*60*	*50*	*100*	*100*	*100*	*50*		*30*	*60*	*60*	*60*
Lake Victoria South	*60*	*60*	*50*	*100*	*100*	*100*	*50*		*30*	*60*	*60*	*60*
Rift Valley			*50*	*100*	*100*	*100*	*50*		*30*	*60*	*60*	*60*
Athi		*50*	*100*	*100*	*100*	*50*			*30*	*60*	*60*	*60*
Tana		*50*	*100*	*100*	*100*	*50*			*30*	*60*	*60*	*60*
Ewaso Ng'iro North		*50*	*100*	*100*	*100*	*50*			*30*	*60*	*60*	*60*

Source: JICA Study Team, based on information from WRMA and MOA

However, for weir irrigation projects located in semi-arid zones in RVCA, ACA, TCA and ENNCA, the annual cropping intensity was assumed to be 100~160% depending on available river discharge in the short rainy season. On the other hand, the annual cropping intensity for large dam irrigation projects was assumed to be 160% from a viewpoint of maximum utilisation of available water in the long rainy season and to be able to justify the project economically. For small dam/pond and water pan irrigation, the annual cropping intensity was assumed at 100% (no cropping in the short rainy season). For groundwater irrigation, the same cropping pattern and intensity assumed for weir irrigation were applied.

The cropping patterns and intensities may differ by condition. Reflecting the hydrological characteristics and availability of water resources for irrigation in each catchment area, the annual cropping intensity applied for water demand estimation was assumed as follows:

- Large dam irrigation (all catchment areas): 160 %
- Weir irrigation in LVNCA and LVSCA: 160 %
- Weir irrigation in RVCA and TCA: 130 % (but 100% in ASAL)
- Weir irrigation in ACA and ENNCA: 100%
- Small dam/pond and water pan irrigation: 100%
- Groundwater irrigation: 160%

(2) Unit Water Requirements

The same procedure and assumptions mentioned in Subsection 6.5.1 (3) were applied for the estimation of future irrigation water demand. As explained in Section 7.5, the introduction of water saving methods is a key concept for irrigation development in order to raise water productivity and to maximise the irrigation area within the available water resources toward 2030 as mentioned in Section 7.5.2 (Overall Concept and Framework).

Irrigation efficiency by type of irrigation method and their combination are shown in the following table.

Irrigation Efficiency by Irrigation Method and Combination

Category	Irrigation Method	Efficiency
Type of Method	Basin irrigation (present)	50-55%
	Furrow irrigation (present)	60%
	Furrow irrigation (piped)	65%
	Sprinkler irrigation	70-75%
	Drip irrigation	90%
Combination	Furrow (50%) + Sprinkler (25%) + Drip (25%)	69%

Source: JICA Study Team based on WRMA Guideline

For the calculation of irrigation water demand by sub-basin in 2030, the overall irrigation efficiency was proposed to be 70% considering the successful introduction of water saving methods (piled, sprinkler and drip methods) by 2030.

(3) Future Irrigation Area

Kenya Vision 2030 has set a national goal of increasing the new irrigation area to 1.2 million ha by 2030. Large-scale (public), small-scale (smallholders) and private irrigation schemes are included. According to the irrigation potential area proposed by MOA in the "Irrigation and Drainage Master Plan" by MWI in 2009, the distribution of 1.2 million ha of the new irrigation area by sub-basin was projected as presented in the table below.

Projected Distribution of New Irrigation Area of 1.2 Million ha

(Without Water Balance Study)

Catchment Area	LVNCA	LVSCA	RVCA	ACA	TCA	ENNCA	Total
New Irrigation Area (ha)	90,786	186,978	63,493	233,628	482,450	142,665	1,200,000

Source: JICA Study Team based on Irrigation and Drainage Master Plan" by MWI in 2009 (Ref. Sectoral Report (E), Section 3.4)

The estimated irrigation water demands for the above areas are shown below.

Estimated Irrigation Water Demand for 1.2 Million ha

Catchment Area	LVNCA	LVSCA	RVCA	ACA	TCA	ENNCA	Total
Demand (MCM/year)	799	2,169	932	2,922	7,072	2,552	16,446

Source: JICA Study Team (Ref. Sectoral Report (E), Section 3.4)

The total irrigation water demand was estimated at 16,446 MCM/year or an overall average of 13,705 m^3/ha, assuming 160% annual cropping intensity and 60% irrigation efficiency without introduction of water saving irrigation method.

However, after the preliminary water balance study, it was revealed that the amount of available water resources was not enough to fulfill the water demands required for the 1.2 million ha irrigation area mentioned above. Therefore, the future possible irrigation area was determined based on the water balance study, aiming to maximise the irrigation area within the available amount of water resources. Irrigation area by water resources and by type of water source facilities will be estimated using the following criteria.

Criteria for Determination of Future Irrigation Area

No	Type	Criteria to Determine Irrigation Area
1	Weir irrigation	Maximum irrigation area by weir is estimated through the water balance study between irrigation water demand and available river discharge for irrigation (after deducting water demand of priority users) in each sub-basin.
2	Dam irrigation	Maximum irrigation area by dam is estimated through the water balance study between irrigation water demand and available river discharge for irrigation (after deducting water demand of priority users) in each sub-basin. Irrigation projects proposed by the government authorities are taking into account.
3	Groundwater irrigation	Maximum irrigation area by groundwater is estimated by dividing available groundwater for irrigation (after deducting water demand of priority users) in each sub-basin by the peak monthly unit water requirement. Average unit water requirement is assumed to be7,500 m^2/year/ha.
4	Water Harvesting Irrigation (Small dam /water pan)	Total irrigation area by water harvesting is assumed to be 4% of the new surface irrigation area and then distributed to six catchment areas based on the agricultural potential areas. Average unit water requirement is assumed to be 8,000 m^2/year/ha.

Source: JICA Study Team

Based on the above criteria, the possible maximum new irrigation areas by weir and dam were estimated through the water balance study between irrigation water demand and available surface water for irrigation (after deducting water demands of priority users) in each sub-basin as shown in Table 6.5.3. Figure 6.5.2 shows the surface water irrigation area by sub-basin.

The possible maximum new groundwater irrigation area estimated by the above criteria is shown in Table 6.5.4. Figure 6.5.3 shows the groundwater irrigation area density by sub-basin.

The irrigation area by the proposed large dam projects (24 dams, consisting of 18 multipurpose dams, four single purpose dams and two existing dams) was estimated at 396,392 ha in total as shown in Table 6.5.5.

The possible maximum irrigation areas in 2030 are given in Table 6.5.6 and summarised in the following table.

Possible Irrigation Area by Catchment Area in 2030

(Unit: ha)

Type of Irrigation	LVNCA	LVSCA	RVCA	ACA	TCA	ENNCA	Total
New Irrigation Area							
Weir Irrigation Area	95,875	27,977	15,335	5,350	4,961	4,202	148,420
Dam Irrigation Area	65,770	73,772	71,850	32,000	131,000	22,000	396,392
Water Harvesting Irrigation Area	3,700	4,590	2,890	4,140	5,730	950	22,000
Groundwater Irrigation Area	3,568	6,867	2,091	4,618	20,108	14,331	51,583
Subtotal	168,913	113,206	92,166	46,108	161,799	41,483	623,675
Existing Irrigation Area	1,876	13,218	9,587	44,898	64,425	7,896	141,900
Total	170,789	126,424	101,753	91,006	226,224	49,379	765,575

Source: JICA Study Team (Ref. Sectoral Report (E), Section 3.4)

(4) Future Irrigation Water Demand

Based on assumptions for the estimation of irrigation demands and future irrigation areas above, the estimated future irrigation demands are presented in Table 6.5.7 and summarised in the following table.

Projected Future Irrigation Water Demand in 2030

(Unit: MCM/year)

Type of Irrigation	LVNCA	LVSCA	RVCA	ACA	TCA	ENNCA	Total
New Irrigation Area							
Weir Irrigation Area	749	183	110	40	37	31	1,150
Dam Irrigation Area	535	732	1,101	311	1,767	302	4,748
Water Harvesting Irrigation Area	30	37	23	33	46	7	176
Groundwater Irrigation Area	27	51	16	35	151	107	387
Subtotal	1,341	1,003	1,250	419	2,001	447	6,461
Existing Irrigation Area	18	155	143	498	696	92	1,602
Total	1,359	1,158	1,393	917	2,697	539	8,063

Source: JICA Study Team

The total annual irrigation water demand for the future irrigation area of 765,575 ha in 2030 was estimated at 8,063 MCM/year, or an overall average unit water demand of 10,532 m^3/ha, assuming 70% irrigation efficiency and 160%~100% annual cropping intensity.

The irrigation water demand in 2050 is the same as that in 2030 because the proposed irrigation area of 765,575 ha in 2030 is the possible maximum irrigation development area determined by the water balance study.

6.6 Livestock Water Demand

6.6.1 Present Livestock Water Demand

The 2009 Census has data on livestock population at district level in the whole of Kenya and such data were used as basis for this projection. In 2009 there were 17.5 million cattle, 17.1 million sheep, 27.7 million goats, and 2.9 million camels.

There are many different forms of livestock. The livestock unit (LU) is used as a standard for the purpose of estimating water demand. According to the Guideline of Water Allocation, 2010, the water consumption ratio is 50 L/head/day as based on livestock units, and the applied conversion factors are shown in the following table.

Livestock Unit

Livestock	Equivalent to One Livestock Unit (LU)
Grade cow	1 head
Indigenous cow	3 head
Sheep or goats	15 head
Donkeys	5 head
Camels	2 head

Source: JICA Study Team based on Guidelines for Water Allocation (WRMA, 2010)

The livestock population per district were then converted to LUs by multiplying the number of animals with their respective LU conversion factor given above. The census shows the number of cattle, but does not classify the respective numbers of grade cow and indigenous cow. Since data on the proportion of grade cow and indigenous cow are not available, the proportions adopted in this study are as shown in the following table.

Proportion of Grade Cow and Indigenous Cow

Area	Grade Cow	Indigenous Cow
Non Arid Area/ Semi-Arid Area	50%	50%
Arid Area	0%	100%

Source: JICA Study Team (Ref. Sectoral Report (C), Sub-section 3.6.2)

For the calculation of livestock water demand, the number of livestock was calculated only for cattle, sheep, goat and camel, while other livestock such as poultry, donkey, pigs etc. were assumed negligible. The number of livestock units in 2010 was estimated at around 14.0 million. The livestock water demand was mainly for drinking and for cattle dips. The estimated present livestock water demand is shown in the table below.

Estimated Present Livestock Water Demand

Year	2010
No. Livestock (million LU)	14.0
Livestock Water Demand (MCM/year)	255

Source: JICA Study Team

6.6.2 Future Livestock Water Demand

The growth of livestock population varies depending mainly on the demand for meat, desire of farmer to breed livestock, and government policy. A simple projection methodology was employed for this study, that is, livestock population will increase in accordance with demand on milk and meat to ensure food security as a minimum. The future demand for milk, beef, and mutton and goat meat were calculated based on standard consumption rates (kg/person/year).

By applying the per capita consumption rates and estimated human population in 2030, the annual growth rate of milk and beef consumption and hence the required production were estimated, as shown in the table below.

Projected Production of Milk, Beef, and Mutton and Goat Meat

Product	2009 Production (million tons)	Urban Consumption (kg/per capita)	Rural Consumption (kg/per capita)	Urban Population in 2030 (million)	Rural Population in 2030 (million)	2030 Production (million tons)	Average Annual Growth Rate to 2030 (%)
Milk	4.326	125	45	46.02	21.81	6.734	2.13
Beef	0.32	12.47	6.23	46.02	21.81	0.710	3.86
Mutton and Goat Meat	0.084	2.41	1.20	46.02	21.81	0.137	2.36

Source: JICA Study Team based on Kenya Dairy Master Plan 2009 and FAO Livestock Sector Brief 2005.

The above methodology does not account for exports or imports but ensures food security. Based on Kenya Vision 2030's goal to achieve an average growth rate of 7% in the agriculture sector, it was assumed that the implementation of Kenya Vision 2030 would have a positive impact especially on livestock exports in the future. Accordingly, the projected average growth rate can be increased by 0.42%, which is approximately the 6% relative contribution of livestock exports in the 7% overall agriculture growth rates (as referred to in Kenya Vision 2030).

The average annual growth rates were adjusted as follows.

Production Growth Rate of Milk, Beef, and Mutton and Goat Meat

Product	Average Annual Growth Rate	
	2010-2030	2030-2050
Milk	2.55%	--
Beef	4.28%	--
Mutton and Goat Meat	2.78%	--
Average	3.20%	1.80%

Source: JICA Study Team, based on Kenya Vision 2030

The future livestock population was projected using the above average annual growth rates up to 2030 and 2050. The projected population was then converted to LUs and multiplied by 50 L/LU/day to calculate water demand, as explained under the present livestock water demand. The projected future livestock water demands in 2030 and 2050 are summarised in the table below.

Projected Future Livestock Water Demand

Year	2030	2050
No. of Livestock (head)	27.2	39.0
Livestock Water Demand (MCM/year)	497	711

Source: JICA Study Team (Ref. Sectoral Report(C), Sub-section 3.6.3)

6.7 Wildlife Water Demand

6.7.1 Present Water Demand

Necessary data relevant to wildlife populations at district level are not available. The data provided by the DRSRS were utilised for this study as they represent the most comprehensive information on wildlife population. The data were the result of aerial surveys in 11 districts across Kenya (Baringo, Garissa, Isiolo, Kajiado, Laikipia, Marsabit, Narok, Samburu, Taita, Tana River, and Turkana) between 2005 and 2011.

Water consumption of animals varies from species to species as well as depends upon their surrounding conditions such as water availability or vegetation. In order to assume the water consumption of animals, species were grouped into two groups, as follows:

Group A: Elephant, zebra, wildebeest, kudu, warthog, and buffalo (species which require relatively much water)

Group B: Giraffe, gazelle, gerenuk, impala, hartebeest, topi, eland, oryx, ostrich (species which require relatively less water)

The unit water consumption rates for the respective groups were assumed as shown in the table below.

Unit Water Consumption Rates of Wildlife

Group	Unit Water Consumption	Remarks	No. of Animals (head)	Water Consumption (m^3/day)
Group A	5 L/100 kg/day	about 50% of standard water consumption of one livestock unit	698,040	348,671
Group B	2.5 L/100 kg/day	about 25% of standard water consumption of one livestock unit	247,000	15,320

Source: JICA Study Team, based on data from DRSRS

Based on the above estimated water consumption rates and number of animals, the present wildlife water demand of major species were estimated, as shown in the table below.

Estimated Present Wildlife Water Demand

Year	2010
No. of Animals (head)	945,040
Wildlife Water Demand (MCM/year)	8

Source: JICA Study Team (Ref. Sectoral Report (C), Sub-section 3.7.2)

6.7.2 Future Wildlife Water Demand

For the future wildlife water demand projection, it was assumed that the 11 districts wherein the DRSRS carried out the aerial surveys contain majority of the wildlife in Kenya, and the water consumption rates used in the present water demand estimate are also applicable for the future projection. Additionally, it was assumed that the water demand of wildlife will remain constant in the future as efforts are being made to sustain the wildlife population in Kenya.

The future wildlife water demands in 2030 and 2050, as shown in the table below, are the same as the estimated present wildlife water demand.

Projected Future Wildlife Water Demand

Year	2030	2050
No. of Animals (head)	945,040	945,040
Wildlife Water Demand (MCM/year)	8	8

Source: JICA Study Team (Ref. Sectoral Report (C), Sub-sector 3.7.3)

6.8 Inland Fisheries Water Demand

6.8.1 Present Inland Fisheries Water Demand

According to the data provided by the Ministry of Fisheries Development (MOFD), there were approximately 8,076 fish ponds in 2007; however, there are no available data on the areas of the fish ponds. In the NWMP (1992), the average area per fish pond was estimated at 528 m^2. Applying this average area, the total area of fish ponds in 2007 was estimated at 4.26 km^2.

Fish farming activities were expanded in 2009 under the Economic Stimulus Programme (ESP). Under Phase I of the ESP, 200 ponds per district for 140 districts were constructed in 2010. The total number of existing ponds was approximately 36,000 in 2010, and the ponds' total surface area was estimated at 19.01 km^2.

There is no information available on the water consumption rate for fish farming in Kenya. Therefore, the following assumptions were made to estimate the present water demand of inland fisheries:

- Number of ponds and area data as provided by MOFD
- Pond depth: average pond depth of 1 m
- Evaporation loss equal to 5 mm
- Percolation loss equal to 1 mm

Water demand is calculated as the amount of water required to compensate for evaporation and percolation losses. The annual losses were estimated at 2.19 m/year (6 mm/day x 365 days) and the present inland fisheries water demand was estimated at 41.63 MCM/year (2.19 m/year x 19.01 km^2), as shown in the table below.

Estimated Present Inland Fisheries Water Demand

Year	2010
Fish Pond Area (km^2)	19.01
Water Demand (MCM/year)	42

Source: JICA Study Team (Ref. Sectoral Report (C), Sub-sector 3.8.2)

6.8.2 Future Inland Fisheries Water Demand

As for the 2030 and 2050 projections, it was hard to predict how the number of fish ponds will increase, although it was assumed that the increasing population will put additional pressure on food security thus demanding more food resources. Due to the lack of any long-term data, the development of fish ponds between 2010 and 2030 was estimated according to the population growth rate in such period, which is 176.1% as mentioned in Section 3.2. Similarly, the development between 2030 and 2050 was estimated according to the population growth rate in such period, which is 142.8%. The projected future inland fisheries water demand is shown below.

Projected Future Inland Fisheries Water Demand

Year	2030	2050
Fish Pond Area (km^2)	33.48	47.80
Water Demand (MCM/year)	74	105

Source: JICA Study Team (Ref. Sectoral Report (C), Sub-sector 3.8.3)

6.9 Hydropower Water Use

6.9.1 Present Hydropower Water Use

Actually, hydropower projects do not consume water; therefore, the amount of water use of existing hydropower plants and the amount of future water use of the planned hydropower projects were estimated in this section. These water use amounts were not taken into account in the water demand for the water balance study.

Major water users are five power stations in Tana River (Masinga, Kamburu, Gitaru, Kindaruma and Kiambere) and two power stations in the western part of the country (Turkwel and Soudu/Miriu).

To estimate the present water use, monthly power generation records was used. In order to avoid underestimation of the water demand, the following points were taken into consideration:

a) For the five power stations in the Tana River, power generation data after the Gitaru extension in 1999 were used.
b) For the five power stations in the Tana River, years with significantly low power generation due to severe drought or maintenance stoppage, i.e., 2000, 2001, and 2009 were excluded.
c) For Turkwel, records for the past ten years, i.e., from 2000 to 2009, were applied.
d) For Sondu/Miriu, as the project commenced in the latter half of 2007, data from 2008 and 2009 were applied.

The following table shows the monthly water use of each power station. Total water use for hydropower in 2010 amounts to 13,946 MCM/year.

Large Hydropower Water Use in the Tana River

(Unit: MCM)

Power Station	Monthly Water Use												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Masinga	147.3	132.3	136.3	117.2	328.9	259.5	155.1	152.7	132.2	144.1	142.3	179.7	2,027.6
Kamburu	226.3	149.7	117.6	398.0	398.0	285.4	191.2	185.6	176.8	168.7	206.1	211.1	2,497.7
Gitaru	230.1	174.9	208.9	487.2	487.2	328.4	223.9	197.7	195.7	201.7	214.4	218.0	2,897.1
Kindaruma	224.7	154.6	197.9	380.6	380.6	278.4	197.7	185.9	181.2	185.3	198.5	213.2	2,596.0
Kiambere	202.2	154.6	191.0	432.8	432.8	301.2	211.3	208.4	185.1	191.5	250.1	234.6	2,754.3

Source: JICA Study Team based on information from KenGen and TARDA

Other Large Hydropower Water Uses

(Unit: MCM)

Power Station	Monthly Water Use												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Turkwel	26.4	26.6	30.8	33.5	37.2	40.7	40.0	34.3	29.6	34.0	33.4	31.5	398.0
Sondu/Miriu	59.6	34.0	52.2	66.4	90.3	77.7	65.1	67.9	71.7	72.3	63.5	54.8	775.5

Source: JICA Study Team

6.9.2 Future Hydropower Water Use

Of the proposed hydropower development projects, required information were collected to roughly estimate the annual water use of hydropower projects. Design features of the proposed projects such as planned installed capacity in megawatt (MW), estimated annual average power generation in gigawatt hour (GWh) and design plant discharge (m^3/s) were used to estimate the annual water use of the proposed hydropower projects. The total annual water use of the proposed hydropower projects were estimated at 39,389 MCM/year as detailed in Table 6.9.1.

6.10 Summary of Water Demands

The water demands of domestic, industrial, irrigation, livestock, wildlife and inland fisheries were estimated for the base year 2010 and also projected for the years 2030 and 2050. Table 6.10.1 gives the present and future water demands by subsector and catchment area and are summarised in the two tables below.

Present and Future Water Demands by Sub-sector

(Before Water Balance Study)

(Unit: MCM/year)

Subsector	2010 (a)	2030 (b)	(b)/(a) (%)	2050 (c)	(c)/(a) (%)
Domestic	1,186	2,561	216	3,657	308
Industrial	125	280	224	613	490
Irrigation	1,602	18,048	1,127	18,048	1,127
Livestock	255	497	195	710	278
Wildlife	8	8	100	8	100
Fisheries	42	74	176	105	250
Total	3,218	21,468	667	23,141	719

Source: JICA Study Team

Present and Future Water Demands by Catchment Area

(Before Water Balance Study)

(Unit: MCM/year)

Catchment Area	2010 (a)	2030 (b)	(b)/(a) (%)	2050 (c)	(c)/(a) (%)
Lake Victoria North	228	1,337	586	1,573	690
Lake Victoria South	385	2,953	767	3,251	844
Rift Valley	357	*1,494	418	*1,689	473
Athi	**1,145	**4,586	401	**5,202	454
Tana	891	8,241	925	8,476	949
Ewaso Ng'iro North	212	2,857	1,348	2,950	1,392
Total	3,218	21,468	667	23,141	719

Notes: * Including water demand of 560 MCM/year for irrigation to be supplied by water resources of Ethiopia in 2030 and 2050.
** Including water demand of 114 MCM/year in 2010 and 154 MCM/year in 2030 and 2050 for irrigation to be supplied by water resources of Tanzania.

Source: JICA Study Team

6.11 Balance of Water Demand and Available Water Resources

Based on the available water resources and water demands estimated and projected for the years 2010, 2030 and 2050 in Chapters 5 and 6, the balance between the available water resources and water demands was preliminarily studied.

Available Water Resources and Water Demands by Catchment Area

(Before Water Balance Study)

(Unit: MCM/year)

Catchment Area	2010			2030			2050		
	Water Resources (a)	Water Demand (b)	(b)/(a)	Water Resources (c)	Water Demand (d)	(d)/(c)	Water Resources (e)	Water Demand (f)	(f)/(e)
Lake Victoria North	4,742	228	5%	5,077	1,337	26%	5,595	1,573	28%
Lake Victoria South	4,976	385	8%	5,937	2,953	50%	7,195	3,251	45%
Rift Valley	2,559	357	14%	3,147	1,494	47%	3,903	1,689	43%
Athi	1,503	1,145	76%	1,634	4,586	281%	2,043	5,202	255%
Tana	6,533	891	14%	7,828	8,241	105%	7,891	8,476	107%
Ewaso Ng'iro North	2,251	212	9%	3,011	2,857	95%	1,810	2,950	163%
Total	22,564	3,218	14%	26,634	21,468	81%	28,437	23,141	81%

Source: JICA Study Team (Ref. Section 5.2.3 and Section 6.10)

The above table shows the seriously tight situation of water balance in ACA at present due to large water use as demonstrated by high water demand/water resource ratio of more than 40%.

In the target year 2030, water demand will increase in all catchment areas, and water balance is expected to be tight in all areas. The catchment areas except LVNCA will have large water deficits as predicted by the high water demand/water resource ratios[4] of more than 40%, and the irrigation water demands corresponding to the irrigation area proposed by Kenya Vision 2030 need to be reduced. On the contrary, LVNCA showing water demand/water resource ratios of less than 40% seems to be able to have a water balance for the predicted water demands by appropriate water resources developments.

As for the water balance in 2050, the ratio between water resources and demands is almost the same as that for 2030 due to the increase of both resources by climate change and demand. However, the ratio is just for reference because of the uncertainty of projection of resources and demands.

The available water resources are the total of renewable surface water resources and sustainable yield of groundwater, which are theoretically available quantities. Since water resources are distributed unevenly in the country in terms of time and space, the actual usable water resources are less than the available water resources. Dividing each catchment area into sub-basins, the balance between the available water resources and water demands were examined for 2010 and 2030 with existing dams and inter-basin and intra-basin transfer facilities. Figures 6.11.1and 6.11.2 show the excess or deficit of water in each sub-basin for 2010 and 2030 respectively.

As seen in the figures, most of sub-basins show water deficits in 2010, while all sub-basins will have deficits in 2030 due to drastic increase of water demands.

The water deficits derived from the above mentioned water balance study and deficit/demand ratios are shown by catchment area for 2010 and 2030 as below.

[4] OECD defines the situation as "under severe water stress" in case the ratio exceeds 40%.

Water Demands and Water Deficits by Catchment Area for 2010 and 2030

(Unit: MCM/year)

Catchment Area	2010			2030		
	Water Demand (a)	Water Deficit (b)	(b)/(a) (%)	Water Demand (c)	Water Deficit (d)	(d)/(c) (%)
Lake Victoria North	228	27	12	1,337	371	28
Lake Victoria South	385	150	39	2,953	1,304	44
Rift Valley	357	92	26	1,494	867	58
Athi	1,145	745	65	4,586	4,153	91
Tana	891	336	38	8,241	5,822	71
Ewaso Ng'iro North	212	68	32	2,857	2,442	85
Total	3,218	1,418	44	21,468	14,959	70

Source: JICA Study Team (Ref. Main Report Part A, Section 6.10, Sectoral Report (G), Sections 3.3 and 3.4)

In 2010, ACA has a high water deficit/water demand ratio of 65% which is much larger than ratios of other catchment areas, because ACA has two large cities of Nairobi and Mombasa.

In 2030, the water deficit/water demand ratio will increase in all catchment areas due to drastic water demand growth compared with the year 2010. Especially, the ratios of RVCA, TCA and ENNCA will increase much.

To cope with the future water deficit, the following actions will be required:

a) Water resources development should be promoted to the maximum in order to meet the future water demand as much as possible.
b) Water demand management such as water saving and effective and efficient water use, recycling of water, etc. should be fully introduced to control water demand increase, especially it is important to control the irrigation water demand accounting for 80% of the total water demand in the catchment area which has insufficient water resources for water demand; and
c) Water resources development balanced with the available quantity of water resources should be made.

The water balance study was carried out in the subsequent development studies as Parts B to G of the Main Report. The water demands satisfiable in the target year 2030 were estimated as given in Table 6.10.1.

CHAPTER 7 OVERALL CONCEPTS AND FRAMEWORKS FOR PLANNING

7.1 Objective and Components of the National Water Master Plan 2030

The NWMP 2030 aims to present a framework for water resources development and management consistent with the country's social and economic development activities.

In line with the National Water Policy 1999 and the targets of Kenya Vision 2030, the specific targets of water resources development and management in the NWMP 2030 were set as follows:

Specific Objectives for Water Resources Development

a) Allocation of water for the reserve, international obligations and inter-basin water transfer is kept to meet basic water needs and to protect the water environment.
b) Improved water and sanitation are available and accessible to all by 2030.
c) Irrigation development is undertaken to the maximum within available water resources toward the national target to increase agricultural production.
d) Livestock, wildlife and inland fisheries are provided with water in sufficient quantities.
e) Hydropower development is undertaken to the maximum potential and as one of the components of a multipurpose projects for effective use of water resources.
f) Domestic and industrial water supply is ensured for 10-year probable drought and irrigation water supply for 5-year probable drought.

Specific Objectives for Water Resources Management

a) All water resources are managed, regulated and conserved in an effective and efficient manner by involving the stakeholders, guaranteeing sustained access to water and equitable allocation of water while ensuring environmental sustainability.
b) Human and economic damages by flood and drought are minimised to protect people's lives and properties.
c) Impacts on the natural environment by water resources development activities are minimised for protection of the natural environment.
d) Organisational and institutional capacity of water resources management is strengthened at the national and regional levels based on the national water policy.

(2) Components of NWMP 2030

NWMP 2030 is to be prepared for six catchment areas which are the management units of WRMA.

NWMP 2030 will consist of the following nine component plans:

Development Plans

a) Water Supply Development Plan
b) Sanitation Development Plan
c) Irrigation Development Plan
d) Hydropower Development Plan
e) Water Resources Development Plan

Management Plans

f) Water Resources Management Plan

g) Flood and Drought Disaster Management Plan

h) Environmental Management Plan

Institutional Plan

i) Institutional Strengthening Plan

The development plans and management plans were prepared by catchment area, while the institutional strengthening plan required national level action and therefore was not prepared by catchment area.

This chapter describes the objectives and above five development plans were prepared in order to grasp the future water demands and water uses of respective subsectors under the water sector in the target year 2030. The formulation of development plans is not the ultimate purpose of this study.

The subsequent sections will mention the overall concepts and frameworks for the planning of development plans and management plans, which are to be commonly applied to the six catchment areas.

7.2 Water Allocation Policy

Currently, the Guidelines for Water Allocation (First Edition, 2010) prepared by WRMA are effective in conformity to the stipulated requirements of Water Act 2002 Section 8 (1) (a) with regard to water allocation and prioritisation, as follows:

a) The allocation of water from a water body should take into consideration four demands on the water, namely: i) the portion of the water resource required to meet ecological demands, which forms part of the reserve; ii) the portion required to meet basic human needs (BHNs), which forms the other part of the reserve; iii) the portion of water for which commitments have been made in international treaties and inter basin water transfers; and iv) the portion of water that can be allocated to individual uses by means of a permit (Section 1.1).

   The individual uses mentioned in the item iv) above include domestic (rural and urban), agriculture (irrigation), livestock, energy, industrial, tourism, recreation, wildlife, and aquaculture (Section 2.2). All users of water resources other than the reserve, international obligations and inter-basin transfers are authorised according to the criteria of equitable allocations (Section 1.1).

b) The reserve commands the highest priority in terms of water allocation (Section 2.1).

c) The domestic water has a higher priority than other uses as stipulated in the Water Act 2002 Section 32 (2), (Sub-section 2.3.1).

d) With respect to all the other types of demands, the Water Act 2002 is silent with respect to priority, although various considerations must be made (Section 32 (1)) in regard to: i) existing lawful uses; ii) efficiency and public benefit; iii) commitments or priorities stated in the Catchment Management Strategies; iv) potential impacts on other water users and the water resources; v) the class and resource quality objectives; vi) existing and future investments by the applicant; vii) strategic importance of the application; viii) quality of the water resource which may be required for the reserve; and ix) probable duration of the water use activity (Sub-section 2.3.1).

According to the Water Resources Management Rules 2007 Section 2, the basic human needs mean the quantity of water required for drinking, food preparation, washing of clothes, bathing, basic sanitation and are assumed to be equal to 25 L/p/d.

On the basis of the requirements of the WRMA Guidelines for Water Allocation and results of discussions with MWI and WRMA, as well as current situations surrounding water allocation, natures of the water demands, and so forth, the policies of water allocation to be adopted in this study are set as follows:

a) The reserve consisting of ecological need and basic human needs has the highest priority as stipulated in the WRMA Guidelines.
b) There have been no international obligations in terms of water allocation according to MWI, therefore, no obligation was considered in the study. The existing inter-basin transfers were incorporated in the study making it second priority considering importance of the existing commitment having been made. In addition to the existing inter-basin transfers, the existing water uses including domestic, industrial and irrigation water uses also have the second priority as these are also deemed to be the existing commitments.
c) The WRMA Guidelines state that after allocating the abovementioned reserve, international obligation, and inter-basin transfer, all other uses of water resources are authorised according to the criteria of equitable allocations, but domestic water has a higher priority than other uses. Therefore, the third priority was given to the newly planned domestic water supply. Newly planned industrial water supply also has the third priority, since the industrial water is generally supplied by the same system as that of the domestic water supply.
d) The fourth priority was given to the newly planned water supply for livestock, wildlife, and inland fisheries demands. These demands have rather small volume compared with the available water resources.
e) After allocating all the above needs, new irrigation water demand was allocated, because the amount of the irrigation water demand is considerably larger compared with the others.
f) Hydropower generation does not consume water and its water use follows the use of other demands in principle.

The above policies are summarised as follows:

Prioritisation of Water Allocation

Priority	Water Use
1	Reserve consisting of ecological and basic human needs
2	Existing water uses for domestic, industrial, irrigation and hydropower, and existing inter-basin transfer water (International obligation to allocate water is not considered, because there is no international commitments so far.)
3	New domestic and industrial water uses
4	New livestock, wildlife and inland fishery water uses
5	New irrigation water use
6	New hydropower generation use

Source: JICA Study Team, based on the Guidelines for Water Allocation (First Edition, 2010) and Water Act 2002

The reserve amount was set at 95% value of the naturalised daily flow duration curve for each river in accordance with WRMA Guidelines for Water Allocation. The probability applied is once in 10 years which was determined based on the discussion with WRMA.

Regarding transboundary water resources, NWMP 2030 includes development of transboundary water resources as an input to achieve the Kenya Vision 2030. The development of transboundary water resources should be undertaken with treaties and agreements with neighboring countries in line with the Transboundary Water Policy currently under formulation by MWI.

7.3 Water Supply Development

7.3.1 Development Target

(1) Current Situation of Water Supply

Based on data of the 2009 Census, the population and ratio of water connections to each drinking water source in 2010 were estimated, as shown in the table below.

Current Situation of Water Supply in 2010

(Unit: million persons)

Drinking Water Source/ Evaluation	Piped by WSP	Spring/ Well/ Borehole	Water Vendor	Stream, lake, pond, others	Total
	Improved Source	Improved and Un-improved	Un-improved Source	Unimproved Source	
Urban Population	7.1 (54%)	3.1 (24%)	1.7 (13%)	1.2 (9%)	13.1 (100%)
Rural Population	4.1 (16%)	10.9 (43%)	0.5 (2%)	9.9 (39%)	25.4 (100%)
Total	11.2 (28%)	14.0 (37%)	2.2 (6%)	11.1 (29%)	38.5 (100%)

Source: JICA Study Team, based on data of the 2009 Census

The definitions of “improved” and “unimproved” drinking water source were based on the WHO/UNICEF Joint Monitoring Programme (JMP) report. Water from unregistered water vendors and water from streams, lakes and ponds without proper treatment are categorised as unimproved drinking water sources. Water from unprotected springs, wells or boreholes are also categorised as unimproved drinking water sources; however, the details of such unprotected water resources are not known. Only 28% of the population have water service from registered water service providers (WSPs), which are clearly improved drinking water sources. The unimproved drinking water sources shall be changed to improved water sources by 2030.

According to the Performance Report of Kenya’s Water Service Sector, Issue No. 4, 2011, the current average unit water consumption of urban water supply was estimated, as shown in the table below.

Average Unit Water Consumption of Urban Water Supply in 2010

(Unit: L/p/d)

Water Service Provider	Nairobi	Mombasa	Kisumu	Nakuru	Eldoret	National Average
Average Water Consumption (except for NRW)	57	27	15	29	75	36

Source: JICA Study Team, based on “Performance Report of Kenya’s Water Services, No. 4, 2011”

The table below shows the design unit water consumption of urban water supply in Kenya, which is indicated in the MWI Design Manual.

Design Unit Water Consumption of Urban Water Supply in Kenya

Category	Design Unit Water Consumption (except for allowance for water loss)
High class housing	200 L/p/d
Middle class housing	120 L/p/d
Low class housing :Individual connection	60 L/p/d
:Non-individual connection	20 L/p/d

Source: MWI Design Manual, based on data of the 2009 Census

According to the draft of the new water law, the minimum unit residential water demand was proposed at 25 L/person/day. The national average of current unit water consumption of 36 L/person/day is higher than the minimum requirement and the design amount for non-individual connection consumption, but it is much lower than the design amount for individual connection consumption of 60-200 L/person/day. In order to meet the requirements of individual connection consumers, the current water supply systems should have more capacities to supply water to the consumers.

The table below shows the NRW ratios in major WSPs, which were presented in the Performance Report of Kenya's Water Service Sector, Issue No 4, 2011

NRW Ratio in 2010

WSP	Nairobi	Mombasa	Kisumu	Nakuru	Eldoret	National Average
NRW	42%	35%	50%	53%	25%	45%

Source: JICA Study Team, based on "Performance Report of Kenya's Water Services, No. 4, 2011"

The national average of 45% means a quite high level of water loss, as compared with the target level of 20%. For effective water use, it is required to reduce the NRW ratio of existing water supply systems.

(2) Development Target

Kenya Vision 2030 aims to ensure that improved water and sanitation are available and accessible to all by 2030. Based on the policy of Kenya Vision 2030, Water Service Strategic Plan 2009 prepared by the MWI, the targets for water supply development plan of the NWMP 2030 were set as follows:

a) Increase coverage of improved supply to 100% in both urban and rural areas
b) Increase coverage of piped water supply by registered WSPs to 100% of the urban population
c) Increase unit water supply amount to suitable national standard levels
d) Decrease NRW rate to 20% for efficient water use[5]

In order to achieve the above targets, the concrete target water connection for 2030 was set as shown in the table below. The proposed unit water supply amount is shown in Section 6.3.1.

[5] There were opinions that the target rate of 20% seemed to be a high target considering the current NRW rate of 45%, however, through discussions with the Kenyan government side, it was decided to apply the target of 20% as stipulated in " Water Service Strategic Plan 2009" to realise Kenya Vision 2030.

Target Water Supply Population and Coverage Ratio for 2030

(Unit: million persons)

Water Supply Method	Piped by WSP	Spring/ Well/ Borehole	Total
Urban Population	46.0 (100%)	0.0 (0%)	46.0 (100%)
Rural Population	4.7 (22%)	17.1 (78%)	21.8 (100%)
Total	50.7 (75%)	17.1 (25%)	67.8 (100%)

Note: The target water supply population by Spring/ Well/ Borehole is determined considering characteristics of each catchment area.
Source: JICA Study Team based on Kenya Vision 2030 and Water Service Strategic Plan in 2009

7.3.2 Overall Concept and Framework for Planning

Based on the current situation and targets mentioned in the previous section, the water supply development plan will be formulated with the following overall concept and framework:

(1) Increase coverage of improved supply to 100% in both urban and rural areas

a) The water supply system development is considered as a combination of three types of water supply system:

i) Urban water supply system (UWSS) is a piped water supply system for urban populations and to be managed by registered WSPs,

ii) Large-scale rural water supply system (LSRWSS) is a piped water supply system for around 30-50 % of rural population in each catchment area with the remaining urban population, which is also to be managed by registered WSPs, and

iii) Small-scale water supply system (SSWSS), which consists of improved water source for the remaining rural populations and to be managed by individuals, communities or institutions.

b) Access to unimproved water supply sources is to be transferred to the above water supply systems.

(2) Development of Urban Water Supply

a) The UWSS would supply water for i) Residential water use of urban populations, ii) Commercial water use, iii) Institutional water use, and iv) Industrial water use in urban areas. It was planned to establish urban water supply systems that would cover an urban population of 44.3 million (2030) in 137 major urban centres, which have more than 10,000 population in the 2009 Census. The list of the 137 target urban centres is shown in Table 7.3.1 and Figure 7.3.1.

b) The water source for the UWSS is surface water in principle because of cost effectiveness. However, considering expected shortage of surface water in the near future, 5% of the total demand is to be met by groundwater. The water source allocation is finalised based on the result of the water balance calculation in the water resource development plan.

c) The UWSS was planned for each urban centre in principle. In case that several urban centres depend on the same water source, one system is to be considered for them.

d) Development and expansion of water supply systems are to be planned to meet suitable national standard levels of unit water supply volume as shown below.

e) In the coastal area, desalination is also proposed where the surface water and groundwater are not sufficiently available.

Proposed Unit Water Supply Amount

Target Area	Unit Water Supply Amount for Residential Water Use (L/p/d)	Planning Ratio of Institutional & Commercial Water Use	NRW Ratio	Unit Water Supply Amount for Domestic Water Use (L/p/d)
1) Urban Water Supply for Nairobi, Mombasa and Kisumu	92	27%	20%	146
2) Urban Water Supply	75	27%	20%	119
3) Large Scale Rural Water Supply	50	22%	20%	76
4) Small Scale Rural Water Supply	36	22%	20%	55
5) Small Scale Rural Water Supply in Arid Area	28	20%	20%	42

Source: JICA Study Team based on MWI Design Manual and "Guidelines for Water Allocation (WRMA, First Edition, March 2010)"

(3) Development of Rural Water Supply (LSRWSS and SSWSS)

a) LSRWSS and SSRWSS are considered in 47 counties. The target rural population covered by LSRWSS is to be estimated by subtracting current piped water supply population from total rural population in the rural area of districts based on Census 2009.

b) Water sources of the LSRWS are to be determined, after consideration of available surface and groundwater sources in each sub-basin. For arid areas, groundwater is the only water source, as long as certain surface water sources are yet to be found.

c) Water sources of the SSWSS are supposed to be groundwater and spring water only.

(4) Rehabilitation of Existing Water Supply System

In order to reduce the NRW ratio from the present 45% of the national average to 20% for effective water use, it was proposed that the existing water supply system should be rehabilitated immediately. Rehabilitation works shall include replacement of unsuitable water pipes that appear to be leaking, and installation of suitable water meters.

It is not easy to achieve a 20% NRW ratio in Kenya. It is a great challenge in the water sector, but new development projects should contribute to reduce the NRW ratio so as to reach the target level.

7.4 Sanitation Development

7.4.1 Development Target

(1) Current Situation of Sanitation Development

Based on data of the 2009 Census , the current situation of sanitation in Kenya was estimated as shown in the table below.

Current Situation of Sanitation in 2010

(Unit: million persons)

Sanitation/ Evaluation	Sewerage	Septic Tank, Pit Latrine, Cesspool	No Treatment (Bush, other)	Total
	Improved Sanitation	Improved and Unimproved	Unimproved Sanitation	
Urban Population	2.4 (18%)	9.2(70%)	1.6 (12%)	13.1 (100%)
Rural Population	0.0 (0%)	20.1(79%)	5.3(21%)	25.4 (100%)
National Average	2.4 (6%)	29.3(76%)	6.9(18%)	38.5 (100%)

Source: JICA Study Team, based on data of the 2009 Census

The definitions of "improved" and "unimproved" sanitation were based on the JMP report as explained in Subsection 7.3.1. Sewerage systems have been developed in only limited areas in Kenya. The current sewerage coverage ratio is only 6%, and around 18% of the population do not use any sanitation facilities. Around 76% of the population use on-site treatment facilities, which include "unimproved sanitation", such as pit latrine without slab.

(2) Development Target

Kenya Vision 2030 aims to ensure that improved water and sanitation are available to all. Based on the policy of Kenya Vision 2030, Water Service Strategic Plan 2009 prepared by the MWI, the targets for sanitation development plan of the NWMP 2030 were set as follows:

a) Increase coverage of improved sanitation to 100% (improve sanitation by sewerage system and on-site sanitation facilities)
b) Increase coverage of sewerage system to 80% of the urban population
c) Install improved on-site sanitation facilities for the remaining population not covered by sewerage systems

The above targets are summarised as shown in the table below.

Target Sanitation Conditions for 2030

(Unit: million persons)

Sanitation/Evaluation	Sewerage	Septic Tank	Total
Urban Population	36.8 (80%)	9.2 (20%)	46.0 (100%)
Rural Population	0.0 (0%)	21.8 (100%)	21.8 (100%)
Total	36.8 (54%)	31.0 (46%)	67.8 (100%)

Source: JICA Study Team based on Kenya Vision 2030 and Water Service Strategic Plan in 2009

The figure below shows the target of sanitation development by 2030. All residents will have access to either sewerage systems or on-site wastewater treatment facilities. The service population of sewerage system will be increased to 36.8 million from 2.4 million.

7.4.2 Overall Concept and Framework for Planning

Based on the current situation and development targets mentioned in Subsection 7.4.1, the sanitation development plan will be formulated with the following overall concept and framework:

(1) Sewerage System Development

a) Sewerage systems will be developed to cover 36.8 million service populations by 2030, which is 80% of the urban population in Kenya. Basically, sewerage systems will be developed in each urban centre.

b) For selection of target urban centres for sewerage system development, priorities are given to urban centres based on the following conditions:

i) Urban centres with large population, which are supposed to generate large amounts of wastewater

ii) Urban centres, which already have plans to develop sewerage systems

iii) Urban centres with their downstream experiencing environmental problems caused by water pollution.

c) As shown in Table 7.4.1 and Figure 7.3.1, 95 urban centres were selected as target of sewerage system development.

d) For the planning of sewerage system, the design wastewater treatment capacity was calculated based on the planned water supply amount and wastewater generation factor, as shown below.

Unit Domestic Wastewater Generation Amount for Each Area

Area	Unit Water Supply Amount for Residential Water Use	Ration of Commercial and Institutional Water Use	Wastewater Generation Factor	Unit Domestic Wastewater Generation Amount
Nairobi, Mombasa and Kisumu	92 L/p/d	27%	80%	93.4 L/p/d
Other Urban Areas	75 L/p/d	27%	80%	76.2 L/p/d

Source: JICA Study Team, based on MWI Design Manual

(2) Areas Outside Sewerage Service

a) Suitable on-site treatment facilities (improved sanitations) are to be provided for all residents outside the sewerage system

b) Large numbers of on-site treatment facilities have been already installed. However, unsuitable facilities (un-improved sanitations), such as put latrine without slab are to be changed to suitable facilities (improved sanitations), such as septic tank.

c) On-site treatment facilities are to be installed and managed by individual or community basis.

7.5 Irrigation Development

7.5.1 Development Target

(1) Current Situation of Irrigation Development

Agriculture is the backbone of Kenya's economy directly contributing to 24% of its GDP, 80% of formal employment and 60% of the export earnings in 2010. However, the agriculture sector continues to face major challenges such as: i) low productivity levels of many crops, ii) low utilisation rate of potential land especially in ASALs, iii) low quality of smallholders' products due to lack of postharvest services and poor access to markets, and iv) limited ability of farmers to add value to agricultural produce.

To strengthen the agriculture sector to contribute to the national economy, the policy for agriculture sector was set to focus on the following: i) production increase of food crops, ii) increase of export earnings by horticultural crops, and iii) reduction of import of rice. To increase agricultural production and productivity, irrigation development is expected to play a key role. In Kenya Vision 2030, the target of new irrigation development was set at 1.2 million ha.

Despite the importance of irrigation, the progress of irrigation development in the recent 20 years (from 1990 to 2010) in Kenya was at 3,845 ha per year, which was only 20% of the target set by the government to develop 20,000 ha per year.

Progress of Irrigation Development in 20 Years

(Unit: ha)

Year	Irrigation Area by Type of Scheme			
	Public	Smallholder	Private	Total
1990	12,000	27,200	25,800	65,000
2010	14,137	51,923	75,840	141,900
Increase	+2,137	+24,723	+50,040	+76,900

Source: JICA Study Team based on NWMP (1992) and inventory survey in this study

The progress of irrigation development by public scheme has stagnated for a long time mainly due to the shortage of government budget. On the other hand, irrigation development by smallholder and private schemes has been progressive. Especially, the private sector has been active recently by introducing advanced technology to produce high quality products for export.

The existing public irrigation schemes managed by government authorities are as shown in the table below.

Existing Public Irrigation Schemes in 2010

Catchment Area	No	Name of Scheme	Name of County	Irrigation Area (ha)	Executing Organisation	Remarks
LVN	1	Bunyala	Busia	363	NIB	Pump
LVS	2	Ahero	Kisumu	900	NIB	Pump, Rice
	3	West Kano	Kisumu	900	NIB	Pump, Rice
RV	4	Perkerra	Baringo	450	NIB	Gravity, Maize
	5	Wei Wei Irrigation	West Pokot	324	KVDA	
Tana	6	Kibirinwi Small	Kirinyaga	420	MOA	
	7	Mwea	Kirinyaga	7,400	NIB	Gravity, Rice
	8	Hola (Phase 1)	Tana River	900	NIB	Pump
	9	Bura	Tana River	2,500	NIB	Pump, Maize
Total				14,157		

Source: NIB and Inventory List of WRMA Water Permits

The largest irrigation scheme is the Mwea irrigation scheme of 7,400 ha maintained properly by the NIB, and produces high quality rice. The Mwea dam irrigation extension project commenced in 2012 to construct Thiba Dam and to expand the irrigation area to 9,485 ha. However, other public schemes faced deterioration of function of existing irrigation systems, especially pump sets, due to shortage of budget for rehabilitation and maintenance. The improvement of these systems to recover the original function has been ongoing since 2009.

Present irrigation area is much less than the irrigation potential of 1.3 million ha. Increase in irrigation areas by implementation of public, smallholder, and private schemes are required to fulfill

the target in Kenya Vision 2030 to develop new irrigation areas of 1.2 million ha by the end of fiscal year 2030/31.

(2) Development Target

As mentioned in the water demand projection in Section 6.5, Kenya Vision 2030 sets the national target to develop new irrigation areas of 1.2 million ha. The target irrigation development area by catchment area to meet the Vision 2030 (1.2 million ha) was provisionally envisaged as presented in the table below based on the distribution of agricultural potential areas proposed by MOA, referring to irrigation potential areas proposed in the "Irrigation and Drainage Master Plan 2009" by MWI, locations of existing and proposed irrigation schemes as well as present cropping areas of counties. For the provisional target irrigation development area, the water balance study was carried out and the possible new irrigation development area for each catchment area was obtained as presented in the table below.

Provisional Irrigation Development Area for Kenya Vision 2030 and Possible New Irrigation Development Area based on Water Balance Study

(Unit: ha)

Catchment Area	LVNCA	LVSCA	RVCA	ACA	TCA	ENNCA	Total
1. Provisional Irrigation Development Target Area (ha) *	90,786	186,978	63,493	233,628	482,450	142,665	1,200,000
2. Possible New Irrigation Development Area **	168,913	113,206	92,166	46,108	161,799	41,483	623,675
Difference (=2-1)	+78,127	-73,772	+28,673	-187,520	-320,651	-101,182	-576,325
3. Existing Irrigation Area（2010）	1,876	13,218	9,587	44,898	64,425	7,896	141,900
Total (=2+3)	170,789	126,424	101,753	91,006	226,224	49,379	765,575

Note: * = Assumed values for target of Kenya Vision 2030 based on data on potential agricultural area proposed by MOA, before water balance study.
** = Maximum possible area for new irrigation development based on water balance study.
Source: JICA Study Team (Ref. Sectoral Report (E), Section 3.4）

In LVNCA and RVCA, the possible new irrigation development area exceeds the provisional development target. On the other hand, in the other catchment areas, it is difficult to achieve the provisional development target due to constrain of the available water resources. For whole of Kenya, the possible new irrigation development area comes to 623,675 ha, therefore the target new irrigation development area for NWMP 2030 was set at 623,700 ha. It is about 52% of the development target area of 1.2 million ha.

The estimated irrigation areas in 2030 are shown in Table 6.5.6 and summarised by type of irrigation as below.

Irrigation Area in 2030

(Unit: ha)

Type of Irrigation	Present Irrigation Area in 2010	New Irrigation Area						Total Irrigation Area in 2030
		Surface Water Irrigation Area			Groundwater Irrigation	Water Harvesting Irrigation**	Total	
		Weir*	Dam	Total				
Large-Scale	14,137	35,843	396,392	432,235	0	0	432,235	446,372
Small-scale	51,923	61,485	0	61,485	25,793	22,000	109,278	161,201
Private	75,840	56,372	0	56,372	25,790	0	82,162	158,002
Total	141,900	153,700	396,392	550,092	51,583	22,000	623,675	765,575

Note: *=including weir irrigation, pump irrigation and spring irrigation
** = by small dams and water pans.
Source: JICA Study Team

7.5.2 Overall Concept and Framework

Kenya is located in the equator and characterised by the existence of arid and semi-arid lands (ASALs) covering about 85% of the county. Water resources available for irrigation are limited especially in ASALs. According to the results of the water balance study, to maximise irrigation area considering the development target of the Kenya Vision 2030, the introduction and promotion of water-saving irrigation methods is indispensable. The overall concept for irrigation development planning was formulated as follows:

a) Irrigation development should be undertaken to the maximum as long as water is available.
b) Water saving methods such as drip and sprinkler irrigation for upland crop cultivation and water saving paddy cultivation (System of Rice Intensification: SRI, etc) should be introduced for efficient water use as much as possible.

More concrete ideas are described hereunder.

(1) Maximum Irrigation Development

The types of irrigation methods are surface irrigation, groundwater irrigation, and water harvesting irrigation by small dam/water pan.

a) Surface Irrigation

The surface water irrigation is to be developed to the maximum by diversion weir and dam. The possible development area is to be determined through a water balance study between available river water and irrigation water demand by sub-basin. The existing irrigation development plans proposed by the government authorities listed are taken into account for planning.

b) Groundwater Irrigation

The groundwater irrigation is to be developed to the maximum using the groundwater resources available for irrigation. The possible irrigation area is determined by sub-basin. The groundwater irrigation will be implemented by smallholders and private sector. The proportion of small irrigation and private irrigation is assumed to be 50 : 50 since no data is available.

c) Water Harvesting Irrigation

For the area having insufficient surface water or groundwater resources, the water harvesting irrigation by small dam/water pan is considered. The development area of the water harvesting irrigation is assumed to be 4% of the new irrigation development area by surface water referring to the ratio of 1.6% of the existing water harvesting irrigation area by small dam/water pan to the total irrigation area in ACA and TCA. The water harvesting irrigation areas of six catchment areas are estimated based on the proportion of agricultural potential areas.

(2) Introduction of Water Saving Irrigation

The following area ratios and irrigation efficiencies of the water-saving irrigation are assumed for both upland crop cultivation and paddy cultivation.

Proposed Area Ratio of Water Saving Irrigation and Irrigation Efficiency

Item	Ratio/Efficiency
Area Ratio of Water Saving Irrigation	As a possible target in 2030, 50% for surface water irrigation area, and 100% for groundwater irrigation area are assumed.
Overall Irrigation Efficiency	• For surface water irrigation, overall irrigation efficiency (IE) of 70% is assumed with a combination of conventional irrigation (IE 60%), sprinkler irrigation (IE 70%), and drip irrigation (IE 90%) at the area ratios of 2:1:1, respectively. • For groundwater irrigation, overall IE of 83% is assumed with a combination of sprinkler irrigation (IE 70%) and drip irrigation (IE 90%). at the area ratios of 1:2, respectively.
Annual Cropping Intensity	• Large dam irrigation: 160% • Diversion weir irrigation: 160% (LVNCA and LVSCA), 130% (RVCA and TCA, but 100% for ASAL) and 100% (ACA and ENNCA) • Water harvesting irrigation: 100% • Groundwater irrigation: 160%

Source: JICA Study Team

The irrigation development plan in the NWMP 2030 was formulated assuming that water saving irrigation is introduced with the ratio as mentioned above, to maximise the new irrigation development area. If the water saving irrigation is not introduced, the possible new irrigation development area in 2030 will decrease from 623,700 ha to 530,800 ha (decrease of about 15%) because the overall irrigation efficiency is lowered. It is expected to actively introduce the water saving irrigation to be close to the target of the Kenya Vision 2030 to the maximum.

7.6 Hydropower Development

7.6.1 Development Target

(1) Current Situation of Hydropower Development

Kenya Electricity Generating Company Limited (KenGen) and other power sector related organisations prepare the Least Cost Power Development Plan (LCPDP) every year in March in order to indicate the power development plan for the next 20 years. On the other hand, as there has not been adequate study conducted for hydropower development since 1991, there are less candidate hydropower projects to be considered for the national power development plan.

A new National Energy Policy (Draft) was published in May 2012 (hereinafter called as “the draft policy”). In the draft policy, the following are the descriptions related to hydropower development:

a) As for countermeasures against climate change, it is better to maintain the ratio of hydropower generation in the energy mixture in an appropriate level;
b) From the point of effective use of limited water resources, future hydropower projects should be developed as multipurpose type development;
c) An inter-ministerial coordination committee should be established to coordinate conflicts among different water users; and
d) A fund for hydrological risk mitigation should be established.

As mentioned above, as countermeasures against climate change in the future, the government directs to decrease dependency on hydropower generation to keep the ratio of hydropower generation at appropriate levels in the energy mixture. Therefore, in the LCPDP 2011-2031, it was planned that the current ratio of hydropower installed capacity against the total installed capacity will be decreased from the current level of around 50% to around 5% toward 2031 as shown in Figure 7.6.1.

There is no definite target for hydropower development at the national level. However, by referring to descriptions in the draft policy, the maximum utilisation of the hydropower component of multipurpose dam projects should be considered from the viewpoint of effective use of limited water resources. As a result of review of such multipurpose dam projects, 13 projects were identified which have hydropower components for development. In addition to the 13 projects, there is one hydropower development project proposed by KenGen. In total, 14 projects listed in Table 10.1.5, which are expected to be implemented by 2030, were identified with an estimated total installed capacity of 1,381 MW.

According to the LCPDP 2011-2031, undeveloped hydropower potential of economic significance is 1,449 MW, out of which 1,249 MW is for projects of 30 MW or bigger.

(2) Development Target

The estimated total installed capacity of 1,381 MW is in the same range as the estimated hydropower potential of 1,449 MW in the LCPDP 2011-2031. The total installed capacity of individual development plan (1,381 MW) is judged to be reasonable. Therefore, the development target of hydropower in NWMP 2030 is set at 1,381 MW.

In addition to the above, a possibility of hydropower component of the multipurpose dam project proposed in this study is considered.

7.6.2 Overall Concept and Framework for Planning

The objective of hydropower development is to develop hydropower potential to the maximum considering effective use of water resources. Based on the current situation and development target, the overall concept for hydropower development plan was set as follows:

a) Take up plans in the LCPDP, which is a key document for power development planning in the country.
b) Take up plans for hydropower components of multipurpose dam development schemes to promote efficient use of water among other water users such as water supply and irrigation.

For item b) above, the hydropower components of the multipurpose developments with more than 10 MW of installed capacity including the existing plans are taken up, which are supposed to be able to bear the development cost of the multipurpose dam by hydropower sector from the economic viewpoint.

7.7 Water Resources Development

7.7.1 Development Target

(1) Current Situation on Water Resources Development

The existing dams for water resources development number to 26 in the country. The number of dams under construction is four. There are ten intra-basin and five inter-basin water transfer schemes in operation. There are 12,444 boreholes and 4,037 small dams/water pans in the country. The national total storage volume is around 3,906 MCM including hydropower purpose storages. These water resources development infrastructures are in operation to meet the current water demands.

As stated in Section 6.11, the total water demands were projected to be 21,468 MCM/year in 2030 amounting to approximately five times the present water demands of 3,218 MCM/year mainly due to the increase of population and irrigation areas. According to Figure 6.11.1 representing water deficits of about 14,660 MCM/year in the country with the present water resources structures, it is apparent that the present water resources infrastructure will not satisfy the rapidly increasing water demands in 2030; therefore, new water resources developments are essential in order to meet such demands.

The MWI's National Water Resources Management Strategy 2010-2016 (April 2012) includes the national water harvesting and storage policy, of which the objectives encompass the provision of a framework for the expansion of infrastructure to increase the national water storage capacity from the current 124 MCM to 4.5 BCM to ensure an increase in per capita storage from 5.3 CM to 16 CM over the next ten years.

(2) Development Target

The target of water resources development is to meet all the water demands projected for the target year 2030 including domestic, industrial, irrigation, livestock, wildlife and inland fisheries water demands, and hydropower use.

The domestic and industrial water supply is ensured for 10-year probable drought and the irrigation water supply for 5-year probable drought as mentioned in Section 7.1. These reliabilities follow the NWMP (1992) and are based on discussion results with MWI and WRMA.

7.7.2 Overall Concept and Framework for Planning

Considering the current situation of the water resources development subsector, the targets of the NWMP 2030, and the needs of the subsector as stated in the preceding subsection, the overall concept and framework for water resources development plan formulation to be applied commonly to the six catchment areas were set as follows:

The overall concepts and frameworks are:

a) Develop water resources to the maximum to meet water demands,
b) Use of water source is as follows: i) domestic use: surface water first, groundwater second, ii) industrial use: surface and groundwater at 50:50, iii) desalination is considered for coastal

area, iv) irrigation use: mainly surface water, groundwater for small scale irrigation, v) livestock, wildlife and inland fisheries: surface water due to small demands.

c) Use the water resources effectively through multipurpose development, inter-basin transfer, intra-basin transfer, water saving, reuse of water, etc.,

d) Allocate the water resources based on the water allocation policy according the WRMA Guidelines as stated in Section 7.2,

e) Formulate the water resources development plan by applying the available water resources estimated considering the impacts of climate change, and

f) Incorporate hydropower development plans into multipurpose dam development plans in accordance with the concept and framework for hydropower development as stated in Section 7.6.

To develop water resources to the maximum, a policy to use surface water and groundwater was set as follows:

a) For domestic and industrial water supply, surface water (including storage dams and water harvesting measures) is to be allocated first, which is generally cheap in development cost. Groundwater is to be allocated where sufficient surface water is not available, available surface water is located far from demand sites, and/or amount of water demand is not substantial.

b) For irrigation water supply, surface water (including storage dams and water harvesting measures) is the main water resource because of the large amount of demand. However, groundwater is also to be used for small-scale irrigation schemes or schemes with drip and sprinkler irrigation systems.

c) For water supply of livestock, surface water (including water harvesting measures particularly small dams/water pans) is to be allocated considering the rather small amount of water required at each demand site and wide distribution of the sites.

d) For water supply of wildlife and inland fishery, surface water (including water harvesting measures particularly small dams/water pans) is the main resource, considering the living style of the wildlife, and nature of the fisheries of which locations are to be selected based on water availability among others.

In order to use water resources effectively, the following development measures were conceived:

a) Dams were planned as necessary to supply relatively large demands such as domestic, industrial and irrigation water demands. Dams play an important role to meet the large water demands projected in 2030. Dams, as much as possible, are to be multipurpose and include flood control function in order to efficiently utilise the limited resources. The availability of river water varies in time and space and dams assist in storage of the water to ensure the availability during the time of scarcity. Since few data were available for current situation of the existing dams including siltation, such costs were not specifically considered.

b) Water transfers were planned wherein both surface water and groundwater are not available within the sub-basin or basin, and such are technically and economically viable and are environmental friendly. The water transfer should be considered after meeting the demand at the source. Inter-basin water transfer, in particular, may need approval of implementation at a national level.

c) Water harvesting measures were planned mainly for small and scattered water demands such as rural domestic, Small-scale irrigation, livestock, wildlife and fisheries water demands.

d) Groundwater usage through boreholes was planned mainly for domestic, industrial and irrigation water demands where surface water is not available.

The storage volumes of dams were planned through the water balance studies so as to supplement the estimated water deficits. The abovementioned structures need to be planned to minimise negative impacts to the natural and social environments induced by the developments. As the catchment degradation leads to siltation as well as reduction of water availability, the watershed conservation is essential. The communities need to be involved in the watershed conservation. Furthermore, water conservation including water saving and recycling of water use is also important for the management of the limited water resources.

To allocate water resources to the respective demands, it is essential to follow the water allocation policy as stated in Section 7.2. In particular, the reserve needs to be strictly maintained in the rivers from ecological and basic human needs.

To consider the climate change effect to water resources development, the water resources were projected for 2030 reflecting impacts of climate change. The water resources projected in 2030 were applied for the water resources development plans to make them more realistic.

The water resources development plans were formulated by setting the reliability of water supply to the water subsectors. The reliability of one in ten years probability for domestic and industrial water uses, and one in five years probability for irrigation water use were applied for the planning. They are the reliability set in the NWMP (1992) and the results of discussions with MWI and WRMA.

Basic conditions applied for the water balance study are as follows:

a) Allocation of surface water is to be based on the water allocation policy and priority mentioned in Section 7.2;

b) Reserve flow as river maintenance flow is to be 95% value (with 10-year probability) of the naturalised present daily flow duration curve for each river in accordance with "Guidelines for Water Allocation (WRMA, First Edition, March 2010)" and results of discussions with WRMA;

c) Return flow is to be 100% for hydropower, 25% for urban water supply[6], 5% for paddy irrigation;

d) The number of sub-basins divided for water balance calculation is to be 204; and

e) Interval of water balance calculation is to be a month.

f) The boreholes were not incorporated into the water balance computation model, but demands to be supplied from the groundwater were subtracted from the demands put into the computation model before calculation.

The water resources are national, and planning, development and management of the water resources should be basin-wise. The projects will be implemented, while managing the challenges through EIA

[6] The return flow ratio of 25% is calculated based on the following assumptions: 1) 80% of intake water reaches to service population through urban water supply system (non-revenue water ratio: 20%), 2) 80% of supplied water reaches to wastewater treatment works (wastewater generation ratio: 80%), and 3) 40% of influent of wastewater treatment works returns to river/channel after the treatment.

implementation, which will address all issues including compensation and water management. It is noted that involvement of county governments in the implementation of the water resources development projects will be based on the relevant government regulations.

In addition to the above, the following are recommendations in relation to the water resources development, although these were not included into the water balance study:

a) Recommend to utilise roof catchment and rock catchment in order to supplement the supply to domestic and livestock water demands, and to prepare for drought risks,
b) Recommend to apply some measures such as dilution of groundwater by surface water or use of bottled water for drinking purpose in the areas where the groundwater is rich in fluoride and/or salinity showing the content level above the allowable ones.

Artificial groundwater recharge during flood is not considered in the master plan as there is not sufficient data for planning and there are many localised specific conditions. Further study will be required considering local specific hydrological and hydrogeological conditions.

7.8 Water Resources Management Plan

7.8.1 Objective of Water Resources Management

(1) Current Situation of Water Resources Management

The water resources management activities in Kenya have been conducted by MWI as policy maker, and WRMA as regulator at the national and regional levels under MWI. According to the mission statement of the WRMA, the objective of water resources management is to manage, regulate and conserve all water resources in an effective and efficient manner by involving the stakeholders, guaranteeing sustained access to water, and equitable allocation of water while ensuring environmental sustainability.

To achieve the objective of water resources management, it is necessary to: i) accurately grasp the quantity and quality of water resources through monitoring; ii) evaluate water resources; and iii) allocate water equitably through water permit issuance. In addition, from the viewpoint of conservation of water resources in the basin, watershed conservation activities are also necessary.

The current situations of the abovementioned i) monitoring, ii) evaluation, iii) water permit issuance and iv) watershed conservation are described hereunder.

1) Monitoring

The WRMA is periodically monitoring surface and groundwater resources in the catchment areas of its six regional offices. Surface water level is observed twice a day by an honorarium gauge reader. The observed water levels are submitted to WRMA regional offices once a month. In addition, WRMA staff conducts discharge measurement by current meter once a month. Water quality of surface water is observed and analysed by WRMA

staff quarterly (for important points[7]: once a month). Groundwater level is observed once a month and quality quarterly by WRMA staff. Rainfall is observed once a day by WRMA staff or honorarium observers.

The target numbers and operational numbers of monitoring stations are presented in Table 7.8.1. River water level is observed once a day and groundwater level once a month. River discharge is observed once a month. Water quality of both surface water and groundwater are observed quarterly. The observed data are kept at each regional office or subregional office and stored in the database of the regional office.

For surface water monitoring, the WRMA targets to make observations at 223 locations all over Kenya; however, actual observations are made at 146 locations only (65% of the target locations) due to restrictions on budget and human resources. For groundwater monitoring, WRMA targets to observe at 202 locations; however,, actual observations are made at 92 locations only (46% of the target locations). Water quality is observed at the same locations as surface water and groundwater monitoring stations. Rainfall is being observed at only 216 locations of the 301 target locations (72% of the target locations).

The existing monitoring system[8] was established from the viewpoints of necessity for water permit issuance and availability of budget and human resources. However, due to insufficient budget for operations and maintenance and human resources, some gauging stations have become nonoperational. The monitoring system should be reviewed for more efficient monitoring taking into consideration future water use.

2) Evaluation of Water Resources

The monitoring data of surface water and groundwater are stored in the database of the WRMA regional offices for evaluation of water resources in the catchment area; however, the stored data are hardly used for evaluation of water resources. There is no water resources evaluation system unified with monitoring.

3) Water Permit Issuance and Control

Water permits are issued and controlled by WRMA in its regional offices. According to the WRMA Performance Report (2009), the status of water permit application, authorisation and issuance are summarised as shown in the table below.

[7] Ref. Sectoral Report (H), Subsection 3.3.2.

[8] Ref. Sectoral Report (H), Section 2.3.

Current Situations of Water Permits

Catchment Area		Applications		Authorisations		Permits		Valid Permits		
		No.	Vol. (Mm^3/ day)	No.	Vol. (Mm^3/ day)	No.	Vol. (Mm^3/ day)	No.	Vol. (Mm^3/ day)	%
LVN	SW	919	-	432	0.161	269	0.868	180	0.308	71
	GW	878	-	540	0.007	140	0.005	110	0.005	
LVS	SW	1,790	-	1,303	5.138	283	2.632	227	2.16	82
	GW	1,361	-	1,326	0.018	35	0.002	34	0.002	
RV	SW	252	-	663	0.168	503	1.752	162	1.625	42
	GW	389	-	1,390	0.134	183	0.116	124	0.11	
Athi	SW	2,999	-	2,751	-	470	0.202	199	0.134	40
	GW	7,449	-	5,895	-	571	0.028	217	0.01	
Tana	SW	6,434	-	3,436	1.631	1,622	2.204	239	0.213	17
	GW	1,710	-	1,057	0.039	145	0.015	68	0.013	
ENN	SW	1,566	-	1,031	1.195	201	0.309	38	0.093	28
	GW	1,421	-	871	0.044	31	0.007	28	0.005	
Total	SW	13,960	-	9,616	8.293	3,348	7.967	1,045	4.533	37
	GW	13,208	-	11,079	0.242	1,105	0.173	581	0.145	

Source: WRMA Performance Report 1(July 2010)

As shown in the table above, the ratio of valid permits to permits issued is as low as 37% on an average. The major reasons for the low ratio are as follows:

a) Accurate status of individual water permits is not fully controlled; and
b) Water permit holders who have expired permits do not renew their permits in compliant to water resources management rules.

The above reason a) is due to the insufficient number of water right officers in regional/subregional offices, and reason b) is due to the lack of awareness of water resources management rules and insufficient workforces to remind such permit holders to take necessary actions.

As is presented in the above table, the total amount of water permit currently issued is 8.170 MCM/day consists of 7.967 MCM/day for surface water and 0.173 MCM/day for groundwater for whole of Kenya. By annualising these amount, total amount of water permit issued is 2,971 MCM/year consists of 2,908 MCM/year for surface water and 63 MCM/year for groundwater.

On the other hand, annual water demand in 2010 was estimated in section 6.10 as 3,218 MCM/year. Though there will be differences between amount of water for issued permit and actual water abstraction, as well as between estimated water demand and actual water use, the above amounts for water permit and water demand are in almost the same range at about 3 BCM/year.

Water demand in 2030, the target year of NWMP 2030, is estimated through water balance study at 12,534 MCM/year. It is supposed that the proposed water resources development projects in NWMP 2030 will be implemented to satisfy the demand. As the proposed water resources development projects progress, amount of more than 9 BCM/year water permits will be able to be issued in addition to the currently issued water permits. Under such circumstances, it is important to periodically confirm the progress of implementation of water

resources development projects to grasp the possible amount of water permit that can be issued.

4) Watershed Conservation

There are five major water source forests which were recognised as "water towers" in Kenya, namely, Mt. Elgon, Cherangani Hills, Mau Forest Complex, Aberdare Range and Mt. Kenya. Major rivers in the country originate from the five water towers.

The major issues identified on watershed conservation are i) deforestation, ii) degradation of small water sources, and iii) soil erosion and sedimentation.

The causes for deforestation are illegal logging, charcoal burning, agriculture, human settlement, overgrazing, encroachment, and so on. During the 20 year period from 1990 to 2010, the forest area in Kenya decreased from 18,300 km^2 (3.2% of forest coverage) to 12,800 km^2 (2.2% of forest coverage), as shown in the table below. To recover deforested areas, Kenya Vision 2030 aimed to increase the forest coverage from the current 2.2% to 4% by 2012 and 10% by 2030.

Change of Forest Area from 1990 to 2010

Catchment Area	Area (km^2)	Forest Area in 1990 (ha)	Coverage in 1990	Forest Area in 2010 (ha)	Coverage in 2010	Rate of Decrease
LVN	18,374	154,000	8.4%	107,000	5.8%	30.5%
LVS	31,734	266,000	8.4%	159,000	5.0%	40.2%
RV	130,452	439,000	3.4%	261,000	2.0%	40.5%
Athi	58,639	253,000	4.3%	120,000	2.0%	52.6%
Tana	126,026	501,000	4.0%	446,000	3.5%	11.0%
ENN	210,226	220,000	1.0%	184,000	0.9%	16.4%
Total	575,451	1,833,000	3.2%	1,277,000	2.2%	30.3%

Source: JICA Study Team based on satellite image analysis

Small water sources such as springs and wetlands are important water sources for people in ASALs and local areas. In the ASALs of RVCA, ACA, and ENNCA, vegetation loss at the surrounding areas of water sources and water quality degradation are current major issues. Such issues were the result of increasing water use and insufficient protection and conservation of water sources.

It was said that soil erosion is caused mainly by deforestation and incurring sedimentation problem in dam reservoirs, irrigation facilities and so on, but the actual situations have not been investigated. In LVNCA and LVSCA, soil erosion due to deforestation of Mt.Elgon and Mau Forest Complex was reported.

(2) Objective of Water Resources Management

The objective of water resources management is to manage, regulate and conserve all water resources in an effective, efficient and sustainable manner for equitable allocation of water according to the mission of WRMA.

7.8.2 Overall Concept and Framework for Planning

Taking into account the current situation of water resources management, the overall concept and framework for water resources management plan formulation to be commonly applied to the six catchment areas were set as follows:

a) Establish more efficient monitoring networks for surface water and groundwater, and for the amount and quality of water resources as well as rainfall;
b) Enhance evaluation of water resources in quantity and quality;
c) Improve water permit issuance and control system; and
d) Implement watershed conservation activities such as forest recovery and conservation, small water sources conservation, and soil erosion control.

Flood and drought aspects will be discussed in the flood and drought disaster management plan separately from the water resources management. More concrete ideas are described hereunder.

(1) Monitoring

In order to establish more efficient monitoring networks for surface water and groundwater, the existing networks should be reviewed based on the following criteria.

1) Surface Water Level

Surface water level gauging stations should be located as follows:

a) Important points that can capture the runoff characteristics of the basin, which are located in major rivers, or points where flow regime changes in representing tributaries,
b) Major lakes,
c) Major springs, and
d) Outflow points of international rivers into neighbouring countries, or inflow points of international rivers from neighbouring countries.

Among the points, one or more points should be selected as reference points, which are referred for water resources development and management purposes. The reference points should be selected as points which have sufficient hydrological data that can be used for hydrological analysis and also closely relate to water resources development and management plans. At the reference point, a normal discharge value is set for monitoring, which value should be kept during drought periods. The normal discharge value is calculated as maintenance flow plus amount of water permits issued (water demand) downstream of the reference point. The normal discharge value is a discharge which ensures domestic and industrial water supply for 10-year probable drought and irrigation water supply for 5-year probable drought.

2) Surface Water Quality

Surface water quality monitoring stations should be located as follows:

a) Points where effluent discharge from cities may affect water quality of rivers, springs and lakes,

b) Points where polluted objects such as wastewater, fertilisers from irrigation areas, etc. may be discharged into rivers, springs and lakes, and

c) Major surface water level monitoring points.

3) Groundwater Level

Groundwater level monitoring stations should be selected at points where current and future groundwater uses are significant. In NWMP 2030, such points are assumed to be urban centres that have both water supply development and sanitation development plans in principle.

4) Groundwater Quality

Groundwater quality monitoring stations should be selected at the same points as groundwater level monitoring stations.

5) Rainfall

Based on the distribution of existing rainfall gauging stations and climatic zones (arid, semi-arid and humid areas), the observation densities of rainfall were classified as follows:

a) One station per 8,000 to 10,000 km^2 in arid areas

b) One station per 3,000 to 5,000 km^2 in semi-arid areas

c) One station per 500 to 1,000 km^2 in humid areas

In this study, the above criteria were applied for review of the rainfall gauging station network. In some parts of arid areas, the above criteria of one station per 10,000 km^2 may not be satisfied due to sparse distribution of residential areas, but review will be made based on the above criteria as much as possible. Stations located close to each other will be merged or shifted as necessary to make the monitoring network efficient.

(2) Evaluation

Enhancement of the water resources evaluation capacity of WRMA should be made for both quantity and quality of water resources. As mentioned in the current situation above, an evaluation system unified with monitoring should be established. More concrete ideas are described hereunder.

1) Enhancement of Water Resources Quantity Evaluation System

It is proposed to evaluate the quantity of water resources annually using monitored water resources data and water permit data. Such evaluation works should be done at the regional office level with assistance from subregional offices. An evaluation team would be formed as follows:

- Team Leader: Chief hydrologist nominated from the regional office
- Team Member: One assistant hydrologist from each subregional offices

The team should evaluate the water resources of its respective catchment area. The evaluation works should include the following:

a) Estimation of river discharges in the catchment area based on the observed data,

b) Estimation of water use amount in the catchment area based on the water permits issued,

c) Estimation of the water resources amount of the catchment area for 10-year probable drought period, and

d) Rainfall-runoff analysis for estimation of the total amount of water resources of the catchment area based on the observed rainfall.

Evaluation work should be done once a year and the results should be compiled in a report so that the report can be used for water resources allocation activities such as water permit issuance for the next year.

2) Enhancement of Water Resources Quality Evaluation System

The WRMA currently owns seven water quality test laboratories, one in Nairobi and one at each of the WRMA's six regional offices. The location of six regional offices with water quality test laboratories are as follows: 1) in Kakamega for the Lake Victoria North Catchment Area, 2) in Kisumu for the Lake Victoria South Catchment Area, 3) Nakuru for the Rift Valley Catchment Area, 4) Machakos for the Athi Catchment Area, 5) in Embu for the Tana Catchment Area, and 6) in Nyeri for the Ewaso Ng'iro North Catchment Area. Considering a timelier test of water quality, the following four additional water quality test laboratories were proposed:

a) Kapenguria and Lodwar for the Rift Valley Catchment Area

b) Mombasa for the Athi Catchment Area

c) Garissa for the Tana Catchment Area

d) Marsabit and Wajir for the Ewaso Ng'iro North Catchment Area

An appropriate number of water quality experts are to be assigned to each water quality test laboratory depending on the condition of each regional office.

(3) Water Permit Issuance and Control

To cope with the current issues and expected water demand increase in the future, it is prerequisite to know the latest status of issued permits and amount of available water resources, amount of water use by issued permits, and possible amount of water for future allocation.

In order to improve the current water permit issuance and control, it is proposed to enhance the water permit issuance and control system and also revision of the guidelines for water allocation.

More concrete ideas are described hereunder.

1) Enhance Water Permit Issuance and Control System

One key point is how to know the latest status of water permit. Considering the present issue, the following actions were proposed:

a) Periodical updates of water permit database

Registration of all the issued water permits should be made timely and certainly. The expiry dates of registered water permits should be confirmed periodically, such as once a month.

b) Enhancement of notification system on permit expiry

The expiry dates of issued water permits should be notified to water permit holders before the expiry date through periodical update of the water permit database.

2) Revision of Guidelines for Water Allocation

To cope with the increase of water demand in the future, it is necessary to have a water allocation plan based on the latest information on water resources and present water demands, and future water demands should also be taken into account. In this connection, the present Guidelines for Water Allocation of the WRMA should be revised. It will be most important to clarify and define the upper limit of water allocation to respective subsectors.

(4) Watershed Conservation

Considering the current situation, the following are the major issues on watershed conservation in this study:

a) Recovery of forest areas through afforestation mainly in the five water towers,
b) Conservation of small water sources, and
c) Control of soil erosion.

More concrete ideas are described hereunder.

1) Recovery of Forest Areas

The devastated forests should be recovered through forestation. The five water towers originate from the major rivers in Kenya, therefore, forest recovery should be carried out mainly in the five water towers. Kenya Vision 2030 targets a forest cover of 10% by 2030. This study adopted the target of Kenya Vision 2030. The target forestation area of each catchment area, as shown in the table below, was estimated based on the current situation of forest area and potential areas for forestation as shown in Figure 7.8.1. In Figure 7.8.1, potential areas for forestation were identified to achieve the target coverage of 10%.

Target Forestation Area by Catchment Area

Catchment Area	Area (km^2)	Forest Area in 2010 (ha)	Coverage in 2010	Forestation Area (ha)	Forest Area in 2030 (ha)	Coverage in 2030
LVNCA	18,374	107,000	5.8%	234,000	341,000	18.5%
LVSCA	31,734	159,000	5.0%	412,000	571,000	18.0%
RVCA	130,452	261,000	2.0%	1,006,000	1,267,000	9.7%
ACA	58,639	120,000	2.0%	868,000	988,000	16.8%
TCA	126,026	446,000	3.5%	1,366,000	1,812,000	14.4%
ENNCA	210,226	184,000	0.9%	592,000	776,000	3.7%
Total	575,451	1,277,000	2.2%	4,478,000	5,755,000	10.0%

Source: JICA Study Team based on Kenya Vision 2030

The recovery of gazetted forests is the responsibility of the Kenya Forest Service, while the recovery of non-gazetted forests should be done by other stakeholders.

2) Conservation of Small Water Sources

A major issue on the conservation of small water sources include insufficient management of water source areas including surrounding areas. In order to make a conservation plan, the actual situations of each water source should be made clear. However, data are unavailable at present.

It was proposed to carry out a survey on small water resources, which includes location, scale, water use, water quality, vegetation condition, management method, major issues, etc.

3) Control of Soil Erosion

Soil erosion is due to the devastation of the catchment area, especially deforestation; however, there are no actual data available for the planning of soil erosion control. It was proposed to carry out a survey on devastated areas which incur soil erosion in the catchment area. The survey should investigate location, scale, current situation, required countermeasures, etc.

7.9 Flood and Drought Disaster Management Plan

7.9.1 Objective of Flood and Drought Disaster Management

(1) Current Situation of the Subsector on Flood Disaster Management

A flood management system has not been established adequately in the past such that flood disasters have been less emphasised compared to the country's severe drought disasters because the frequency of widespread flooding was low especially prior to the 1997-1998 El Niño floods.

In order to perform appropriate flood management, it is essential to legally stipulate considerations and the detail procedures in the process of various decisions making and planning. However, a responsible organisation for flood management has not been clearly authorised at the moment. Flood management has not been consolidated though several relevant organisations are involved in such. Currently MWI, WRMA, KMD, DOC, NWCPC, each District Disaster Management Committee (DDMC), etc. are involved in flood management. In recent years, the Disaster Management and Risk Reduction Unit under the MWI and the Flood Management Unit (FMU) under WRMA were established in 2009 and in 2010, respectively. However, such units have not yet been fulfilling their roles as governing bodies.

Out of the five priority projects proposed in the NWMP (1992), only river improvement works in the Nzoia and Nyando Rivers have been implemented by NWCPC. However, such implementation works have not been carried out in a systematic manner; instead they are conducted as financing becomes available.

Flood early warning systems, which are considered useful for reducing flood damages, have not been established in Kenya, except for an installation in the Nzoia River basin as a pilot project. In the current management system, WRMA regional offices give flood warnings based on their past

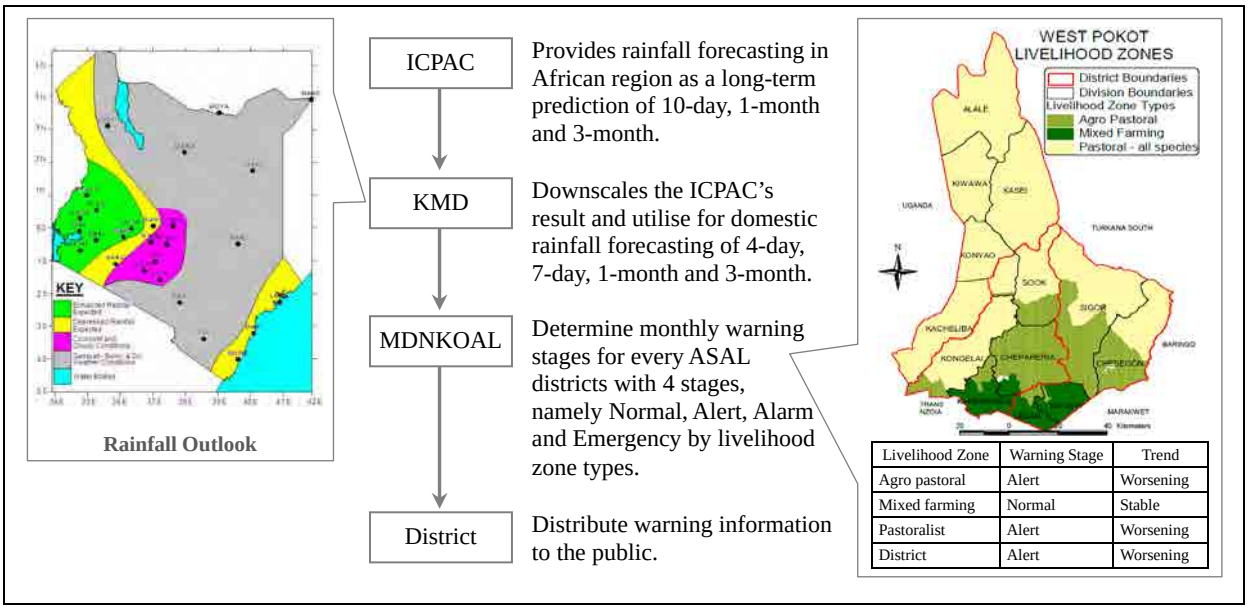
experiences and disseminate the warning to the public through DDMC, etc.; however, such information does not reach the public in most cases. The key issues regarding evacuation activities include sharing information among the concerned organisations and disseminating information to the public.

(2) Current Situation of the Subsector on Drought Disaster Management

Drought management systems have been generally established since the government has focused on drought disasters for a long time. As a drought crisis response system in terms of food, water, energy, etc., the Kenya Food Security Steering Group (KFSSG) and the Crisis Response Centre (CRC) were organised. MWI is one of the member organisations of KFSSG.

In ASAL districts, comprehensive drought management systems including early forecasting and warning, drought assessment, non-structural measures such as effective rainwater use, groundwater harvesting, public relation activities, etc. have been developed through the Arid Land Resources Management Project II primarily by the Ministry of State for Development of Northern Kenya and Other Arid Lands (MDNKOAL) in cooperation with the MWI. The drought early warning in every ASAL district is determined based on the result of long-term rainfall forecast issued by KMD.

In times of drought, WRMA adjusts water provision by restricting water intake with a priority order of domestic, agriculture, industry and others. However, there are some issues in this system. That is, water resources are taken either illegally when it is restricted or by large water intake associations such as irrigation operators are outside the jurisdiction of WRMA's water restriction. In addition, although both long-term rainfall forecasting system and drought early warning system have been established and operated by KMD and MDNKOAL, respectively, those results have not been utilised effectively for WRMA's adjustment of water provision because cooperation systems between WRMA and KMD or MDNKOAL are not sufficiently performed. The flow and image of existing systems are summarised in the figure below. It should be noted that although river discharge is adjusted, drought conciliation of reservoirs has not been implemented yet in any dams.



Livelihood Zone	Warning Stage	Trend
Agro pastoral	Alert	Worsening
Mixed farming	Normal	Stable
Pastoralist	Alert	Worsening
District	Alert	Worsening

Source: Interview with the MDNKOAL, Drought Early Warning Bulletin (January 2011, West Pokot District), and The Outlook for the June-July-August (JJA) 2012 Period (Issue Date: June 4, 2012)

Images of Existing Rainfall Forecast System and Drought Early Warning System

Considering impacts by climate change, damages caused by flood and drought disasters are expected to increase in the future, and countermeasures against those disasters are becoming imperative.

(3) Objective

Among various natural disasters, the NWMP 2030 deals with water-related disasters, namely flood and drought, focusing on the preparedness in the pre-disaster stage. The objective is to minimise human and economic damages caused by flood and drought.

7.9.2 Overall Concept and Framework for Planning for Flood Disaster Management

The flood protection plan in the NWMP (1992) was formulated giving focus to structural measures; however, most of the projects have not been implemented yet. It is effective to incorporate non-structural measures as immediate measures to mitigate flood damage before completion of structural measures, and as measures to mitigate damage by extraordinary floods exceeding a design level of the structural measures. Considering the current situation and objective of flood disaster management, the overall concept and framework for flood disaster management plan formulation to be applied commonly to the six catchment areas were set as follows:

a) Take measures combining structural and non-structural measures comprehensively.

A whole basin strategy for flood risk management can be summarised as follows:

Step 1 For critical areas:	Protection using structures: Strategically protecting urban and densely-populated areas and critical facilities using levees and other structures
Step 2 For other areas:	No settlement: Integrating the no settlement policy into development regulations and regional development programs, and constructing flood-proof buildings only with adequate evacuation arrangements.

Step 3 For unavoidable inundation:	Community-based disaster management (CBDM) and crisis management: Establishing a crisis management framework where communities build their disaster management capacity and local governments and NGOs to support them.

CBDM means an approach that aims to improve a community's capacity against flood. The crucial difference between CBDM and the normal disaster management system is that the community's cooperative activities are placed at the heart of disaster management system. In particular, CBDM includes: i) systematisation of communities and establishment of a flow of monitoring, information dissemination and evacuation in cooperation with local government offices, ii) construction of evacuation centres and evacuation routes by community involvement, iii) voluntary monitoring by community by using simple rain gauges and water level gauges, iv) community involvement in flood fighting activities, and v) construction of small-scale structural measures (such as a small revetment) by community involvement.

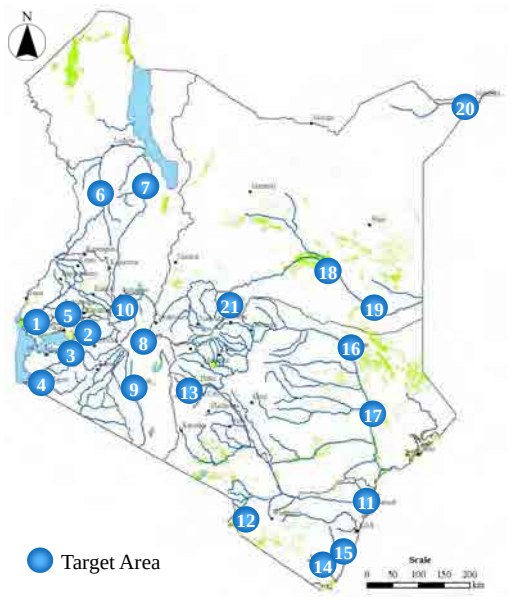
b) Provide structure measures such as dyke, river improvement works, retarding basin, multipurpose dam, etc. for densely populated areas.

c) Provide non-structural measures such as flood forecasting and warning systems, evacuation plan, flood fighting plan, flood hazard map, CBDM, etc. Depending on the number of affected population and damage condition, the approach of CBDM shall be incorporated.

d) Incorporate the concept of natural retarding effects by lands subject to frequent flooding such as pasture, paddy and dry fields. In this case, it is essential to select multiple measures which urban areas in the downstream are prevented from flooding by ring dykes while performing flood plain management and increase and/or maintenance of the function of retention and retardation in upstream areas.

e) From the aspects of respecting the existing plans and strategies formulated by GOK and ensuring consistency with those official documents, areas subject to the flood disaster management plan include 21 proposed basins/areas as identified through the Flood Mitigation Strategy (MWI, June 2009), the NWCPC Strategic Plan 2010-2015, and the NWMP (1992). The proposed basins/areas are summarised in the table and figure below. Also, Table 7.9.1 shows the process of selecting the areas.
It is reasonable to say that not all the 21 areas were determined as target areas for the plan. Although it was confirmed that flooding occurs frequently in these basins/areas through past flood records and the damage survey carried out in this study, the necessity of countermeasures shall be judged by taking into account the extent of flood damage in the respective deliberation processes.

Catchment Area	Proposed Examination Area
LVNCA	1. Yala Swamp
LVSCA	2. Kano Plain 3. Sondu Rivermouth 4. Kuja Rivermouth 5. Kisumu
RVCA	6. Middle/Lower Turkwel 7. Lower Kerio 8. Nakuru 9. Narok 10. Mogotio
ACA	11. Downmost Athi 12. Lumi Rivermouth 13. Nairobi City 14. Kwale 15. Mombasa
TCA	16. Lower Tana 17. Ijara
ENNCA	18. Middle/Lower Ewaso Ng'iro North 19. Wajir 20. Mandera 21. Isiolo



Source: JICA Study Team based on Figure 2.3.1 of Sectoral Report (J) "Flood Area in Kenya"

Proposed Areas for Examination of Flood Disaster Management Plan

f) Propose a basic idea due to insufficient flood data necessary for formulation of specific flood management plan.

7.9.3 Overall Concept and Framework for Planning for Drought Disaster Management

Based on the current situation and objective of the drought disaster management, the overall concept and framework for drought disaster management plan formulation to be applied commonly to the six catchment areas were set as follows:

a) Prepare water use restriction rules for existing and proposed reservoirs to avoid water conflict during times of drought.

It is essential to take the approach in which limited water resource stored in reservoirs be utilised effectively and impartially by adjusting or restricting water intake during times of drought. The adjustment or restriction should be determined on the basis of a river basin unit from the perspective of adjustment of water intake reduction rate within the river basin. The restriction rules prepared shall be properly reviewed in association with construction of new reservoirs and change of water demand in the future.

b) Monitor reference water levels which correspond to reserve or normal discharge

This work is to be implemented as a part of water resources management plan.

c) Establish the Basin Drought Conciliation Council with authority to discuss on water use restriction so as to minimise drought damage

To impose restrictions on water intake from reservoirs for the purpose of mitigation of drought damages, the Basin Drought Conciliation Council shall be established with authority to legally mediate a water conflict associated with drought damage.

d) Establish drought early forecasting system to obtain information on expected drought for preparedness.

In order to commence water use restriction timely, it is necessary to effectively utilise both the existing long-term rainfall forecasting system and drought early warning system, which

are operated by KMD and MDNKOAL, respectively. A specialised drought early forecast system for water use restriction shall be established based on these two systems.

The basic ideas for reservoir water use restriction are as follows:

a) The target reservoirs for water use restriction include all reservoirs that are incorporated into the water resources development plan, including both existing and proposed dams.
b) Three steps of reference reservoir water levels, namely the normal, alert and alarm levels, shall be set for the respective reservoirs for the purpose of clear understanding the timing of necessary actions for water use restriction.
c) The Basin Drought Conciliation Council shall be summoned to discuss actions to be taken when the reservoir water level is expected to become lower than the normal level.
d) Once the reservoir water level reaches the alert level, water use restriction shall commence. The reservoir water level shall not be lower than the alarm level by controlling the outflow discharge from the reservoir.
e) In order to enable early actions based on the existing drought forecasting and early warning systems, a coordination system between KMD and WRMA regional offices shall be developed.

The method to determine reduction rate in water intake among water users in times of drought shall be basically adjusted in the following manner:

a) Based on the current water level of reservoirs, the water level shall be forecasted by considering the future weather forecast. Then necessary reduction rate in water intake for whole basins will be determined.
b) Based on the above clause a), the reduction rate shall be determined for respective intended purposes such as domestic water supply, industry, agriculture, etc. considering possible water saving volume for each purpose. At this time, it is essential to consider the order of priority that has been conventionally stipulated in Kenya.
c) With reference to actual data on reduction rates during past droughts, the final reduction rate shall be determined.

Figure 7.9.1 provides an example record of reservoir water use restriction implemented in Sameura Dam on the Yoshino River in Japan, during the severe drought in 2005.

In addition, as the institutional framework for effective and impartial implementation of water use restriction, it is recommended to set up the following institutional arrangement:

a) In order to create a consultation mechanism, the Basin Drought Conciliation Council shall be established consisting of relevant bodies and organisations.
b) All the water users including irrigation water users shall be registered as members of the Water Resources Users Associations (WRUAs).
c) In times of water use restriction, conflicts between water users may likely to occur. To resolve such conflicts involving water resources, a specialised court shall be established. The court was assumed to be similar to the National Environmental Tribunal (NET)[9], which

[9] NET was established under Section 125 of the Environmental Management and Coordination Act (EMCA) of 1999. NET reviews administrative decisions made by NEMA relating to issuance, revocation or denial of license and conditions of license. The Tribunal consists of five members: a Chairman, appointed by the Judicial Service Commission; two lawyers, one nominated by the law society of Kenya and the other appointed by the Minister for Environment and Natural Resources; and two persons, appointed by the Minister, with

plays the role of formal courts in environmental dispute settlement and also provides legal opinion to the National Environmental Management Authority (NEMA) on complex matters where the authority seeks such advice.

7.10 Environmental Management Plan

7.10.1 Objective of Environmental Management

(1) Current Situation of Environmental Management

Kenya has various natural environmental resources such as forests, grasslands, wetlands, coral reefs and mangroves and a rich biodiversity supported by them. These natural environmental resources are very important in terms of biology and have brought large benefits to Kenya as tourism resources. For the conservation of natural environmental resources, it is important to conserve water bodies such as rivers, lakes, wetlands etc. which produce water resources and are also habitats and water sources of wildlife; however, the natural environmental resources are being degraded with the expansion of human settlements due to rapid population growth, illegal logging/cultivation, climate change, etc.

Kenya has policies, legal and administrative frameworks for environmental management. The environmental management plans for national parks, reserves and specified areas have been developed; however, an environmental management plan for the whole of Kenya has yet to be developed.

The Environmental Management and Coordination Act (EMCA) was enacted in 1999 and environmental impact assessment (EIA) was obligated for development projects. The NEMA is responsible for approval and licensing of the EIA process.

National parks, national reserves and sanctuaries are conserved and managed by the Kenya Wild Service (KWS) according to the Wildlife Act. KWS is obligated to prepare an environmental management plan for each protected area. All the reserved forests (including the five water towers and private forests) are protected and managed by the Kenya Forest Services (KFS) based on the Forest Act. Protected areas in reserved forests, such as the Mt. Kenya National Park, the Mt. Elgon National Park/Reserve, and the Aberdare Range National Park, are managed by KWS.

In Kenya, water resources development is urgently needed due to the rapid economic growth; however, the water resources development projects should be implemented ensuring environmental sustainability. The water resources development projects will change river flow conditions and may give undesirable impacts on the ecosystems of rivers and lakes.

WRMA's Guidelines for Water Allocation stipulates requisite river flow as the "Reserve". The Reserve shall not be less than the flow value that exceed 95% of the time as measured by naturalised flow duration curve at any point along the water course. The Reserve consists of basic human needs and ecological needs, but the ecological needs were not quantified in the guidelines. The ecological needs are recognised as environmental river flow to protect the ecosystems of rivers and lakes. It is necessary to determine the environmental flow rate for major rivers and lakes based on the ecosystem surveys.

competence in environmental conservation.

The WRMA monitors the water quality and quantity of water bodies such as rivers, lakes and springs, while the NEMA issues licenses for effluent discharged by industries. Such monitoring are not always intended for environmental conservation. From the viewpoint of environmental conservation, the water quantity and quality of major rivers and lakes should be continuously monitored to grasp impacts by the water resources development projects to be implemented from now on.

(2) Objective of Environmental Management

Considering the relation of water resources development activities and environmental sustainability, the objective of environmental management in the NWMP 2030 was set such that negative impacts on the natural environment[10] as caused by water resource development activities are to be minimised.

7.10.2 Overall Concept and Framework

Based on the current situation and the objective of environmental management in this study, the overall concept to be applied to the six catchment areas was set as follows:

a) Setting of environmental flow rates at strategic points of major rivers and lakes through environmental surveys, and
b) Implementation of environmental monitoring at strategic points for major rivers and lakes.

The basic ideas for the above overall concept are as described below.

(1) Setting of Environmental Flow Rate

1) Setting Points

The environmental flow rate should be set at strategic points. In the study, they were selected under the following criteria.

a) Reference points of major rivers and lakes which are important for water resources development and management,
b) Confluence of mainstream and major tributaries where river discharges largely change, and
c) Locations where important or precious ecosystem exists.

2) Environmental Survey

The environmental flow rate should be determined based on the environmental surveys for ecosystems of the rivers and lakes. The proposed contents of the environmental survey are as shown in the table below. The proposed environmental survey should be conducted for one year.

[10] Strategic Environmental Assessment (SEA) on the proposed development projects are scheduled to be implemented by WRMA after the formulation of the master plan.

Proposed Contents of Environmental Survey

Subject	Survey Item	Detailed Contents	Frequency
River	River Discharge	Fixed point observation	Monthly for one year
	Water Quality	Temperature, pH, DO, SS, BOD and E. Coliform	Monthly for one year
	Ecosystem	Aquatic flora and fauna, important habitat area and sediment	Semiyearly (Wet season / Dry season)
Lake	Water Level	Fixed point observation	Monthly for one year
	Water Quality	Temperature, pH, DO, SS, COD and coliform	Monthly for one year
	Ecosystem	Aquatic flora and fauna including surrounding wetland area, important habitat area and sediment	Semiyearly (Wet season / Dry season)

Source: JICA Study Team

(2) Environmental Monitoring for Major Rivers and Lakes

1) Monitoring Points

Environmental monitoring should be implemented to grasp the latest conditions of quantities and qualities of river and lake water from the viewpoint of environmental conservation.

The environmental monitoring points were selected under the following criteria:

a) Points where rare or characteristic ecosystem exists (e.g. estuary area, closed basin etc.),
b) Points where large city or town is located,
c) Points upstream from the protected area,
d) Major lakes in the catchment area, and
e) International rivers and lakes.

2) Monitoring Items and Frequencies

The contents and frequency of environmental monitoring are tentatively proposed as shown in the table below. They will be subject to change depending on the conditions.

If any serious environmental impact is expected or observed, WRMA has to report to the responsible agencies such as the National Environmental Management Authorities (NEMA) and the Ministry of Environment and Mineral Resources (MOEMR) immediately. In response to the report, necessary actions should be taken by the responsible agencies to avoid or minimise the damage to the environment.

Proposed Contents and Frequencies of Environmental Monitoring

Subject	Monitoring Item		Frequency
River	River Flow	Discharge at Fixed-point	Monthly
	Water Quality	Water temperature, pH, DO, SS, BOD, and Faecal Coliform	Quarterly
Lake	Water Level	Water Level at Fixed-point	Monthly
	Water Quality	Water temperature, pH, DO, SS, COD, Faecal Coliform T-N, T-P, and Microorganism	Quarterly

Source: JICA Study Team

CHAPTER 8 INSTITUTONAL STRENGTHENING PLAN

8.1 Introduction

(1) Objective of Institutional Strengthening

The objective of institutional development is to strengthen the organisational and institutional capacity on water resources management at the national and regional levels based on the national water resources development and management policy. This will ensure the implementation of the action plan up to the year 2022 of the NWMP to achieve the goals of Kenya Vision 2030.

(2) Background of the Water Act 2002

Since 1927 the Water Ordinance had been enforced. The Water Act, which is the supreme law on water, was initiated in 1951 and was revised once in 1972. The draft revision of the Water Act 1972 had been discussed around May 1992 when the draft final report of the Study on the National Water Master Plan (NWMP) was edited. Sessional Paper No. 1 of 1999 on the National Policy on Water Resources Management and Development (April 29, 1999) was enacted based on the NWMP (1992). Sessional Paper No. 1 of 1999 is the base law to enact the Water Act 2002 and to establish new organisations required for the specified water sector reform. The Water Act 2002 was enacted in October 2002. Its implementing rules, the Water Resources Management Rules 2007 was issued five years later.

(3) Aligning the Water Act with the Constitution of Kenya

Aligning the Water Act 2002 with the Constitution of Kenya 2010 (CoK 2010) has not been completed yet as of end January 2013.

The schedule of the Water Act Bill was delayed though the revision should have been completed within 18 months according to the Fifth Schedule, legislation on land (Article 68 of the CoK 2010). Water resources are part of land (river, lakes and other water bodies) according to the CoK 2010[11].

The key three documents required for the revision were:

a) New National Water Policy 2012
b) Draft Water Bill 2012 (new Water Act)
c) Concept Paper for Aligning Water Act 2002 by Task Force (Chairman Professor Mumma)

Consultation on the draft proposal for the concept paper was extended by the donors until October 2011. Drafting of these three were scheduled to be completed by December 2011, but are still in progress under MWI.

[11] The Constitution of Kenya May 2010, Public land, Article 62 (1) Public land is- (i) all rivers, lakes and other water bodies as defined by an Act of Parliament, (l) all land between the high and low water marks; Interpretation, Article 260, "land" includes- (b) any body of water on or under the surface; (d) natural resources completely contained on or under the surface;
National Land Commission, Article 67 (2) The functions of the National Land commission are- (d) to conduct research related to land and use of natural resources, and make recommendations to appropriate authorities;

The content of the final draft proposal of the concept paper by the Task Force focused on the articles of revision which are required by the CoK 2010. The contents of the Draft Water Bill 2012 (version of March 2012) also covers extensive reform not directly related to the required alignment by the CoK 2010. The concrete powers and functions of the organisations for water resources management have not been consolidated yet. The draft of the National Water Policy 2012 was also still a draft, which is subject to further elaboration as of the end of January 2013.

8.2 Existing Institutional Framework in Water Sector

8.2.1 Existing Laws for Water Resources Management

(1) Hierarchy of Laws in Kenya

The hierarchy of Kenya's laws starts with the constitution, followed by acts of parliament, rules and regulations, gazette notices, circulars, and bylaws.

Hierarchy of Laws

Law	Body Responsible	Remarks
Constitution	The People of Kenya	For all concerned
Acts of parliament	Parliament	For all concerned
Rules and regulations	Ministry	For all concerned
Gazette notice	Ministry	For all concerned
Circulars	Ministry	For all concerned
By laws	County councils, municipal councils, city councils, urban councils, and registered organisations	The bylaws only affect those who are members of the organisations.

Source: JICA Study Team based on information from government authorities

(2) The Constitution and Acts Related with Water Resources Management

The CoK 2010 is the basis of water resources management at the national level. The main influential reform in the CoK 2012 on water resources management covers the sovereignty of the people (Chapters One and Two), the fundamental human rights (Chapter Four), and the land, water resources, and environment (Chapter Five). The sovereignty of people at the national level and the county level is so called localisation: demolition of provinces and devolution to 47 counties (refer to Chapter Eleven and the First Schedule). The distribution of the functions between the national government and the county governments is stipulated in the Fourth Schedule. The right to water entitles every person to have access to sufficient, affordable water and sanitation of acceptable quality for personal and domestic use. Water resources are treated as part of public land (Section 62).

The Water Act 2002 provides the principles and mandates for regulation and management of water resources in the country. The Water Resources Management Rules of 2007 provides detailed implementing rules of the Water Act. The key institutions established in the Water Act include the MWI, the WRMA, the Catchment Area Advisory Committee (CAAC), the Water Service Regulatory Board (WSRB), the WSBs, the Water Appeal Board (WAB) and the Water Services Trust Fund (WSTF).

The Water Act 2002, No.8 of 2002 was assented on October 17, 2002. It was an Act of Parliament to provide for the management, conservation, use and control of water resources and the acquisition and

regulation of rights to use water; to provide for the regulation and management of water supply and sewerage services; to repeal the Water Act (Cap 372) and certain provisions of the Local Government Act; and for related purposes. The act is composed of six parts including 114 Sections and five schedules. The Minister for Water and Irrigation made the Water Resources Management Rules 2007, Legal Notice No. 171 which is conferred by Section 110 of the Water Act 2002. The Management Rule is composed of 13 parts including 154 rules and 12 schedules.

The other acts related with the three main legal documents are the Agriculture Act, the Forest Act, Land Act, the Environmental Management and Coordination Act, the Irrigation Act, the Lakes and Rivers Act, the Electric Power Act, the Mining Act, the Wildlife Act, the Land Planning Act, the Local Government Act, the Fisheries Act, the Public Health Act, the Tana and Athi River Development Authority Act, etc. Table 8.2.1 lists the water related acts, orders, and rules. Table 8.2.2 lists the water related policies and strategies.

8.2.2 Institutional Framework under the Water Act 2002

(1) Existing Representation of Institutional Framework of the Water Sector

The existing representation of the institutional framework of the water sector under MWI is illustrated in Figure 8.2.1. Under the Water Act 2002, water resources management is comprised of two pillars: the regulation of water resources, and the regulation of water supply and sewerage services. The regulation of water resources is mainly allocation and enforcement of water rights while the regulation of water supply and sanitation is mainly regulation and monitoring of water supply service providers. MWI is composed of the department of water services, the department of irrigation, drainage and water storage, the department of land reclamation and head of donor coordination, and the department of water resources. The organisational chart of the MWI is shown in Figure 8.2.2.

The roles and responsibilities of the MWI include development of legislation, policy formulation, sector coordination and guidance, and monitoring and evaluation. The WRMA, which is comprised of a head office and regional offices, is a regulatory body for planning, regulation and management of water resources and contribution to policy formulation at the national and regional levels. WRMA is under the jurisdiction of MWI. The CAAC is an advisory body to WRMA for the regulation of water resources issues at the regional level. The subregional offices of WRMA provide water resources management services at the catchment level under the regional offices of WRMA. The functional organisation structure of WRMA is shown in Figure 8.2.3. The functional organisation structure of WRMA at the regional level is shown in Figure 8.2.4. WRUAs are local bodies set up by water resources users to enable communities and water users/consumers to participate in water resources management.

The Water Services Regulatory Board (WASREB) is a regulatory body for the regulation of matters related to water supply and sanitation services at the national level. WSBs are the regional regulatory bodies for the regulation and planning of water and sewerage services. WSPs are local bodies responsible for water and sewerage services to consumers/water users under license from the WSBs.

WSTF provides financing of water supply and sanitation for disadvantaged groups. WAB is a resolution body for the arbitration of water related disputes and conflict. The NWCPC is responsible for the construction of dams and drilling of boreholes. The Kenya Water Institute (KEWI) is responsible for water related training and research. NIB is a regulatory body for the development of irrigation infrastructure. In Figure 8.2.1 the relationship among NIB, irrigation services provision at the regional and local levels, and the Irrigation Water User Associations (IWUAs) is not included.

(2) WRMA's Roles and Functions

WRMA's mission statement is "to manage, regulate and conserve all water resources in an effective and efficient manner by involving the stakeholders, guaranteeing sustained access to water and equitable allocation of water while ensuring environmental sustainability".

The role and functions of WRMA are as follows:

- Regulate and protect water resources from adverse impacts
- Delineate catchment areas for gazettement
- Identify with stakeholders protected areas for gazettement
- Liaise with other bodies for better management and regulation of water bodies
- Monitor and enforce conditions attached to water permits and water use
- Regulate water infrastructure, use and effluent discharge
- Develop principles, guidelines and procedures for allocation of water
- Manage and protect water catchments
- Formulate catchment management strategies
- Manage and conserve water resources
- Declare state and community schemes
- Coordination with other bodies for early warning, preparedness, and mitigation measures against water related disasters such as floods and droughts
- Advising the minister with respect to water resources management
- Determine and collect charges for water use
- Seek legal address with consent of the attorney general in case of contraventions
- Constitute CAACs and support WRUAs
- Establish water resources monitoring networks
- Collect, analyse, collate and disseminate water resources information
- Encourage stakeholder participation in water resources management including resilience to water related disasters such as floods and droughts

(Source: Section 2.2 of Strategic Plan 2012-2017, WRMA, June 2012)

8.2.3 Sector Framework of Water Resources Management and Policy Measures

Though water use management is the main trunk, a comprehensive approach of water resources management has been envisaged in the Republic of Kenya. Among the three key management components of water resources management, MWI and WRMA exercise jurisdiction over water use

and flood control. NEMA exercises jurisdiction over management of the water environment (water quality and aquatic ecology) including watershed management under the Ministry of Environment (MoE). Catchment protection is under WRMA according to the Water Act 2002, but it is not clear if catchment protection includes flood control. Watershed management is part of catchment protection.

Water quality management is also partly conducted by WRMA at present. The functions of water quality management of fresh water bodies must be concretely clarified between WRMA and the NEMA. Discharge of effluents from municipal and industrial water uses will be significantly increased. Fertiliser and pesticides discharges due to the increase of irrigation water use will also become significant particularly large-scale irrigation areas. Monitoring of such effluents and appropriate sewerage treatment will be required.

The water resources management framework will take into consideration the present and future needs of various water-related sectors, the policy and non-policy measures and requirements, alternative measures, and appropriate balance of policies and measures. Water resources management covers drought regulation and flood management but it excludes drought and flood disaster management. The study drafted approximately the water sector framework as a trial, as shown in Figure 8.2.5, because the present sector framework of water resources management is not very clear.

8.2.4 Supply Side Management and Demand Side Management

Development of huge amounts of new surface water and groundwater sources will be required to achieve the goals of Kenya Vision 2030. In particular, the expansion policy of irrigation areas will require the construction of large-scale dams, inter-catchment surface water transfer and development of groundwater, and such might induce conflicts on water rights allocation. Water shortage issues will not be resolved by the supply side management (development of new water sources) only but will also require appropriate demand side management (water saving, recycle, reduction of loss, etc.). Appropriate combination of supply side management and demand side management was envisaged in water use management, particularly for irrigation, and domestic and industrial water supply, in the future.

8.3 Key Issues in Water Resources Management

8.3.1 Existing Issues Identified by Interview Survey

The interview survey was done to identify the existing issues in water resources management at the six WRMA regional offices in the period of January 26 to February 28, 2011, namely, Tana, Athi, Lake Victoria North, Lake Victoria South, Rift Valley, Ewaso Ng'iro North. The common issues are as follows:

a) Low level of implementation of water resources management,
b) Low enforcement of law,
c) Serious deficiency in legal provisions,
d) Insufficient functions of organisations concerned,
e) Insufficient amount of financial and human resources, and

f) In adequate allocation of financial and human resources at the national and regional levels.

There are some reports which noted the low level of implementation of water resources management. The present water resources management at WRMA regional offices, however, has been conducted rather well, even with very limited human and financial resources and limited experiences since the establishment of the Water Resources Management Rules in 2007.

In the Republic of Kenya the mandates and responsibilities of the national government and sector agencies are governed by laws and regulations. However, the authority and responsibility for sector policymaking, planning, regulating, implementing and monitoring of projects are severely fragmented, spreading across different government tiers and various national government agencies. This issue might be related with the issue items b), c) and d) mentioned above. The fragmentation might be partly induced by frequent rationalisation or reform of the water sector, the policy of decentralisation, and severe shortage of government funds and other resources.

8.3.2 Future Key Issues

Expected future issues which would be induced by the national economic development, i.e., Kenya Vision 2030, were identified through the plan formulation process of the NWMP 2030. The identified existing and future issues were aggregated into eight key issues to formulate strategy of institutional strengthening, as set out below.

(1) Issue 1: How to Set Up a Comprehensive Water Resources Management Institution

Low level of implementation in water resources management has been reported partly due to serious deficiency in legal provisions of water related acts and insufficient functions of water resources management. The following could be more serious in the future:

a) How to clarify conflicting roles of regulators, service providers and water users at both the national and regional (catchment) levels,
b) How to harmonise the conflicting acts in their operations with the Water Act2002 which include the Agriculture Act, the Irrigation Act, the Forest Act, the Land Act, and Ethe MCA 1999 where the conflicting mandates of such acts were never repealed,
c) How to strengthen the capacity to enforce the regulations where prosecution capacity is a key to enforcement,
d) How to facilitate the law to effectively recognise the representatives of WRUAs as catchment forums with mandates for policy and coordination of catchment issues like water uses, flood and conservation,
e) How to clarify the functions on water quality management since management conflicts prevail between the NEMA and WRMA,
f) How to make clearer the mandates, roles and responsibilities for all levels established in law without conflicting with other laws, where there is no need of reorganisation.

(2) Issue 2: How to Regulate International, Inter-catchment and Multisector Issues

The CoK 2010 allocates the function of the use of international waters and water resources to the national government (The Fifth Schedule of item 2 of Part 1- National Government). However, the

following mandates of the water resources administrator (the minister in charge) are not well-defined in the Water Act 2002.

a) Administration and regulation of water uses in international/shared rivers,
b) Regulation of inter-catchment and inter-subcatchment water transfer (inter-catchment water rights regulations),
c) Inter-sector/ministerial coordination (multisector water uses, flood control, water environment, multipurpose dams),
d) Regulation of water uses and development from both supply side and demand side management.

The record of water rights registration is not effectively used in the present water rights regulation. Under the Water Act 2002, WRMA takes sole authority to grant water use permits to all water users, public or private, for both surface water and groundwater. At present, however, the national government, development authorities and power companies construct water source facilities, such as large storage dams, irrigation intake facilities, water supply intake facilities, and groundwater abstraction, without applying for water use permits from WRMA. If the present situation is kept unchanged, serious overlapping of water use permits, significant shortage of usable water, reduction of reliability of water supply security, exhaustion of groundwater and water rights conflicts will arise in the near future.

It is necessary to establish a monopolistic and unified regulatory power and functions of water resources at both national and regional levels in order to achieve a unified national regulation of water resources covering international, inter-catchment, inter-subcatchment water uses, conflicting water rights, and other multisector issues. The WRMA regional offices shall be kept directly under WRMA. The regulatory and coordination functions of water resources would be significantly weakened at both the national and regional levels if the upper national and lower regional structure of the WRMA is independently separated.

The WRMA regional offices function as river basin organisations (RBOs) in reality. It would be too early to operate the WRMA regional offices as totally independent institutionally, financially and technically from the national government and international donor communities. The present resource capacity of the local governments and the private sector might not be sufficient enough to sustain locally independent RBOs in terms of personnel, finance and technology. Further, it is expected that WRMA might become bureaucratic apart from field work in catchments, hence conflicts between WRMA and RBOs might prevail.

(3) Issue 3: How to Set Up Quantitative Water Rights Allocation and Regulation

Grant of new surface water rights will require construction of many new dams in water stress areas in the future in order to avoid significant reduction of water supply security/guarantee level. There is no quantitative water rights management system considering regional water supply security level which is widely adopted in advanced industrialised countries. The present institution also does not require formulation of scientific and quantitative basin water resources development plans. Scientific and quantitative basin water resources development plans will be required soon to achieve credible,

transparent and accountable regulation and enforcement of water rights. The existing six catchment area water resources management strategies do not include any scientific and quantitative basin water resources development plan. WRMA has no experience in formulating scientific and quantitative basin water resources development plans.

How to exercise water resources assessment and water rights to manage the increasing demand must be quantitatively addressed where there is no direct incentive for water users to legalise water use.

(4) Issue 4: How to Achieve Transparent and Scientific Management of Water Resources

The present databases of the WRMA regional offices are not sufficient to implement quantitative management of water rights. It is important to address how to use effectively the present three components of regulation, monitoring, and data and information management system for grant of water use permits, monitoring of discharge and abstraction records, and regulation of water rights.

(5) Issue 5: How to Set Up a Water Saving Society and Economic Structure for the Future

At present various activities of water resources development and water saving measures are in practice. However, the dramatic water demand increase required to achieve Kenya Vision 2030 will not be fulfilled neither by present supply side management nor present demand side management only. The promotion of surface water development including multipurpose dam construction will be necessary. The promotion of a water saving society in the urban and rural areas and structural change of water use economy are necessary, particularly for irrigation and the livestock industry.

(6) Issue 6: How to Strengthen the Capacity of WRMA Regional Offices as RBOs

The WRMA regional offices, which correspond to RBOs, face more water resources management issues on site as they have limited personnel and technical capacity. The prevailing issues include the following:

a) How to increase the number of the subregional offices for effectiveness exercise, where
   - The current level of organisations are adequate as long as the mandates of WRUAs are fully prepared bylaws, and
   - WRUAs are a key in water resources management and must be facilitated and empowered to undertake their mandates.

b) How to capacitate the present organisation of WRMA which includes its headquarters for policy and regulation, regional offices for coordination, subregional offices for implementation and WRUAs to participate in the implementation, where
   - Human resources allocation should ensure majority of technical staff are at the subregional level with appropriate technical assistance,
   - A catchment forum set at the regional level may function as basis for an interregional forum, where interregional coordination is not sufficient at present, and
   - Coordination among stakeholders (the national government, local governments, national sector agencies, stakeholders) is not functioning well as different mandates and programs of national agencies overlap.

(7) Issue 7: How to Consolidate Legal Position of WRUAs

WRUAs are defined in the Article 15 (5) of the Water Act 2002 as fora for conflict resolution and cooperative management of water resources in the catchment areas which is consistent with the CoK 2010. However, there is a movement to change the role of WRUAs. For example, Article 16 of the Draft Water Bill 2012 (version of March 2012) where, (1) WRUAs as a community based association at the sub-basin level; (2) establishment and operations of WRUAs facilitated by the basin area water resources management strategy; (3) to contract WRUAs as agents to perform some duties. The WRUAs are community based water users (or implementers) at the sub-basin level. The WRUAs shall not be used as agents for the basin area water resources management strategy which is a strategy of a regulatory body not of an implementing body. If WRUAs are subcontracted for duty tasks of regulatory bodies, WRUAs would lose their position as water users in case of conflict resolution. WRUAs can participate in preparing Strategic Catchment Management Plans (SCMPs), but are not entitled to prepare SCMPs under the Water Act 2002. If the preparation of SCMPs is entrusted to WRUAs, WRMA subcatchment offices would lose their legal functions as regulators.

It is important to address how to setup the legal position for catchment forum, where there is need for the forum for two or more catchments to discuss inter-basin transfer so as to share information and experiences, e.g. between Tana and Athi.

(8) Issue 8: How to Find Sufficient Funds for Water Resources Management

The insufficient amount of financial resources is a critical issue in national and regional water resources management. The prevailing issues include the following:

a) How to allocate the water resources management budget for implementation of conservation activities, information gathering and sharing and training of staff of WRUAs, where the operations and maintenance budget of the regional offices is not sufficient,
b) How to diversify sources of funds for WRMA direct from government revenue, donor funds and beneficiaries' contribution other than funding based on the WRMA's revenue only, and
c) How to ensure the budget funds are released timely.

Water resources management costs cannot be financed only through the collected water permit fees and other water related charges. The present amount of budget allocated to the water resources management institution at the national and regional levels is not sufficient and efficient in terms of amount, sources, and timing of delivery. The costs required for water resources management are mainly financed by the government in most of the countries because the purpose of water permit fees and charges is different (regulatory) and the amount is not enough to meet the required costs. The water use permit fees generally constitute only a fraction of the required costs.

8.4 Strategy and Actions for Institutional Strengthening

8.4.1 Strategy

(1) Assumption

The strategy for institutional strengthening of water resources management was drafted based on the following assumptions:

- Sessional Paper No. 1 on National Policy on Water Resources Management and Development 1999 (NWRDP 1999) is effective as of end January 2013, and
- The water resources management framework stipulated in the Water Act 2002 is effective as of end January 2013.

It was reported that the draft of the National Water Policy 2012 and the draft Water Bill will not be enacted before the general elections in March 2013 due to the limited term of the Tenth Parliament November 20 to January 15, 2012).

(2) Strategy

The strategy components were formulated at the national level for each of the key issues identified in Section 8.3.2 as set out below.

a) Clarify the integrated framework of water resources management at both the national and regional (catchment) levels in terms of regulation, service provision and water users;
b) Establish monopolistic and unified regulatory functions of water resources at the national level (WRMA) and regional level (WRMA regional offices) for regulation of inter-basin/sub-basin water transfer, and equitable and sustainable allocation of water rights in terms of national and regional interests;
c) Establish unitary management of water rights and basin water resources development plans in line with granting of water use permits;
d) Establish scientific and quantitative management of water resources to achieve credible, transparent and accountable regulations and enforcement of water rights;
e) Enhance both supply management and demand management to achieve the target of water supply security, and efficient, beneficial and sustainable water uses;
f) Strengthen the capacity of the WRMA regional offices for scientific and quantitative water rights regulation at site being consistent with the national level regulation and enforcement;
g) Enhance the establishment of WRUAs and strengthen the capacity of WRUAs as fora for conflict resolution and cooperative management of water resources in catchment areas; and
h) Improve the financial capacity of water resources management institutions at the national and regional levels through effective government financing.

8.4.2 Strategic Actions

Strategic actions (or measures) were prepared for each of the eight components of the strategy formulated in the foregoing section.

(1) Strategic Action 1: Define Concrete Framework of Water Resources Management

The Water Act 2002 reflects the historic and political background of water supply services in Kenya where large water users such as irrigation and hydropower are still at a starting stage. The water resources management framework is not comprehensive. The concept of integrated water resources management (IWRM) is at an initial level. The functions stipulated in the Water Act, the Land Act, the Irrigation Act, the Environmental Management and Coordination Act, etc. are still duplicated or inconsistent.

For example, the regulation on irrigation water services is not included in the present sector framework of water resources management in Kenya because it is regulated by the Irrigation Act. Regulations on irrigation and drainage services are one of the main pillars of water resources management. In reality irrigation water services will be conducted as illustrated in Figure 8.4.1.

Thus, Strategic Action 1 proposes to regulate that irrigation water services and water supply services together as IWRM to be consistent with the Irrigation Act. The comprehensive framework of water resources management at the national and regional levels shall be clearly defined to avoid confusion between regulator, implementer (service provider), and water users.

(2) Strategic Action 2: Establish Monopolistic and Unified Regulation of Water Resources at the National Level and Regional Level

It is necessary to establish a framework (law and institution) which prevents grant of water rights for development from regional water rights conflicts due to development of water resources including inter-basin and intra-basin water transfer crossing county boundaries in response to dramatic increase in future water use.

Strategic Action 2 proposes to establish monopolistic and unified regulatory power and functions of water resources at both the national and regional levels. The present power and functions of the national apex body shall be strengthen to facilitate regulation of inter-basin/sub-basin water transfer, and equitable and sustainable allocation of water rights in terms of both national and regional interests. The WRMA shall be equipped with strong competence to regulate and enforce all the water sector regulatory bodies and various water users for water rights allocation and regulation.

The natural resources including water resources are assets of the state under the CoK 2010 and the Water Act 2002. The two laws allow the national government to execute unitary management of water resources at both national and regional levels under one unified rule, which is a very valuable institution. There is no inconsistency with the constitution to execute unitary regulation of water resources both at the national level and the county level from policymaking to coordination.

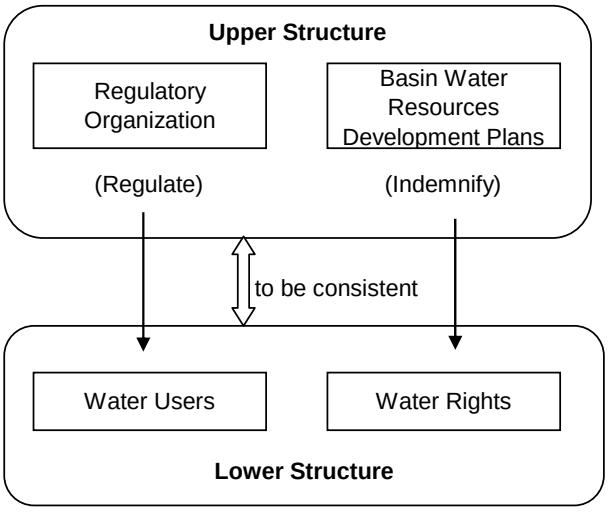
(3) Strategic Action 3: Unitary Management of Water Rights and Basin Water Resources Development Plans

For provision to future water demand increase and climate change it is important to grant water rights appropriately from the stage of water resources development plan to ensure regional water supply security or confidence level.

Strategic Action 3 proposes to establish unitary regulation and enforcement of water rights which links grant of all water permits (water rights) with river basin water resources development plans which are widely adopted in advanced industrialised countries. The water permit registers all water abstraction from and/or for the existing and new storage dams regardless of public or private, and sectors of irrigation, domestic water supply or hydropower generation.

Water rights institution is composed of the upper and lower structures, as illustrated in the following figure. The upper structure is composed of regulatory organisations and river basin water resources development plans. The lower structure is composed of water users and water rights. The apex regulatory organisation manages the entire upper and lower structures and water uses. The river basin water resources development plans indemnify or guarantee water rights and also support regulation of water users together with the water rights. The upper structure is deliberately and generally under the jurisdiction of the national or regional governments[12].

In Kenya, river basin water resources development plans linked with water use rights are not available, and the upper structure is still in process. It is desirable to keep the functions of the upper structure under the national government in order to practice effectively and scientifically the planned regulations on water rights allocation.



Source: Sambongi (2005)

Upper and Lower Structure for Water Rights Regulation

After introduction of Strategic Action 3, the establishment of a basin drought conciliation committee would be required for some river basins where conflict resolution of reservoir operation of some dams prevails during extreme drought period exceeding the water supply security level of the river basin. The establishment of a specific reservoir operation rule will be required for drought regulation of respective river basins.

[12] Mizutani Y., "Institutional Capital Stock Required for Water Resources Management in Developing Economies", XIVth IWRA World Water Congress September 2011

(4) Strategic Action 4: Establish Scientific and Quantitative Management of Water Resources

In order to materialize Strategic Actions 2 and 3 it is necessary to establish scientific and quantitative management of water resources trusted by stakeholders. Strategic Action 4 proposes to establish scientific and quantitative management of water resources to achieve credible, transparent and accountable regulation and enforcement of water rights. The scientific and quantitative management of water resources integrates the following components of regulation, monitoring and corresponding data system:

a) Grant of water use permits and their monitoring records of database,
b) Monitoring of discharge and abstraction records and their database, and
c) Regulation of water rights and drought regulation linked with the relevant basin water resources development plan and their database.

Strategic Action 3 and Strategic Action 4 provide basis for Strategic Action 2 to establish monopolistic and unified regulation of water resources at the national and regional levels.

(5) Strategic Action 5: Enhance Supply Side Management and Demand Side Management

Strategic Action 5 proposes to enhance supply side management and demand side management in order to achieve the target of water supply security, and efficient, beneficial and sustainable water uses.

For supply side management, Strategic Action 5 proposes to enhance the development of water resources for both surface water and groundwater by implementing specific laws, such as laws on water resources promotion and specific multipurpose dam. The concept of the laws on water resources promotion and specific multipurpose dam are also to be included in the revised Water Act.

For demand side management, Strategic Action 5 proposes to legally enhance efficient and beneficial use of water resources both for agricultural water uses and domestic and industrial water use such as water saving, recycle, reduction of loss, water rights transfer and trading, etc.

(6) Strategic Action 6: Capacity Development of the WRMA Regional Offices

Strategic Action 6 proposes to execute capacity development of the WRMA regional offices as a lower structure of WRMA. Technical capacity development of the WRMA regional offices shall be executed as an integrated program with Strategic Actions 2, 3, 4 and 7. In particular, an increase in the number of staff in subregional offices and technical capacity development of such staff are basic requirements.

(7) Strategic Action 7: Enhance the Establishment and Strengthening of Water Resources Users Associations (WRUAs)

Strategic Action 7 proposes to enhance establishment of WRUAs and to strengthen the capacity of WRUAs as fora for conflict resolution and cooperative management of water resources in catchment areas (Article 15 (5) of the Water Act 2002). WRUAs are representation of respective water users such as irrigation water users associations, county water supply providers, government water users,

private enterprise water users, and individual domestic water users. WRUAs shall keep their position as water users or service providers, but not regulators.

(8) Strategic Action 8: Improvement of Financial Capacity for the Water Resources Management Institution at National and Regional Levels

Strategic Action 8 proposes the improvement of financial capacity for the water resources management institution at national and regional levels through effective government financing to secure smooth implementation of water resources management activities.

8.5 Implementation Action

The eight strategic actions above are the core for institutional strengthening of water resources management so as to materialise the NWMP 2030. It is recommended to implement them all together as soon as possible to end the prevailing water rights conflicts.

8.6 Further Studies

(1) Organisation for Flood Management

It is not yet ready to establish independent flood management sections in the WRMA regional offices due to the following present situations:

a) The roles of the WRMA regional offices are not clear since the draft Water Bill 2012, which aligns the Water Act 2002 and the CoK 2010, is still pending.
b) The study on financial sustainability of WRMA (October 2012) recommended to separate the present WRMA head office and the WRMA regional offices, and to break up the WRMA regional offices due to shortage of government funds. However, the question remains who will take charge of water resources management of the river basins.
c) Under the present legal basis it is difficult to allocate new functions of flood control management to WRMA and the WRMA regional offices. In order to operate flood control management the functions of basin flood control planning, design and implementation of flood control projects (structural and non-structural measures), operations and maintenance of flood control facilities (structural and non-structural measures) are to be well-defined and allocated to relevant organisations with provisions of adequate funds.

(2) Trial Study for Strategic Actions 3 and 4

It is recommended to execute a trial study for Strategic Action 3 (unitary management of water rights and basin water resources development plans), and Strategic Action 4 (establish scientific and quantitative management of water resources) as part of institutional strengthening of the WRMA and the WRMA regional offices. The trial can be started with the use of the relevant catchment water resources development and management plan of the NWMP 2030. For example, it can be implemented in two stages: stage 1 is trial using of outputs of the NWMP 2030, and stage 2 is formulating prototype basin water resources development plans after the capacity of the WRMA regional offices is well-developed.

CHAPTER 9 FINANCING ASPECT

9.1 Required Investment Cost

The overall investment costs for the proposed development projects up to 2030 are summarised in the following table.

Investment Costs of Proposed Development Projects

Development Sector		Investment Cost		% of Total
		US$ billion	KSh billion	
1	Water Supply Development			
	(a) Urban Water Supply (137 UC)	12.8	1,089.0	36.2%
	(b) Rural Water Supply (Large-Scale)	2.3	198.9	6.6%
	Subtotal	15.1	1,287.9	42.8%
2	Sewerage Development (95 UC)	5.6	476.5	15.8%
3	Irrigation Development			
	(a) Large-Scale Irrigation Schemes (432,235 ha)	8.5	725.6	24.1%
	(b) Small-scale Irrigation Schemes (109,278 ha)	0.8	70.6	2.3%
	(c) Private Irrigation Schemes (82,162 ha)	1.9	159.3	5.3%
	Subtotal (623,675ha)	11.2	955.5	31.7%
4	Hydropower Development (14 Projects)	3.4	290.5	9.7%
Total		35.3	3,010.3	100%

Note: Cost of dams and water transfer facilities is included in respective subsectors.
Physical contingency (15% of investment cost) and engineering services are included in the estimated investment costs.
Source: JICA Study Team

Of the total investment costs, urban water development is the largest subsector in terms of required investments, amounting to 36.2% of the total investment costs. When adding rural water supply, domestic water supply development requires KSh1,287.9 billion to meet the target of Kenya Vision 2030 to provide the entire population with access to improved water supply by 2030. A considerable investment is also required for sewerage projects to meet the requirement for improved sanitation for around 80% of the urban population, which is estimated at KSh476.5 billion. Based on the water balance analysis in this study, additional 623,675 ha of land are to be irrigated, of which 432,235 ha consist of large-scale irrigation and requires KSh955.5 billion of investment costs in total. Hydropower development is relatively smaller in terms of required investment costs, standing at KSh290.5 billion for 14 hydropower projects.

9.2 Current Budget in the Water Sector

The current government's budget for development expenditure in the water sector is summarised in the following table. The water sector development budget consists of around 3.2% of the total government's budget, amounting to KSh26.9 billion in 2012/13. In terms of GDP, the water sector's development expenditure accounts for less than 1% of GDP.

On the other hand, external resources are larger than government budget in the water sector, which is around 3.5% of the government's budget.

Current Budget of Water Sector

Budget by Ministries	2012/13		% of GDP	% of GOK Budget
	KSh billion	US$ million		
Total Revenue by the Government	838.2	9,834	24.0%	-
Ministry of Water and Irrigation				
Development Grants from the Government	16.9	198	0.5%	2.0%
External Resources	23.7	278	0.7%	2.8%
Ministry of Regional Development				
Development Grants from the Government (Regional Development)	5.6	65	0.2%	0.7%
Ministry of Energy				
Hydropower Development*	1.3	15	0.0%	0.2%
Total Available Budget by the Government**	23.8	279	0.7%	2.8%

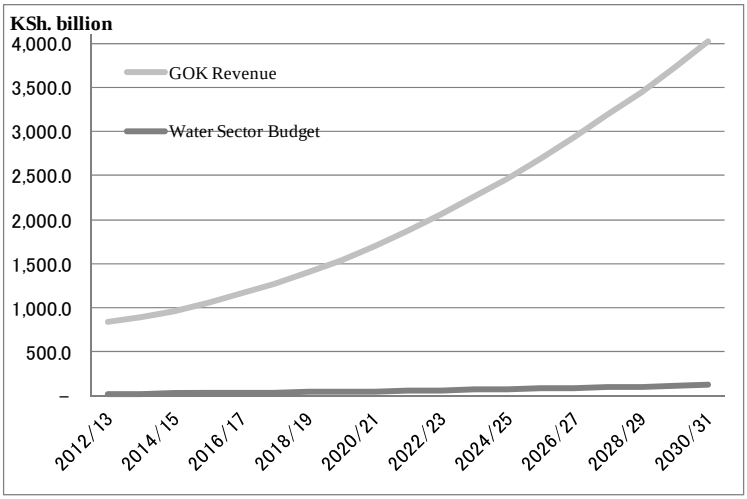
Note: * The GOK budget in the Ministry of Energy is estimated at 20% of development budget in hydropower projects.
** This category excludes external resources for water resource development.
Source: Budget Policy Statement 2012, Ministry of Finance; the data from the Ministry of Water and Irrigation; the data from KenGen

9.3 Estimate of Available Financial Resources

In this study, the following assumptions were made for estimating the available resources for the NWMP 2030:

a) Available financial resources for development projects are defined as available financial resources for water sector development (development expenditure) in the government's budget.

b) The real GDP of Kenya is expected to grow in line with the projection made in Kenya Vision 2030 (2012-2015: 5-9%, 2016-2023: 10%: 2024-2030: 8-9%; See Sectoral Report on Socio-Economy). The estimated GDP (2011 constant price) in 2030 is KSh16,769 billion. The following figure demonstrates the increase of the government's budget and the water sector's budget between 2012/13 and 2030/31.



Source: JICA Study Team

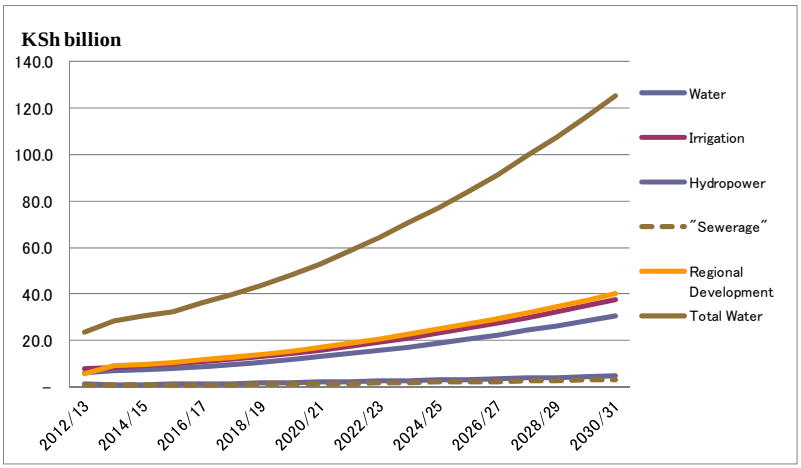
Projection of GOK Budget and Water Sector Budget between 2012/13 and 2030/31

c) The government's future budget and expenditure are expected to increase in proportion to the projected GDP growth. The current proportion of budget to GDP (24% of GDP) and expenditure to GDP (28% of GDP) were applied. The government's budget is expected to increase from KSh806 billion in 2011/12 to KSh4,025 billion in 2030/31.

d) The budget in the water sector is also projected to increase in proportion with the GDP growth rate. Since the implementation of multipurpose dams is expected to commence from the 2013/14 financial year, the budget for regional development is considered to increase from 0.7% of the total GOK budget to 1.0% from the 2013/14 fiscal year (interview with the Ministry of Finance).

e) The estimated development expenditure for water storage and multipurpose dams are then integrated into other water subsectors in order to compare the estimated required investment costs. It was assumed that water storage and multipurpose dams would be used for water supply, irrigation, and hydropower in the end, so the proportion of available resources in irrigation, water supply, and hydropower in the government budget are used to allocate available resources from water storage and multipurpose dams to each water subsector.

The estimated available resources for development projects by subsectors up to 2030 are summarised in the following figure. The total available resources in the water sector between 2013/14 and 2030/31 were estimated at KSh1,247 billion (US$14.6 billion), which is around 3.2% of the total government budget or 0.8% of the GDP in the same period.



Source: JICA Study Team

Projection of Water Sector Budget between 2012 and 2030

In the water supply and hydropower subsectors, a large share of development expenditure has been financed by external resources, while the irrigation subsector has been mainly financed by the GOK development grants (around 80% of the total investments).

The sewerage subsector is relatively underinvested. The government's development expenditure on the sewerage subsector amounts to 0.08% of the total GOK budget or 0.02% of the GDP in 2012/13. External resources in the sewerage subsector consists of around 85% of the total investment, and even adding external resources, the sewerage subsector stands at 0.5% of the GOK's budget or 0.13% of GDP. A study by the African Infrastructure Country Diagnostic (AICD, 2007) shows that Sub-Saharan African countries have spent an average of around 0.5% of their respective GDP for new sanitation facilities, which is exactly the same figure recommended by the AICD to meet the Millennium Development Goals on sanitation.[13]

[13] World Bank, "Climbing the Ladder: The State of Sanitation in Sub-Saharan Africa," Africa Infrastructure Country

Table 9.3.1 provides the available financial resources projected up to 2030, and the following table summarises the available financial resources in the water sector.

Summary of Available Resources for Development Projects in Water Sector up to 2030

(Unit: KSh billion)

Item	2012	2017	2022	2030	Total	Adjusted Total
	2012/13	2017/18	2022/23	2030/31	2013/14-2030/31	2013/14 - 2030/31
	Projection					
Total Revenue by the Government	838.2	1,277.6	2,057.6	4,024.6	38,687.3	
Development Expenditure						
Water Supply	6.1	9.7	15.6	30.5	293.4	561.5
Sewerage	0.7	1.0	1.6	3.2	30.9	30.9
Irrigation	8.0	11.9	19.2	37.6	361.1	580.4
Hydropower	1.3	1.5	2.4	4.7	45.0	74.0
Water Storage*	5.2	7.5	12.0	23.5	226.2	
Multipurpose*	4.2	9.6	15.4	30.2	290.2	
Total	25.5	41.2	66.3	129.7	1,246.7	1,246.7
% of GOK Budget	3.0%	3.2%	3.2%	3.2%	3.2%	
% of GDP	0.7%	0.8%	0.8%	0.8%	0.8%	

Note: * The estimated development expenditure in water storage and multi-purpose are integrated into other water sub-sectors in the "adjusted total" column.

Source: Budget Policy Statement 2012; Data from Ministry of Water and Irrigation; General Economic, Commercial and Labour Affairs, Sector Report for the Medium Term Expenditure Framework 2013/14-2015/16.

9.4 Comparison of Required Cost and Available Resources

Based on the above assumptions, the required investment costs (development costs) and the estimated available resources up to 2030 were compared. As shown in the following table, the available financial resources cannot cover the required investment costs in all subsectors.

Estimated Required Investment Costs and Available Resources

Water Development Sub-Sectors	Estimated Required Investment Costs		Available Government Budget for Development		Coverage (%)
	US$ billion	KSh billion	US$ billion	KSh billion	
Water Supply	15.1	1,287.9	5.8	561.5	43.6%
Sewerage	5.6	476.5	0.4	30.9	6.5%
Irrigation*	9.3	796.2	7.4	580.4	72.9%
Hydropower	3.4	290.5	0.9	74.0	25.5%
Total	33.4	2,851.1	14.5	1,246.8	43.7%

Note: * Private irrigation schemes are excluded.
Source: JICA Study Team

The government budget for water supply subsector covers around 44% of the required investment costs. However, there is a possibility to finance the costs if the same level of external resources would be available in the future, because around 70-80% of water supply development projects in this subsector have currently been financed by external resources. In addition, if the economy will grow

Diagnostic (AICD), June 2008

at more than 10% of the growth rate and capital formation in the private sector will increase consequently, private sector participation in financing water supply projects is expected in future.

The financing gap is largest in the sewerage subsector, in which the government's development budget could cover only 6.5% of the required costs. However, it is very important to invest in the sanitation subsector to prevent waterborne diseases, such as malaria and cholera, which are caused by poor sanitation, and to protect the environment from water pollution. A recent study by the Water and Sanitation Program shows that the economic cost of poor sanitation was estimated at KSh27 billion every year, which includes premature deaths and healthcare costs caused by waterborne diseases, access time to finding an open defection, and productivity loss due to sanitation attributable diseases. The recommended spending for new sewerage facilities as set by AICD at 0.5% of the GDP can be referred to in achieving the target on sanitation spending in Kenya Vision 2030. Contrary to water supply projects, private sector participation may not be much expected in this subsector, therefore more public investments and ODA funds are required to meet the required costs. As in the water supply subsector, it was assumed that at least 30% of the required investment costs could be covered by the government budget, while the remaining cost could be financed by external resources. This indicates that, of the required sewerage investment cost, at least KSh142.2 billion of government development grants are necessary for sewerage investments.

The irrigation subsector may have the largest available GOK resources which is around 73% of the required investment cost, but it is still insufficient to meet the required costs. For a large-scale irrigation scheme, most of the deficient resources could be sought after from ODA funds, while financially viable large-scale projects can be invested by the private sector. For a small-scale irrigation scheme, more government investments should be required to cover the required costs.

The hydropower subsector can cover around 25% of the required investment costs. Since the available GOK financial resources in the hydropower subsector was estimated at 20% of the current spending, the financing for this subsector could be covered, provided external resources, including international ODA financing and private sector financing, continue to be available for financing of hydropower projects.

9.5 Proposed Financing Plan

Based on the above analysis, the proposed financing plan is summarised in the following table. The study proposes a financing plan for each water development subsector within three major types of financing resources, namely, 1) government budget, 2) external ODA fund, and 3) private sector participation. To achieve the targets in Kenya Vision 2030, more government budget are required for the sewerage and irrigation subsectors, as described in the table. This can be partly met by: 1) the gradual transfer of government budget from water supply to sewerage projects, 2) more private financing for financially viable water supply and hydropower projects that enables to allocate government resources used for water supply and hydropower to sewerage projects[14], and 3) the increase of government budget to the water sector from the current 0.7% of GDP to at least 1.0% of

[14] The possibility of private participation can be scrutinised during the course of individual project formulation.

GDP (or 4.2% of the GOK budget), which is a very conservative figure compared to the average of African governments' spending on water supply and sanitation; 0.7% of GDP were spent by African governments for water supply and sanitation infrastructure, which can be compared to 0.2-0.3% of GDP in Kenya[15].

Proposed Financing Plan for Development Projects

Development	Proposed Financing Plan		
	Government budget	External ODA Fund	Private Sector
Water Supply	Government budget is required for urban and rural water supply projects, although gradual reduction of government budget allocated to water supply projects and more private sector financing are recommended. Equalisation funds and decentralised financing schemes are proposed for rural water supply.	External resources would be required especially for large-scale urban water projects and rural water projects.	More private sector financing is required for financially viable urban water supply projects. Infrastructure bonds and development bank for infrastructure financing are recommended measures for encouraging private sector participation.
Sewerage	More government budget is required to meet the target of Kenya Vision 2030. For the sewerage subsector investment, 0.5% of the GDP can be referred to meet the required costs. The GOK's sewerage spending can be gradually increased from 0.08% of the GOK budget to 0.5% by 2019 to cover at least 30% of the required costs.	External resources from international financing agencies need to be increased and it can be transferred from water supply projects. To meet 70% of the required cost, US$3.9 billion will be required, which could be financed by external resources.	If sewerage projects are integrated into water supply project with the sanitation component in tariff structure, private sector financing can be a possible choice.
Irrigation	More government budget is necessary because external resources in this subsector are relatively small compared to other subsectors. Government budget is especially required for the investment of small-scale irrigation schemes.	External ODA fund needs to be encouraged, especially for large-scale irrigation schemes.	Private sector participation is expected for large-scale irrigation schemes with financially viable project.
Hydropower	Financing in this subsector can be gradually moved from government budget to private sector financing, especially for financially viable hydropower projects.	External ODA financing is expected in this subsector as before.	More private sector participation can be encouraged for financially viable hydropower projects

Source: JICA Study Team

[15] *Africa's Water and Sanitation Infrastructure: Access, Affordability, and Alternatives*, the World Bank, 2011. In middle-income countries, 0.9% of GDP were spent for water supply and sanitation infrastructure on average. To meet the level of the average African government spending in water supply and sanitation infrastructure, the Kenyan government needs to spend around 2.1 to 3.5 times as much as the current development expenditure in the water sector.

CHAPTER 10 SUMMARY OF PROPOSED PLANS BY SUBSECTOR

In Sectoral Report (C) to Sectoral Report (K), the proposed water allocation plans, development plans (water supply, sanitation, irrigation, hydropower and water resources development plans) and management plans (water resources, flood and drought disaster and environmental management plans) are described by catchment area for six catchment areas. In this chapter, the proposed development plans and management plans are summarised by subsector together with summary of water allocation plans.

Table 10.1.1 presents the summary of water allocation plans. The proposed development plans are summarised in Tables 10.1.2 – 10.1.6 and the proposed management plans are summarised in Tables 10.1.7 – 10.1.9. Also, the locations of the proposed development and management plans are shown in Figures 10.1.1 – 10.1.14.

CHAPTER 11 RECOMMENDATIONS

The NWMP 2030 aims to present a framework for water resources development and management which is consistent with the country's social and economic development activities. It is expected that the NWMP 2030 is largely utilised for the water resources development and management hereafter.

The followings are recommendations and remarks on utilisation of the NWMP 2030 and implementation of the proposed plans.

(1) Periodical Update of National Water Master Plan and Accumulation of Basic Data

The NWMP 2030 is an updated version of the NWMP prepared in 1992 and it took almost 20 years to realise the update. To cope with the change of situation surrounding the water sector as mentioned in Section 1.1, it is desirable to update the national water master plan around every ten years.

Through preparation of the NWMP 2030, it was revealed that the basic information and data required for formulation of the national water master plan were insufficient. It is recommended to establish a database to accumulate the basic information and data continuously toward the next update of the national water master plan. In concrete, necessary information includes the followings but not limited to:

1) Data related to the current water use (accurate amount of water supply for each subsector, existing irrigation area, irrigation efficiency, cropping intensity etc.)
2) Information required for appropriate planning (amount of water resources, total amount of issued water permits, information on water resource development, information related to flood, environmental flow, reserve etc.)
3) Basic socio-economic information for water demand projection (population projection by administrative boundary, basic industrial information related to industrial water demand projection, numbers of livestock and required daily water for feeding, areas of fishpond for inland fisheries etc.)

(2) Early Implementation of Required Surveys for Planning

During the course of the master plan study, formulation of the master plan was rather difficult in the following areas due to lack of related data. Early implementation of the required surveys and accumulation of the data are recommended.

1) Detailed flood survey[16] for formulation of flood management plan
2) Survey on the current situation of soil erosion[17] and degradation of small water sources[18]

[16] Survey items for planning should include location, depth, area and time of flooding, flood discharge, river conditions, topographic maps, etc. (Refer to Sectoral (J) Flood and Drought Disaster Management 7.4 (1)).
[17] Survey items for planning should include location, scale, current situation, and the required countermeasures. (Refer to Sectoral (H) Water Resources Management 3.2 (4)3)).
[18] Survey items for planning should include location, scale, water use, water quality, vegetation condition, management method, and major issues. (Refer to Sectoral (H) Water Resources Management 3.2 (4)2)).

(3) Continuous Monitoring and Evaluation of Water Resources

The monitoring and evaluation of water resources are basis for the water resources management and they should be continuously conducted. The reliable water resources data will realise the proper water resources management.

The NWMP 2030 presents the basic information and data for water resources management such as available water resources, present and future water demands, water resources monitoring networks, water allocation plans based on water balance study, change of flow regime at reference points, etc. However, it is recommended to realise equitable water allocation and proper water right issuance based on the latest data obtained from the continuous monitoring and evaluation of water resources.

The future water demand to achieve the Kenya Vision 2030 will increase to about four times of the present water demand in total. This indicates that it will be quite severe to keep the balance between water supply and demand in the future. It is recommended to steadily develop water resources to meet the water demands; to manage the water resources so as to promote efficient water use and water saving; and to attain equitable water allocation. Strengthening of capability of the water resources management is therefore essential, which requires institutional strengthening of WRMA such as maintenance and expansion of the observation stations and increase of workforces.

As for groundwater potential, a potential map was prepared during the master plan as general information. Detailed information on groundwater potential should be rectified through survey and further studies.

(4) Actions on Institutional Strengthening for Water Resources Management

The institutional strengthening plan in the NWMP 2030 proposed eight strategic actions on institutional strengthening of water resources management. It is recommended to take those actions as early as possible to avoid conflicts on water rights caused by increased the water demands toward future and to attain proper water resources management.

(5) Financing Aspect

According to rough analysis on financing aspect, the government budget allocated to water sector cover only around 44% of the required total investment cost to implement the proposed plans assuming that the water sector budget increases in proportion to a growth rate of GDP. Currently the water sector budget accounts for 0.7% of GDP. It is recommended to increase this ratio of 0.7% to around 1.0% and also to make use of the private funds and ODA funds to cover the required investment cost.

(6) Revision of National Water Policy and Water Act

The present national water policy was established in 1999 and the present water act in 2002. They are presently effective and the NWMP 2030 is based on them. However, they are under process of revision to align with new Constitution of Kenya established in 2010. It is necessary to review the relevant parts of NWMP 2030 after enactment of the revised national water policy and water act.

(7) Formulation of Development Master Plans of Subsectors

The NWMP 2030 was formulated based on the national development targets presented in the Kenya Vision 2030, but no concrete development master plans for respective subsectors are presented. It is recommended to prepare the development master plans of subsectors such as water and sanitation master plan, irrigation master plan, hydropower master plan, urban development master plan, regional development master plan, etc. to quantify the future water demands more clearly.

(8) Water Resources Management for International Rivers

There is no international treaties on the transboundary water with related countries so far. Therefore, no consideration was made for international water allocation in the NWMP 2030. The NWMP 2030 includes development of transboundary water as an input to achieve the Kenya Vision 2030. However, it is necessary to build consensus prior to implementation of water resources development projects in international river basins. The NWMP 2030 assumes that international agreements and treaties with neighboring countries will be made in line with the Transboundary Water Policy which is currently under formulation by MWI. It is recommended to have the Transboundary Water Policy completed promptly as the policy is important for implementation of NWMP 2030.

Tables

Table 3.2.1 Population of 47 Counties

No.	County	The 2009 Census			District	The 1999 Census			Ref. 50 Districts [1)]
		Male	Female	Total		Male	Female	Total	
1	Nairobi	1,605,230	1,533,139	3,138,369	Nairobi	1,153,828	989,426	2,143,254	Nairobi
2	Kilifi	535,526	574,209	1,109,735	Kilifi	258,505	285,798	544,303	Kilifi
					Malindi	139,340	142,212	281,552	
3	Kwale	315,997	333,934	649,931	Kwale	240,764	255,369	496,133	Kwale
4	Lamu	53,045	48,494	101,539	Lamu	37,553	35,133	72,686	Lamu
5	Mombasa	486,924	452,446	939,370	Mombasa	363,552	301,466	665,018	Mombasa
6	Taita Taveta	145,334	139,323	284,657	Taita Taveta	123,329	123,342	246,671	Taita
7	Tana River	119,853	120,222	240,075	Tana River	90,613	90,288	180,901	Tana River
8	Garissa	334,939	288,121	623,060	Garissa	206,117	186,393	392,510	Garissa
9	Mandera	559,943	465,813	1,025,756	Mandera	131,062	119,310	250,372	Mandera
10	Marsabit	151,112	140,054	291,166	Marsabit	60,940	60,538	121,478	Marsabit
					Moyale	26,559	26,920	53,479	
11	Wajir	363,766	298,175	661,941	Wajir	171,318	147,943	319,261	Wajir
12	Embu	254,303	261,909	516,212	Embu	136,499	141,697	278,196	Embu
					Mbeere	81,885	89,068	170,953	
13	Isiolo	73,694	69,600	143,294	Isiolo	51,214	49,647	100,861	Isiolo
14	Kitui	481,282	531,427	1,012,709	Kitui	243,045	272,377	515,422	Kitui
15	Machakos	543,139	555,445	1,098,584	Machakos	442,891	463,753	906,644	Masaku
16	Makueni	430,710	453,817	884,527	Makueni	372,639	398,906	771,545	Makueni
17	Meru	670,656	685,645	1,356,301	Meru Central	248,027	250,853	498,880	Meru
					Meru North	293,385	310,665	604,050	
					Nithi(Meru S.)	100,226	105,225	205,451	
18	Tharaka	178,451	186,879	365,330	Tharaka	48,196	52,796	100,992	Tharaka Nithi
19	Kiambu	802,609	820,673	1,623,282	Kiambu	369,101	374,909	744,010	Kiambu
					Thika	323,479	322,234	645,713	
20	Kirinyaga	260,630	267,424	528,054	Kirinyaga	226,665	230,440	457,105	Kiranyaga
21	Muranga	457,864	484,717	942,581	Muranga	164,670	183,634	348,304	Murang'a
					Maragua	187,128	200,841	387,969	
22	Nyandarua	292,155	304,113	596,268	Nyandarua	235,052	244,850	479,902	Nyandarua
23	Nyeri	339,725	353,833	693,558	Nyeri	322,521	338,635	661,156	Nyeri
					Mwingi	141,778	162,050	303,828	Mwingi
									Nyambene
24	Turkana	445,069	410,330	855,399	Turkana	224,548	226,312	450,860	Turkana
25	Baringo	279,081	276,480	555,561	Baringo	130,054	134,924	264,978	Baringo
					Koibatek	69,236	68,927	138,163	
26	Bomet	359,727	364,459	724,186	Bomet	185,999	196,795	382,794	Bomet
27	Elgeyo Marakwet	183,738	186,260	369,998	Marakwet	69,068	71,561	140,629	Elgeyo Marakwet
					Keiyo	71,147	72,718	143,865	
28	Kajiado	345,146	342,166	687,312	Kajiado	206,353	199,701	406,054	Kajiado
29	Kericho	381,980	376,359	758,339	Kericho	237,821	230,672	468,493	
					Buret	162,703	154,179	316,882	
30	Laikipia	198,625	200,602	399,227	Laikipia	161,698	160,489	322,187	Laikipia
31	Nakuru	804,582	798,743	1,603,325	Nakuru	598,703	588,336	1,187,039	Nakuru
32	Nandi	376,488	376,477	752,965	Nandi	290,003	288,748	578,751	Nandi
33	Narok	429,026	421,894	850,920	Narok	184,231	181,519	365,750	Narok
34	Samburu	112,007	111,940	223,947	Samburu	69,378	74,169	143,547	Samburu
35	Trans-Nzoia	407,172	411,585	818,757	Trans Nzoia	286,836	288,826	575,662	Trans Nzoia
36	Uasin Gishu	448,994	445,185	894,179	Uasin Gishu	315,932	306,773	622,705	Uasin Gishu
37	West Pokot	254,827	257,863	512,690	West Pokot	151,506	156,580	308,086	West Pokot
					Trans Mara	83,773	86,818	170,591	Transmara
									Kipsigis
38	Kakamega	800,989	859,662	1,660,651	Kakamega	290,343	313,079	603,422	Kakamega
					Lugari	105,273	110,647	215,920	
					Butere/Mumias	227,043	249,885	476,928	
39	Bungoma	795,595	835,339	1,630,934	Bungoma	425,957	450,534	876,491	Bungoma
					Mt. Elgon	66,783	68,250	135,033	
40	Busia	232,075	256,000	488,075	Busia	174,368	196,240	370,608	Busia
					Teso	87,926	93,565	181,491	
41	Vihiga	262,716	291,906	554,622	Vihiga	232,720	266,163	498,883	Vihiga
42	Homa Bay	462,454	501,340	963,794	Homa Bay	136,728	151,812	288,540	Homa Bay
					Rachuonyo	145,793	161,333	307,126	
					Suba	75,167	80,499	155,666	
43	Kisii	550,464	601,818	1,152,282	Gucha(S.Kisii)	221,249	239,690	460,939	Gusii
					Kisii Central	234,448	257,338	491,786	
					N.Kisii(Nyamira)	239,851	258,251	498,102	
44	Kisumu	474,760	494,149	968,909	Kisumu	248,735	255,624	504,359	Kisumu
					Nyando	146,635	153,295	299,930	
45	Migori	444,356	472,814	917,170	Migori	247,131	267,766	514,897	Migori
					Kuria	73,989	77,898	151,887	
46	Nyamira	287,048	311,204	598,252					Nyamira
47	Siaya	398,652	443,652	842,304	Siaya	220,997	259,187	480,184	Siaya
					Bondo	113,583	125,197	238,780	
	Total	19,192,458	19,417,639	38,610,097	Total	14,205,589	14,481,018	28,686,607	

Note: 1) District used in Aftercare Study (NWMP 1998)
Source: The 2009 Population and Housing Census

Table 6.5.1 Existing Irrigation Schemes by County and Catchment Area in 2010

(1) Existing Irrigation Schemes by County

Province	County	Large Scale		Small Scale		Private		Total	
		Nos.	Area (ha)	Nos.	Area (ha)	Nos.	Area (ha)	Nos.	Area (ha)
Western	Bungoma	0	0	2	60	0	0	2	60
	Busia	1	363	2	50	0	0	3	413
	Kakamega	0	0	3	87	0	0	3	87
	Vihiga	0	0	0	0	0	0	0	0
Nyanza	Homa Bay	0	0	33	5,866	3	10	36	5,876
	Migori	0	0	4	74	1	5	5	79
	Kisii	0	0	6	132	1	7	7	139
	Nyamira	0	0	2	253	0	0	2	253
	Kisumu	2	1,800	15	3,620	5	1,028	22	6,448
	Siaya	0	0	30	731	1	6	31	737
Rift Valley	Baringo	1	450	19	1,220	36	774	56	2,444
	Kericho	0	0	0	0	12	143	12	143
	Bomet	0	0	2	280	0	0	2	280
	Elgeyo Marakwet	0	0	16	795	0	0	16	795
	Kajiado	0	0	43	6,022	10	150	53	6,172
	Laikipia	0	0	0	0	51	1,394	51	1,394
	Nakuru	0	0	0	0	61	1,579	61	1,579
	Nandi	0	0	6	344	4	8	10	352
	Narok	0	0	3	70	42	335	45	405
	Samburu	0	0	2	15	0	0	2	15
	Trans Nzoia	0	0	0	0	6	99	6	99
	Turkana	0	0	20	2,065	4	53	24	2,118
	Uasin Gishu	0	0	4	55	4	73	8	128
	West Pokot	1	324	102	1,520	6	78	109	1,922
Central	Kiambu	0	0	2	320	175	9,203	177	9,523
	Kirinyaga	2	7,800	92	3,629	192	11,766	286	23,195
	Muranga	0	0	5	106	206	2,389	211	2,495
	Nyandarua	0	0	7	121	5	203	12	324
	Nyeri	0	0	5	260	367	5,316	372	5,576
Nairobi	Nairobi	0	0	51	100	6	183	57	283
Eastern	Embu	0	0	20	1,810	151	2,587	171	4,397
	Isiolo	0	0	10	1,160	3	269	13	1,429
	Kitui	0	0	3	68	29	375	32	443
	Machakos	0	0	41	1,419	42	534	83	1,953
	Makueni	0	0	14	751	32	2,658	46	3,409
	Marsabit	0	0	0	0	0	0	0	0
	Meru	0	0	58	6,811	600	10,901	658	17,712
	Tharaka-Nithi	0	0	2	70	99	3,097	101	3,167
Coast	Kilifi	0	0	20	469	0	0	20	469
	Kwale	0	0	11	608	1	2	12	610
	Lamu	0	0	10	41	0	0	10	41
	Mombasa	0	0	1	2	0	0	1	2
	Taita Taveta	0	0	35	3,854	24	18,644	59	22,498
	Tana River	2	3,400	11	1,190	12	839	25	5,429
North Eastern	Garissa	0	0	62	818	52	1,132	114	1,950
	Mandera	0	0	287	4,858	0	0	287	4,858
	Wajir	0	0	10	200	0	0	10	200
Total		9	14,137	1071	51,924	2243	75,840	3,323	141,900

(2) Existing Irrigation Scheme by Catchment Area

Catchment Area	Large Scale		Small Scale		Private		Total	
	Nos.	Area (ha)	Nos.	Area (ha)	Nos.	Area (ha)	Nos.	Area (ha)
Lake Victoria North	1	363	37	1,327	1	186	39	1,876
Lake Victoria South	2	1,800	45	10,225	5	1,193	52	13,218
Rift Valley	2	774	217	5,791	236	3,022	455	9,587
Athi	0	0	185	13,524	780	31,374	965	44,898
Tana	4	11,200	278	14,823	1,167	38,402	1,449	64,425
Ewaso Ng'iro North	0	0	309	6,233	54	1,663	363	7,896
Total	9	14,137	1,071	51,924	2,243	75,840	3,323	141,900

Source: JICA Study Team based on data from NIB, MOA, KVDA, WRMA, and Inventory Survey in this study

Table 6.5.2 Monthly Unit Irrigation Water Requirement by Sub-basin (1/4)

(Unit: $m^3/s/1{,}000$ ha)

Catch-ment Area	Sub-basin	Unit Irrigation Water Requirement under 60% Irrigation Efficiency and Full Cropping*											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
LVNCA	1AA	0.83	0.73	0.59	0.05	0.00	0.00	0.34	0.32	0.70	0.37	0.32	0.54
	1AB	0.83	0.73	0.59	0.05	0.00	0.00	0.34	0.32	0.70	0.37	0.32	0.54
	1AC	0.83	0.73	0.59	0.05	0.00	0.00	0.34	0.32	0.70	0.37	0.32	0.54
	1AD	0.83	0.73	0.59	0.05	0.00	0.00	0.34	0.32	0.70	0.37	0.32	0.54
	1AE	0.83	0.73	0.59	0.05	0.00	0.00	0.34	0.32	0.70	0.37	0.32	0.54
	1AF	0.83	0.73	0.59	0.05	0.00	0.00	0.34	0.32	0.70	0.37	0.32	0.54
	1AG	0.83	0.73	0.59	0.05	0.00	0.00	0.34	0.32	0.70	0.37	0.32	0.54
	1AH	0.83	0.73	0.59	0.05	0.00	0.00	0.34	0.32	0.70	0.37	0.32	0.54
	1BA	1.01	0.97	0.86	0.48	0.10	0.19	0.00	0.12	0.57	0.44	0.78	0.87
	1BB	1.01	0.97	0.86	0.48	0.10	0.19	0.00	0.12	0.57	0.44	0.78	0.87
	1BC	0.81	0.91	0.72	0.25	0.00	0.10	0.00	0.00	0.07	0.25	0.52	0.72
	1BD	1.01	0.97	0.86	0.48	0.10	0.19	0.00	0.12	0.57	0.44	0.78	0.87
	1BE	1.01	0.97	0.86	0.48	0.10	0.19	0.00	0.12	0.57	0.44	0.78	0.87
	1BG	1.01	0.97	0.86	0.48	0.10	0.19	0.00	0.12	0.57	0.44	0.78	0.87
	1BH	1.01	0.97	0.86	0.48	0.10	0.19	0.00	0.12	0.57	0.44	0.78	0.87
	1CA	0.98	0.99	0.92	0.41	0.29	0.22	0.00	0.00	0.41	0.72	0.78	0.89
	1CB	0.98	0.99	0.92	0.41	0.29	0.22	0.00	0.00	0.41	0.72	0.78	0.89
	1CC	0.81	0.96	0.91	0.14	0.27	0.03	0.08	0.02	0.79	0.72	0.74	0.85
	1CD	0.98	0.99	0.92	0.41	0.29	0.22	0.00	0.00	0.41	0.72	0.78	0.89
	1CE	0.98	0.99	0.92	0.41	0.29	0.22	0.00	0.00	0.41	0.72	0.78	0.89
	1DA	0.98	0.99	0.92	0.41	0.29	0.22	0.00	0.00	0.41	0.72	0.78	0.89
	1DB	1.01	0.97	0.86	0.48	0.10	0.19	0.00	0.12	0.57	0.44	0.78	0.87
	1DC	0.83	0.73	0.59	0.05	0.00	0.00	0.34	0.32	0.70	0.37	0.32	0.54
	1DD	0.83	0.73	0.59	0.05	0.00	0.00	0.34	0.32	0.70	0.37	0.32	0.54
	1EA	0.87	0.91	0.78	0.24	0.00	0.00	0.00	0.00	0.14	0.35	0.56	0.69
	1EB	0.87	0.91	0.78	0.24	0.00	0.00	0.00	0.00	0.14	0.35	0.56	0.69
	1EC	0.87	0.91	0.78	0.24	0.00	0.00	0.00	0.00	0.14	0.35	0.56	0.69
	1ED	0.83	0.73	0.59	0.05	0.00	0.00	0.34	0.32	0.70	0.37	0.32	0.54
	1EE	0.83	0.73	0.59	0.05	0.00	0.00	0.34	0.32	0.70	0.37	0.32	0.54
	1EF	0.87	0.94	0.65	0.41	0.16	0.56	0.78	0.76	0.81	0.78	0.71	0.74
	1EG	0.87	0.94	0.65	0.41	0.16	0.56	0.78	0.76	0.81	0.78	0.71	0.74
	1FA	0.81	0.96	0.91	0.14	0.27	0.03	0.08	0.02	0.79	0.72	0.74	0.85
	1FB	0.87	0.91	0.78	0.24	0.00	0.00	0.00	0.00	0.14	0.35	0.56	0.69
	1FC	0.87	0.91	0.78	0.24	0.00	0.00	0.00	0.00	0.14	0.35	0.56	0.69
	1FD	0.87	0.91	0.78	0.24	0.00	0.00	0.00	0.00	0.14	0.35	0.56	0.69
	1FE	0.87	0.91	0.78	0.24	0.00	0.00	0.00	0.00	0.14	0.35	0.56	0.69
	1FF	1.02	0.98	0.76	0.34	0.38	0.66	0.82	0.72	0.91	0.97	0.84	0.83
	1FG	0.87	0.94	0.65	0.41	0.16	0.56	0.78	0.76	0.81	0.78	0.71	0.74
Average of LVNCA		0.90	0.88	0.75	0.26	0.09	0.13	0.20	0.20	0.54	0.49	0.58	0.72
LVSCA	1GA	0.91	0.99	0.93	0.25	0.18	0.02	0.00	0.00	0.00	0.51	0.59	0.86
	1GB	0.70	0.78	0.64	0.00	0.00	0.10	0.19	0.28	0.49	0.48	0.53	0.68
	1GC	0.70	0.78	0.64	0.00	0.00	0.10	0.19	0.28	0.49	0.48	0.53	0.68
	1GD	1.11	1.08	0.89	0.27	0.40	0.50	0.72	0.74	0.99	0.86	0.83	0.81
	1GE	1.11	1.08	0.89	0.27	0.40	0.50	0.72	0.74	0.99	0.86	0.83	0.81
	1GF	1.11	1.08	0.89	0.27	0.40	0.50	0.72	0.74	0.99	0.86	0.83	0.81
	1GG	0.70	0.78	0.64	0.00	0.00	0.10	0.19	0.28	0.49	0.48	0.53	0.68
	1HA1	0.87	0.94	0.65	0.41	0.16	0.56	0.78	0.76	0.81	0.78	0.71	0.74
	1HA2	0.87	0.94	0.65	0.41	0.16	0.56	0.78	0.76	0.81	0.78	0.71	0.74
	1HB1	0.87	0.94	0.65	0.41	0.16	0.56	0.78	0.76	0.81	0.78	0.71	0.74
	1HB2	0.87	0.94	0.65	0.41	0.16	0.56	0.78	0.76	0.81	0.78	0.71	0.74
	1HC	0.87	0.94	0.65	0.41	0.16	0.56	0.78	0.76	0.81	0.78	0.71	0.74
	1HD	0.87	0.94	0.65	0.41	0.16	0.56	0.78	0.76	0.81	0.78	0.71	0.74
	1HE	0.87	0.94	0.65	0.41	0.16	0.56	0.78	0.76	0.81	0.78	0.71	0.74
	1HF	0.87	0.94	0.65	0.41	0.16	0.56	0.78	0.76	0.81	0.78	0.71	0.74
	1HG	0.87	0.94	0.65	0.41	0.16	0.56	0.78	0.76	0.81	0.78	0.71	0.74
	1JA	0.74	0.66	0.62	0.24	0.34	0.47	0.52	0.66	0.81	0.81	0.73	0.69
	1JB	0.74	0.66	0.62	0.24	0.34	0.47	0.52	0.66	0.81	0.81	0.73	0.69
	1JC	0.74	0.66	0.62	0.24	0.34	0.47	0.52	0.66	0.81	0.81	0.73	0.69
	1JD	0.74	0.66	0.62	0.24	0.34	0.47	0.52	0.66	0.81	0.81	0.73	0.69
	1JE	0.74	0.66	0.62	0.24	0.34	0.47	0.52	0.66	0.81	0.81	0.73	0.69
	1JF	0.74	0.66	0.62	0.24	0.34	0.47	0.52	0.66	0.81	0.81	0.73	0.69

Table 6.5.2 Monthly Unit Irrigation Water Requirement by Sub-basin (2/4)

(Unit: $m^3/s/1{,}000$ ha)

Catch-ment Area	Sub-basin	Unit Irrigation Water Requirement under 60% Irrigation Efficiency and Full Cropping											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
LVSCA	1JG1	0.74	0.66	0.62	0.24	0.34	0.47	0.52	0.66	0.81	0.81	0.73	0.69
	1JG2	0.74	0.66	0.62	0.24	0.34	0.47	0.52	0.66	0.81	0.81	0.73	0.69
	1KA	1.00	0.96	0.62	0.14	0.21	0.62	0.83	0.83	1.00	0.83	0.69	0.77
	1KB	1.00	0.96	0.62	0.14	0.21	0.62	0.83	0.83	1.00	0.83	0.69	0.77
	1KC	1.00	0.96	0.62	0.14	0.21	0.62	0.83	0.83	1.00	0.83	0.69	0.77
	1LA1	0.74	0.66	0.62	0.24	0.34	0.47	0.52	0.66	0.81	0.81	0.73	0.69
	1LA2	0.74	0.66	0.62	0.24	0.34	0.47	0.52	0.66	0.81	0.81	0.73	0.69
	1LA3	0.74	0.66	0.62	0.24	0.34	0.47	0.52	0.66	0.81	0.81	0.73	0.69
	1LB1	0.74	0.66	0.62	0.24	0.34	0.47	0.52	0.66	0.81	0.81	0.73	0.69
	1LB2	0.74	0.66	0.62	0.24	0.34	0.47	0.52	0.66	0.81	0.81	0.73	0.69
Average of LVSCA		0.84	0.83	0.67	0.26	0.24	0.47	0.59	0.65	0.79	0.77	0.71	0.73
RVCA	2AA	1.30	1.39	1.28	0.92	1.14	1.18	1.18	1.21	1.37	1.25	1.22	1.23
	2AB	1.30	1.39	1.28	0.92	1.14	1.18	1.18	1.21	1.37	1.25	1.22	1.23
	2BA	1.14	1.22	1.01	0.84	0.99	0.96	0.98	0.94	1.19	1.15	1.09	1.15
	2BB	1.14	1.22	1.01	0.84	0.99	0.96	0.98	0.94	1.19	1.15	1.09	1.15
	2BC	1.14	1.22	1.01	0.84	0.99	0.96	0.98	0.94	1.19	1.15	1.09	1.15
	2BD	1.30	1.39	1.28	0.92	1.14	1.18	1.18	1.21	1.37	1.25	1.22	1.23
	2CA	1.30	1.39	1.28	0.92	1.14	1.18	1.18	1.21	1.37	1.25	1.22	1.23
	2CB	1.14	1.22	1.01	0.84	0.99	0.96	0.98	0.94	1.19	1.15	1.09	1.15
	2CC	1.14	1.22	1.01	0.84	0.99	0.96	0.98	0.94	1.19	1.15	1.09	1.15
	2D	1.14	1.22	1.01	0.84	0.99	0.96	0.98	0.94	1.19	1.15	1.09	1.15
	2EA	0.69	0.96	0.75	0.36	0.32	0.44	0.44	0.36	0.67	0.60	0.42	0.70
	2EB	0.69	0.96	0.75	0.36	0.32	0.44	0.44	0.36	0.67	0.60	0.42	0.70
	2EC	0.69	0.96	0.75	0.36	0.32	0.44	0.44	0.36	0.67	0.60	0.42	0.70
	2ED	0.69	0.96	0.75	0.36	0.32	0.44	0.44	0.36	0.67	0.60	0.42	0.70
	2EE	1.13	1.18	1.09	0.83	0.84	0.86	0.75	0.76	1.09	1.01	0.95	1.03
	2EF	0.69	0.96	0.75	0.36	0.32	0.44	0.44	0.36	0.67	0.60	0.42	0.70
	2EG1	0.69	0.96	0.75	0.36	0.32	0.44	0.44	0.36	0.67	0.60	0.42	0.70
	2EG2	0.69	0.96	0.75	0.36	0.32	0.44	0.44	0.36	0.67	0.60	0.42	0.70
	2EH	0.69	0.96	0.75	0.36	0.32	0.44	0.44	0.36	0.67	0.60	0.42	0.70
	2EJ	0.69	0.96	0.75	0.36	0.32	0.44	0.44	0.36	0.67	0.60	0.42	0.70
	2EK	0.69	0.96	0.75	0.36	0.32	0.44	0.44	0.36	0.67	0.60	0.42	0.70
	2FA	0.69	0.96	0.75	0.36	0.32	0.44	0.44	0.36	0.67	0.60	0.42	0.70
	2FB	0.69	0.96	0.75	0.36	0.32	0.44	0.44	0.36	0.67	0.60	0.42	0.70
	2FC	0.69	0.96	0.75	0.36	0.32	0.44	0.44	0.36	0.67	0.60	0.42	0.70
	2GA	0.89	0.89	0.77	0.41	0.43	0.49	0.66	0.63	0.79	0.74	0.64	0.78
	2GB	0.69	0.96	0.75	0.36	0.32	0.44	0.44	0.36	0.67	0.60	0.42	0.70
	2GC	0.89	0.89	0.77	0.41	0.43	0.49	0.66	0.63	0.79	0.74	0.64	0.78
	2GD	0.89	0.89	0.77	0.41	0.43	0.49	0.66	0.63	0.79	0.74	0.64	0.78
	2H1	1.14	1.22	1.01	0.84	0.99	0.96	0.98	0.94	1.19	1.15	1.09	1.15
	2H2	1.14	1.22	1.01	0.84	0.99	0.96	0.98	0.94	1.19	1.15	1.09	1.15
	2H3	1.14	1.22	1.01	0.84	0.99	0.96	0.98	0.94	1.19	1.15	1.09	1.15
	2JA	1.30	1.39	1.28	0.92	1.14	1.18	1.18	1.21	1.37	1.25	1.22	1.23
	2KA	1.30	1.39	1.28	0.92	1.14	1.18	1.18	1.21	1.37	1.25	1.22	1.23
	2KB	1.28	1.33	1.23	0.92	0.96	1.06	1.15	1.13	1.33	1.30	1.23	1.25
	2KC	1.28	1.33	1.23	0.92	0.96	1.06	1.15	1.13	1.33	1.30	1.23	1.25
Average for RVCA		0.97	1.12	0.95	0.63	0.70	0.75	0.77	0.74	0.98	0.92	0.81	0.95
ACA	3AA	1.04	1.09	0.80	0.16	0.23	0.44	0.50	0.66	1.02	0.91	0.61	0.88
	3AB	0.96	0.91	0.67	0.35	0.56	0.63	0.62	0.66	0.93	0.91	0.29	0.72
	3AC	0.95	0.86	0.72	0.00	0.00	0.16	0.40	0.46	0.76	0.96	0.38	0.31
	3BA	0.95	0.86	0.72	0.00	0.00	0.16	0.40	0.46	0.76	0.96	0.38	0.31
	3BB	0.96	0.91	0.67	0.35	0.56	0.63	0.62	0.66	0.93	0.91	0.29	0.72
	3BC	1.04	1.09	0.80	0.16	0.23	0.44	0.50	0.66	1.02	0.91	0.61	0.88
	3BD	0.95	0.86	0.72	0.00	0.00	0.16	0.40	0.46	0.76	0.96	0.38	0.31
	3CB	0.95	0.86	0.72	0.00	0.00	0.16	0.40	0.46	0.76	0.96	0.38	0.31
	3DA	1.04	1.09	0.80	0.16	0.23	0.44	0.50	0.66	1.02	0.91	0.61	0.88
	3DB	1.04	1.09	0.80	0.16	0.23	0.44	0.50	0.66	1.02	0.91	0.61	0.88
	3EA	1.03	1.14	0.94	0.70	0.73	0.79	0.81	0.84	1.10	1.06	0.52	0.47
	3EB	1.03	1.14	0.94	0.70	0.73	0.79	0.81	0.84	1.10	1.06	0.52	0.47
	3EC	1.03	1.14	0.94	0.70	0.73	0.79	0.81	0.84	1.10	1.06	0.52	0.47
	3ED	1.03	1.14	0.94	0.70	0.73	0.79	0.81	0.84	1.10	1.06	0.52	0.47

Table 6.5.2 Monthly Unit Irrigation Water Requirement by Sub-basin (3/4)

(Unit: $m^3/s/1{,}000$ ha)

Catch-ment Area	Sub-basin	Unit Irrigation Water Requirement under 60% Irrigation Efficiency and Full Cropping											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ACA	3FA	1.03	1.14	0.94	0.70	0.73	0.79	0.81	0.84	1.10	1.06	0.52	0.47
	3FB	1.03	1.14	0.94	0.70	0.73	0.79	0.81	0.84	1.10	1.06	0.52	0.47
	3G	0.90	1.15	0.96	0.78	0.80	0.90	0.89	0.89	1.03	1.04	0.88	0.59
	3HA	0.90	1.15	0.96	0.78	0.80	0.90	0.89	0.89	1.03	1.04	0.88	0.59
	3HB	0.90	1.15	0.96	0.78	0.80	0.90	0.89	0.89	1.03	1.04	0.88	0.59
	3HC	1.12	1.19	1.05	0.80	0.68	0.77	0.90	0.99	1.07	1.02	0.94	0.68
	3HD1	1.20	1.21	1.13	0.77	0.02	0.17	0.46	0.68	1.11	1.08	1.12	1.16
	3HD2	1.20	1.21	1.13	0.77	0.02	0.17	0.46	0.68	1.11	1.08	1.12	1.16
	3J	0.96	1.07	0.71	0.44	0.50	0.75	0.75	0.84	1.03	1.04	0.85	0.75
	3K	1.17	1.25	1.14	0.63	0.26	0.44	0.55	0.79	0.95	0.96	1.00	0.84
	3LA	0.90	1.15	0.96	0.78	0.80	0.90	0.89	0.89	1.03	1.04	0.88	0.59
	3LB	0.90	1.15	0.96	0.78	0.80	0.90	0.89	0.89	1.03	1.04	0.88	0.59
	3MA-1	1.15	1.14	1.03	0.83	0.76	0.90	0.86	0.90	1.02	1.04	0.91	0.98
	3MA-2	1.15	1.14	1.03	0.83	0.76	0.90	0.86	0.90	1.02	1.04	0.91	0.98
	3MB	1.15	1.14	1.03	0.83	0.76	0.90	0.86	0.90	1.02	1.04	0.91	0.98
	3MC	1.15	1.14	1.03	0.83	0.76	0.90	0.86	0.90	1.02	0.96	1.00	0.84
	3MD-1	1.15	1.14	1.03	0.83	0.76	0.90	0.86	0.90	1.02	0.96	1.00	0.84
	3MD2	1.15	1.14	1.03	0.83	0.76	0.90	0.86	0.90	1.02	0.96	1.00	0.84
	3N	1.15	1.14	1.03	0.83	0.76	0.90	0.86	0.90	1.02	0.96	1.00	0.84
Average of ACA		1.04	1.09	0.92	0.57	0.52	0.65	0.71	0.78	1.00	1.00	0.72	0.69
TCA	4AA	1.04	0.95	0.69	0.24	0.00	0.34	0.25	0.62	0.83	0.84	0.41	0.52
	4AB	1.04	0.95	0.69	0.24	0.00	0.34	0.25	0.62	0.83	0.84	0.41	0.52
	4AC	1.04	0.95	0.69	0.24	0.00	0.34	0.25	0.62	0.83	0.84	0.41	0.52
	4AD	1.04	0.95	0.69	0.24	0.00	0.34	0.25	0.62	0.83	0.84	0.41	0.52
	4BA	1.04	0.95	0.69	0.24	0.00	0.34	0.25	0.62	0.83	0.84	0.41	0.52
	4BB	1.04	0.95	0.69	0.24	0.00	0.34	0.25	0.62	0.83	0.84	0.41	0.52
	4BC	1.05	1.14	0.85	0.34	0.34	0.59	0.61	0.84	1.02	0.88	0.42	0.74
	4BD	1.04	0.95	0.69	0.24	0.00	0.34	0.25	0.62	0.83	0.84	0.41	0.52
	4BE	1.06	1.16	0.78	0.15	0.43	0.51	0.50	0.56	0.93	0.85	0.45	0.69
	4BF	1.06	1.16	0.78	0.15	0.43	0.51	0.50	0.56	0.93	0.85	0.45	0.69
	4BG	1.06	1.16	0.78	0.15	0.43	0.51	0.50	0.56	0.93	0.85	0.45	0.69
	4CA	1.06	1.16	0.78	0.15	0.43	0.51	0.50	0.56	0.93	0.85	0.45	0.69
	4CB	1.06	1.16	0.78	0.15	0.43	0.51	0.50	0.56	0.93	0.85	0.45	0.69
	4CC	1.06	1.16	0.78	0.15	0.43	0.51	0.50	0.56	0.93	0.85	0.45	0.69
	4DA	1.05	1.14	0.85	0.34	0.34	0.59	0.61	0.84	1.02	0.88	0.42	0.74
	4DB	1.05	1.14	0.85	0.34	0.34	0.59	0.61	0.84	1.02	0.88	0.42	0.74
	4DC	1.05	1.14	0.85	0.34	0.34	0.59	0.61	0.84	1.02	0.88	0.42	0.74
	4DD	0.99	0.93	0.72	0.27	0.57	0.50	0.68	0.61	0.95	0.78	0.28	0.50
	4DE	0.99	0.93	0.72	0.27	0.57	0.50	0.68	0.61	0.95	0.78	0.28	0.50
	4EA	1.07	1.07	1.04	0.96	1.04	0.91	0.98	0.98	1.08	1.09	0.81	0.84
	4EB	1.07	1.07	1.04	0.96	1.04	0.91	0.98	0.98	1.08	1.09	0.81	0.84
	4EC	1.07	1.07	1.04	0.96	1.04	0.91	0.98	0.98	1.08	1.09	0.81	0.84
	4ED	1.07	1.07	1.04	0.96	1.04	0.91	0.98	0.98	1.08	1.09	0.81	0.84
	4FA	1.07	1.07	1.04	0.96	1.04	0.91	0.98	0.98	1.08	1.09	0.81	0.84
	4FB	1.07	1.07	1.04	0.96	1.04	0.91	0.98	0.98	1.08	1.09	0.81	0.84
	4GA	1.07	1.07	1.04	0.96	1.04	0.91	0.98	0.98	1.08	1.09	0.81	0.84
	4GB	1.07	1.07	1.04	0.96	1.04	0.91	0.98	0.98	1.08	1.09	0.81	0.84
	4GC	1.07	1.07	1.04	0.96	1.04	0.91	0.98	0.98	1.08	1.09	0.81	0.84
	4GD	1.07	1.07	1.04	0.96	1.04	0.91	0.98	0.98	1.08	1.09	0.81	0.84
	4GE	1.16	1.17	1.04	0.96	1.00	0.92	0.98	1.06	1.14	1.05	0.85	0.97
	4GF	1.16	1.17	1.04	0.96	1.00	0.92	0.98	1.06	1.14	1.05	0.85	0.97
	4GG	1.16	1.17	1.04	0.96	1.00	0.92	0.98	1.06	1.14	1.05	0.85	0.97
	4HA	1.16	1.17	1.04	0.96	1.00	0.92	0.98	1.06	1.14	1.05	0.85	0.97
	4HB	1.16	1.17	1.04	0.96	1.00	0.92	0.98	1.06	1.14	1.05	0.85	0.97
	4HC	1.16	1.17	1.04	0.96	1.00	0.92	0.98	1.06	1.14	1.05	0.85	0.97
	4JA	1.30	1.41	1.33	1.13	1.54	1.39	1.37	1.44	1.51	1.40	1.00	1.08
	4JB	1.30	1.41	1.33	1.13	1.54	1.39	1.37	1.44	1.51	1.40	1.00	1.08
	4KA	1.30	1.41	1.33	1.13	1.54	1.39	1.37	1.44	1.51	1.40	1.00	1.08
	4KB	1.30	1.41	1.33	1.13	1.54	1.39	1.37	1.44	1.51	1.40	1.00	1.08
Average of TCA		1.09	1.11	0.93	0.63	0.71	0.74	0.76	0.88	1.05	0.99	0.64	0.78

Table 6.5.2 Monthly Unit Irrigation Water Requirement by Sub-basin (4/4)

(Unit: $m^3/s/1,000$ ha)

Catch-ment Area	Sub-basin	Unit Irrigation Water Requirement under 60% Irrigation Efficiency and Full Cropping											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ENNCA	5AA	1.04	0.95	0.69	0.24	0.00	0.34	0.25	0.62	0.83	0.84	0.41	0.52
	5AB	1.04	0.95	0.69	0.24	0.00	0.34	0.25	0.62	0.83	0.84	0.41	0.52
	5AC	0.93	1.00	0.97	0.64	0.65	0.60	0.58	0.61	0.93	0.89	0.76	0.83
	5AD	0.93	1.00	0.97	0.64	0.65	0.60	0.58	0.61	0.93	0.89	0.76	0.83
	5BA	0.70	0.65	0.52	0.51	0.79	0.69	0.78	0.67	0.95	0.60	0.35	0.50
	5BB	0.70	0.65	0.52	0.51	0.79	0.69	0.78	0.67	0.95	0.60	0.35	0.50
	5BC1	0.70	0.65	0.52	0.51	0.79	0.69	0.78	0.67	0.95	0.60	0.35	0.50
	5BC2	0.70	0.65	0.52	0.51	0.79	0.69	0.78	0.67	0.95	0.60	0.35	0.50
	5BD	0.70	0.65	0.52	0.51	0.79	0.69	0.78	0.67	0.95	0.60	0.35	0.50
	5BE	0.70	0.65	0.52	0.51	0.79	0.69	0.78	0.67	0.95	0.60	0.35	0.50
	5CA	1.16	1.17	1.04	0.96	1.00	0.92	0.98	1.06	1.14	1.05	0.85	0.97
	5CB	1.16	1.17	1.04	0.96	1.00	0.92	0.98	1.06	1.14	1.05	0.85	0.97
	5CC	1.16	1.17	1.04	0.96	1.00	0.92	0.98	1.06	1.14	1.05	0.85	0.97
	5DA	1.16	1.17	1.04	0.96	1.00	0.92	0.98	1.06	1.14	1.05	0.85	0.97
	5DB	1.16	1.17	1.04	0.96	1.00	0.92	0.98	1.06	1.14	1.05	0.85	0.97
	5DC	1.16	1.17	1.04	0.96	1.00	0.92	0.98	1.06	1.14	1.05	0.85	0.97
	5DD	1.16	1.17	1.04	0.96	1.00	0.92	0.98	1.06	1.14	1.05	0.85	0.97
	5EA	1.30	1.41	1.33	1.13	1.54	1.39	1.37	1.44	1.51	1.40	1.00	1.08
	5EB	1.30	1.41	1.33	1.13	1.54	1.39	1.37	1.44	1.51	1.40	1.00	1.08
	5EC	1.30	1.41	1.33	1.13	1.54	1.39	1.37	1.44	1.51	1.40	1.00	1.08
	5ED	1.30	1.41	1.33	1.13	1.54	1.39	1.37	1.44	1.51	1.40	1.00	1.08
	5FA	1.30	1.41	1.33	1.13	1.54	1.39	1.37	1.44	1.51	1.40	1.00	1.08
	5FB	1.30	1.41	1.33	1.13	1.54	1.39	1.37	1.44	1.51	1.40	1.00	1.08
	5GA	1.22	1.25	1.14	0.86	0.98	1.01	1.01	1.03	1.13	1.00	0.94	1.05
	5GB	1.22	1.25	1.14	0.86	0.98	1.01	1.01	1.03	1.13	1.00	0.94	1.05
	5H	1.21	1.27	1.24	0.85	1.06	1.15	1.12	1.18	1.26	0.95	0.99	1.14
	5J	1.21	1.27	1.24	0.85	1.06	1.15	1.12	1.18	1.26	0.95	0.99	1.14
Average of ENNCA		1.07	1.09	0.98	0.81	0.98	0.93	0.95	1.00	1.15	0.99	0.75	0.87
Average of Whole Area		0.98	1.02	0.86	0.52	0.54	0.61	0.66	0.71	0.92	0.86	0.70	0.79

Note: * : full amount for every month (no consideraton of cropping intensiy)

Source: Water Requirements for Irrigation in Kenya, Ministry of Water Development, 1985 (arranged by JICA Study Team)

Table 6.5.3 Possible Surface Water Irrigation Area by Sub-basin in 2030

LVNCA		LVSCA		RVCA		ACA		TCA		ENNCA	
Sub-basin	Possible Irrigation Area (ha)	Sub-basin	Possible Irrigation Area (ha)	Sub-basin	Possible Irrigation Area (ha)	Sub-basin	Possible Irrigation Area (ha)	Sub-basin	Possible Irrigation Area (ha)	Sub-basin	Possible Irrigation Area (ha)
1AA	709	1GA	812	2AA	0	3AA	1,272	4AA	1,004	5AA	154
1AB	695	1GB	2,512	2AB	35,310	3AB	1,523	4AB	1,032	5AB	55
1AC	267	1GC	246	2BA	2,044	3AC	382	4AC	697	5AC	160
1AD	648	1GD	3,607	2BB	7,756	3BA	1,890	4AD	1,557	5AD	393
1AE	448	1GE	1,010	2BC	9,854	3BB	729	4BA	738	5BA	206
1AF	1,139	1GF	730	2BD	782	3BC	1,438	4BB	1,698	5BB	663
1AG	955	1GG	147	2CA	112	3BD	966	4BC	3,271	5BC-1	18,576
1AH	843	1HA1	8,072	2CB	3,034	3CB	2,194	4BD	1,703	5BC-2	477
1BA	119	1HA2	873	2CC	14,422	3DA	15,442	4BE	1,593	5BD	93
1BB	1,760	1HB1	800	2D	866	3DB	217	4BF	455	5BE	1,474
1BC	1,734	1HB2	792	2EA	90	3EA	275	4BG	548	5CA	154
1BD	1,446	1HC	396	2EB	155	3EB	291	4CA	1,081	5CB	0
1BE	21,186	1HD	1,328	2EC	175	3EC	275	4CB	731	5CC	0
1BG	25,171	1HE	1,012	2ED	349	3ED	237	4CC	3,431	5DA	5,804
1BH	644	1HF	1,650	2EE	187	3FA	20,213	4DA	10,175	5DB	201
1CA	666	1HG	625	2EF	206	3FB	1,944	4DB	6,651	5DC	717
1CB	527	1JA	2,680	2EG1	86	3G	7,009	4DC	1,880	5DD	3,632
1CC	982	1JB	25	2EG2	405	3HA	1,120	4DD	700	5EA	86
1CD	1,154	1JC	1,074	2EH	136	3HB	1,663	4DE	350	5EB	143
1CE	11,845	1JD	1,262	2EJ	274	3HC	1,420	4EA	1,974	5EC	268
1DA	8,627	1JE	2,107	2EK	124	3HD1	523	4EB	1,556	5ED	0
1DB	2,660	1JF	2,053	2FA	110	3HD2	614	4EC	943	5FA	0
1DC	2,814	1JG1	15,630	2FB	31	3J	7,478	4ED	2,443	5FB	29
1DD	3,050	1JG2	576	2FC	307	3K	436	4FA	3,966	5GA	0
1EA	2,985	1KA	2,418	2GA	58	3LA	4,706	4FB	110,885	5GB	811
1EB	5,324	1KB	41,860	2GB	114	3LB	528	4GA	1,263	5H	0
1EC	1,804	1KC	5,546	2GC	94	3MA-1	2,191	4GB	25,720	5J	0
1ED	99	1LA1	1,590	2GD	220	3MA-2	3,130	4GC	685		
1EE	23,346	1LA2	264	2H-1	900	3MB	115	4GD	2,120		
1EF	5,027	1LA3	3,416	2H-2	533	3MC	79	4GE	1,580		
1EG	3,776	1LB1	7,956	2H-3	0	3MD1	43	4GF	3,542		
1FA	426	1LB2	1,898	2J	0	3MD2	9	4GG	1,578		
1FB	1,182			2KA	2,128	3N	1,893	4HA	189		
1FC	628			2KB	15,571			4HB	829		
1FD	1,127			2KC	342			4HC	631		
1FE	5,106							4JA	369		
1FF	2							4JB	143		
1FG	22,600							4KA	316		
								4KB	359		
LVN	163,521	LVS	114,967	RV	96,772	ATHI	82,248	TANA	200,387	ENN	34,097
Whole Country: 691,992 ha											

Note: Above figures include Irrigation area having water source outside the water balance study, i.e. Todanyand-Omo irrgation (35,000 ha in 2AB) to be supplied from a dam in Ethiopia, and irrigation area to be supplied from water soruce outside the Athi river basin (1,500 ha in 3G and 3,780 ha in 3J)

Source: JICA Study Team

Table 6.5.4 Possible Groundwater Irrigation Area by Sub-basin in 2030

LVNCA		LVSCA		RVCA		ACA		TCA		ENNCA	
Sub-basin	Possible Irrigation Area (ha)	Sub-basin	Possible Irrigation Area (ha)	Sub-basin	Possible Irrigation Area (ha)	Sub-basin	Possible Irrigation Area (ha)	Sub-basin	Possible Irrigation Area (ha)	Sub-basin	Possible Irrigation Area (ha)
1AA	88	1GA	38	2AA	39	3AA	0	4AA	0	5AA	184
1AB	0	1GB	195	2AB	0	3AB	0	4AB	0	5AB	73
1AC	55	1GC	42	2BA	0	3AC	0	4AC	0	5AC	123
1AD	105	1GD	310	2BB	0	3BA	0	4AD	0	5AD	12
1AE	207	1GE	371	2BC	0	3BB	0	4BA	0	5BA	74
1AF	184	1GF	579	2BD	304	3BC	0	4BB	0	5BB	23
1AG	253	1GG	92	2CA	0	3BD	0	4BC	0	5BC-1	382
1AH	324	1HA1	0	2CB	11	3CB	0	4BD	0	5BC-2	16
1BA	224	1HA2	684	2CC	723	3DA	0	4BE	0	5BD	1
1BB	308	1HB1	0	2D	353	3DB	336	4BF	0	5BE	234
1BC	306	1HB2	6	2EA	0	3EA	13	4BG	0	5CA	85
1BD	0	1HC	74	2EB	0	3EB	14	4CA	0	5CB	3
1BE	38	1HD	0	2EC	0	3EC	10	4CB	0	5CC	0
1BG	0	1HE	52	2ED	0	3ED	11	4CC	0	5DA	1,168
1BH	0	1HF	0	2EE	4	3FA	1,565	4DA	0	5DB	119
1CA	56	1HG	0	2EF	0	3FB	457	4DB	0	5DC	109
1CB	0	1JA	376	2EG1	0	3G	232	4DC	0	5DD	50
1CC	82	1JB	156	2EG2	0	3HA	62	4DD	0	5EA	524
1CD	0	1JC	0	2EH	125	3HB	387	4DE	0	5EB	1,287
1CE	0	1JD	0	2EJ	0	3HC	383	4EA	0	5EC	1,355
1DA	0	1JE	643	2EK	0	3HD1	591	4EB	0	5ED	4,775
1DB	0	1JF	7	2FA	0	3HD2	28	4EC	0	5FA	1,959
1DC	0	1JG1	0	2FB	0	3J	179	4ED	0	5FB	131
1DD	0	1JG2	69	2FC	0	3KA	0	4FA	1,044	5GA	492
1EA	0	1KA	0	2GA	0	3KB	0	4FB	3,756	5GB	0
1EB	0	1KB	654	2GB	0	3LA	0	4GA	1,070	5H	70
1EC	0	1KC	1,034	2GC	158	3LB	0	4GB	721	5J	1,081
1ED	0	1LA1	115	2GD	0	3MA-1	0	4GC	413		
1EE	0	1LA2	0	2H-1	52	3MA-2	0	4GD	1,635		
1EF	345	1LA3	201	2H-2	0	3MB	0	4GE	2,608		
1EG	0	1LB1	54	2H-3	0	3MC	0	4GF	3,196		
1FA	159	1LB2	1,113	2J	0	3MD1	0	4GG	2,999		
1FB	29			2KA	114	3MD2	0	4HA	1,150		
1FC	0			2KB	16	3N	349	4HB	890		
1FD	79			2KC	193			4HC	157		
1FE	0							4JA	165		
1FF	0							4JB	145		
1FG	725							4KA	158		
								4KB	245		
LVNCA	3,568	LVSCA	6,867	RVCA	2,091	ACA	4,618	TCA	20,108	ENNCA	14,331
Whole Country: 51,583 ha											

Source: JICA Study Team

Table 6.5.5 Large Scale Irrigation Projects Selected (1/2)

No	Name of Project	County	Sub-basin Code	Irrigation Area (ha)	Project Type*[1]	Water Source Facilities*[2]		Present Status*[3] (Oct. 2012)	Estimated Cost*[4] (KSh mil.)	Executing Agency
						Type	Name of Dam			
LVNCA										
1.	Kibolo Irrigation	Kakamega	1CE	11,500	New	Dam	Kibolo	Proposed	6,435	LBDA
2.	Lower Nzoia Irrigation	Busia & Siaya	1EF	10,470	New	Weir/M-dam	Nzoia 42A	D/D done	6,334	NIB
3.	Lower Sio Irrigation	Busia	1AH	6,600	New	Weir	-	D/D done	5,566	NIB
4.	Moi's Bridge Irrigation	Bungoma	1BE	19,800	New	Multi-dam	Moi's Bridge	Proposed	13,585	LBDA
5.	Upper Nzoia Irrigation	Bungoma	1BG	24,000	New	Multi-dam	Nzoia 34B	Proposed	13,728	NIB
6.	Yala Swamp Drainage & Irrigation	Siaya	1FG	4,600	New	Weir	-	F/S done	2,317	LBDA
	Weir Irrigation under construction			1,400	Reh+Ext	Weir	-	On-going	560	
Total				78,370					48,525	
LVSCA										
1.	Ahero and West Kano Irrigation	Kisumu	1HD	1,800	Reh+Ext	Weir	-	F/S done	871	NIB
2.	Amala Irrigation	Bomet	1LB1	5,000	New	Multi-dam	Amala	Proposed	2,860	LBDA
3.	Ilooiterre Irrigation	Narok	1KC	3,000	New	Multi-dam	Ilooiterre	Proposed	1,716	LBDA
4.	Kano Plain Irrigation	Nyamira/Kisumu	1JG1	15,000	New	Multi-dam	Magwagwa	D/D on-going	14,300	LBDA
5.	Lower Kuja Irrigation (Stage-1)	Migori	1KB	7,800	New	Weir	-	D/D done	6,578	NIB
6.	Lower Kuja Irrigation (Stage-2)	Migori	1KB	32,700	New	Multi-dam	Katieno	Proposed	17,160	NIB
7.	Nandi Forest Irrigation	Nyando/Kisumu	1HA2	7,272	New	Multi-dam	Nandi Forest	F/S done	15,730	LBDA
8.	Nyando Irrigation	Kericho	1GD	3,000	New	Multi-dam	Nyando	Proposed	1,716	LBDA
Total				75,572					60,931	
RVCA										
1.	Arror Irrigation	Elgeyo Marakwet	2CC	10,850	New+Ext	Multi-dam	Arror	F/S done	7,865	KVDA
2.	Embobut Irrigation	Elgeyo Marakwet	2BB	2,000	Ext	Dam	Embobut	Proposed	1,001	KVDA
3.	Kimwarer Irrigation	Baringo	2CB	2,000	New	Multi-dam	Kimwarer	Proposed	1,144	KVDA
4.	Lower Ewaso Ng'iro Irrigation	Kajiado	2KB	15,000	New	Multi-dam	Oletukat	F/S on-going	8,580	NIB/ENSDA
5.	Norera Irrigation	Narok	2KA	2,000	New	Dam	Upper Narok	F/S on-going	1,144	ENSDA
6.	Oldekesi Irrigation	Narok	3KA	2,000	New	Weir	-	Proposed	1,373	ENSDA
7.	Perkera Irrigation Extension	Baringo	2EE	3,000	Reh+Ext	Weir/Dam	Perkera (E)	F/S on-going	2,217	NIB
8.	Todonyang-Omo Irrigation	Turkana	2AB	35,000	New	Multi-dam	Gibe 3 in Ethiopia	Proposed	24,310	KVDA
9.	Turkwel Irrigation	West Pokot	2BD	5,000	New	Dam (E)	Turkwel (E)	F/S done	3,575	KVDA
	Weir Irrigation under construction			2,000	Reh+Ext	Weir	-	On-going	800	KVDA
Total				78,850					52,009	

Table 6.5.5 Large Scale Irrigation Projects Selected (2/2)

No	Name of Project	County	Sub-basin Code	Irrigation Area (ha)	Project Type*[1]	Water Source Facilities*[2]		Present Status*[3] (Oct. 2012)	Estimated Cost*[4] (KSh mil.)	Executing Agency
						Type	Name of Dam			
ACA										
1.	Kanzalu Irrigation Extension	Makueni	3DA	15,000	Ext	Multi-dam	Munyu	Proposed	6,050	NIB
2.	Kibwezi Irrigation Extension	Makueni	3FA	17,000	New+Ext	Multi-dam	Thwake	Proposed	6,800	NIB/TARDA
3.	Mt. Kilimanjaro Irrigation	Kajiado	3G	1,500	Reh+Ext	Spring	-	Proposed	484	ENSDA
4.	Taita Taveta Irrigation	Taita Taveta	3J	3,780	Reh+Ext	Weir	-	F/S on-going	1,815	TARDA
Total				37,280					15,149	
TCA										
1.	High Grand Falls Irrigation	Garissa/Tana River	4EB	106,000	New	Multi-dam	High Grand Falls	F/S done	242,000	TARDA
2.	Hola Irrigation Expansion	Tana River	4GF	800	Reh+Ext	Pump	-	On-going	402	NIB
3.	Hola Irrigation Greater Extension	Tana River	4GF	4,161	Reh+Ext	Weir	-	F/S on-going	3,146	NIB
4.	Kora Irrigation	Tana River	4GB	25,000	New	Dam	Kora	Proposed	12,870	TARDA
Total				135,961					258,418	
ENNCA										
1.	Kieni Irrigation	Nyeri	5BC	4,202	New	Weir	-	F/S on-going	2,200	NIB
2.	Kihoto Irrigation	Laikipia	5BC	18,000	New	Multi-dam	Kihoto	Proposed	7,700	ENNDA
3.	Kom (Wajir) Irrigation	Isiolo/Samburu	5DA	4,000	New	Multi-dam	Archer's Post	F/S on-going	2,000	ENNDA
Total				26,202					11,900	
Grand Total				432,235					446,932	

Note: *1: Reh = Rehabilitation, Ext = Extension; *2: Multi = Multipurpose, E = Existing; *3: F/S = Feasibility study, D/D = Detailed design,
*4: Irri. Cost = Construction cost for irrigation system (excluding cost allocation of multipurpose dam)

Source: JICA Study Team, based on information from government authorities

Table 6.5.6 Possible Irrigation Area by Catchment Area in 2030

(Unit: ha)

Category	Existing Irrigation Area in 2010	New Irrigation Area in 2030						Total Irrigation Area in 2030
		Surface Water Irrigation			Ground water Irrigation	Water Harvesting Irrigation*2	Total New Irrigation Area	
		Weir*1	Dam	Total				
LVNCA								
Large Scale Irrigation	363	12,600	65,770	78,370	0	0	78,370	78,733
Small Scale Irrigation	1,327	41,638	0	41,638	1,784	3,700	47,122	48,449
Private Irrigation	186	41,637	0	41,637	1,784	0	43,421	43,607
Total	1,876	95,875	65,770	161,645	3,568	3,700	168,913	170,789
LVSCA								
Large Scale Irrigation	1,800	1,800	73,772	75,572	0	0	75,572	77,372
Small Scale Irrigation	10,225	14,477	0	14,477	3,434	4,590	22,501	32,726
Private Irrigation	1,193	11,700	0	11,700	3,433	0	15,133	16,326
Total	13,218	27,977	73,772	101,749	6,867	4,590	113,206	126,424
RVCA*3								
Large Scale Irrigation	774	7,000	71,850	78,850	0	0	78,850	79,624
Small Scale Irrigation	5,791	5,335	0	5,335	1,046	2,890	9,271	15,062
Private Irrigation	3,022	3,000	0	3,000	1,045	0	4,045	7,067
Total	9,587	15,335	71,850	87,185	2,091	2,890	92,166	101,753
ACA*4								
Large Scale Irrigation	0	5,280	32,000	37,280	0	0	37,280	37,280
Small Scale Irrigation	13,524	35	0	35	2,309	4,140	6,484	20,008
Private Irrigation	31,374	35	0	35	2,309	0	2,344	33,718
Total	44,898	5,350	32,000	37,350	4,618	4,140	46,108	91,006
TCA								
Large Scale Irrigation	11,200	4,961	131,000	135,961	0	0	135,961	147,161
Small Scale Irrigation	14,823	0	0	0	10,054	5,730	15,784	30,607
Private Irrigation	38,402	0	0	0	10,054	0	10,054	48,456
Total	64,425	4,961	131,000	135,961	20,108	5,730	161,799	226,224
ENNCA								
Large Scale Irrigation	0	4,202	22,000	26,202	0	0	26,202	26,202
Small Scale Irrigation	6,233	0	0	0	7,166	950	8,116	14,349
Private Irrigation	1,663	0	0	0	7,165	0	7,165	8,828
Total	7,896	4,202	22,000	26,202	14,331	950	41,483	49,379
TOTAL								
Large Scale Irrigation	14,137	35,843	396,392	432,235	0	0	432,235	446,372
Small Scale Irrigation	51,923	61,485	0	61,485	25,793	22,000	109,278	161,201
Private Irrigation	75,840	56,372	0	56,372	25,790	0	82,162	158,002
Grand Total	141,900	153,700	396,392	550,092	51,583	22,000	623,675	765,575

Note: *1 = including weir irrigation, pump irrigation and spring irrigation.
*2 = by small dam and water pan
*3 = including the Todonyang-Omo irrigation project (35,000 ha) to be supplied water by a dam in Ethiopia.
*4 = including existing irrigation areas (11,339 ha) and proposed irrigation areas (5,280 ha) to be supplied water from the outside of the Athi river basin.

Source: JICA Study Team

Table 6.5.7 Irrigation Water Demand by Catchment Area in 2030

(Unit: MCM/year)

Category	Existing Irrigation Demand in 2010	New Irrigation Water Demand in 2030						Total Irrigation Water Demand in 2030
		Surface Water Irrigation			Ground water Irrigation	Water Harvesting Irrigation*2	Total New Irrigation Demand	
		Weir*1	Dam	Total				
LVNCA								
Large Scale Irrigation	4	133	535	668	0	0	668	672
Small Scale Irrigation	13	308	0	308	14	30	352	365
Private Irrigation	1	308	0	308	13	0	321	322
Total	18	749	535	1,284	27	30	1,341	1,359
LVSCA								
Large Scale Irrigation	22	25	732	757	0	0	757	779
Small Scale Irrigation	121	83	0	83	26	37	146	267
Private Irrigation	12	75	0	75	25	0	100	112
Total	155	183	732	915	51	37	1,003	1,158
RVCA*3								
Large Scale Irrigation	12	49	1,101	1,150	0	0	1,150	1,162
Small Scale Irrigation	90	38	0	38	8	23	69	159
Private Irrigation	41	23	0	23	8	0	31	72
Total	143	110	1,101	1,211	16	23	1,250	1,393
ACA*4								
Large Scale Irrigation	0	40	311	351	0	0	351	351
Small Scale Irrigation	164	0	0	0	18	33	51	215
Private Irrigation	334	0	0	0	17	0	17	351
Total	498	40	311	351	35	33	419	917
TCA								
Large Scale Irrigation	130	37	1,767	1,804	0	0	1,804	1,934
Small Scale Irrigation	173	0	0	0	76	46	122	295
Private Irrigation	393	0	0	0	75	0	75	468
Total	696	37	1,767	1,804	151	46	2,001	2,697
ENNCA								
Large Scale Irrigation	0	31	302	333	0	0	333	333
Small Scale Irrigation	74	0	0	0	54	7	61	135
Private Irrigation	18	0	0	0	53	0	53	71
Total	92	31	302	333	107	7	447	539
TOTAL								
Large Scale Irrigation	168	315	4,748	5,063	0	0	5,063	5,231
Small Scale Irrigation	635	429	0	429	196	176	801	1,436
Private Irrigation	799	406	0	406	191	0	597	1,396
Total	1,602	1,150	4,748	5,898	387	176	6,461	8,063

Note *1 = including weir irrigation, pump irrigation and spring irrigation.

*2 = by small dam and water pan

*3 = including the Todonyang-Omo irrigation project (560 MCM/year) to be supplied water by a dam in Ethiopia.

*4 = including existing irrigation areas (114 MCM/year) and proposed irrigation areas (40 MCM/year) to be supplied water from the outside of the Athi Catchment Area.

Source: JICA Study Team

Table 6.9.1 Estimated Water Use for Propoed Hydropower Development Plan

Catchment Area	No.	Name of Plan	Installed Capacity (MW)	Annual Power Generation (GWh)	Plant Discharge (m^3/s)	Plant Factor (%)	Annual Water Use (MCM/year)	Remarks
LVNCA	1	Nzoia (34B) Multipurpose Dam Development Plan	16	56	30.5	40%	962	Plant Factor is assumed at 40%.
	2	Nzoia (42A) Multipurpose Dam Development Plan	25	88	126	40%	3,974	Plant Factor is assumed at 40%.
	3	Nandi Forest Multipurpose Dam Development Plan	50	138	12	32%	378	
		Sub-total	91	282			5,314	
LVSCA	4	Magwagwa Multipurpose Dam Development Plan	115	570	60.6	57%	1,911	
		Sub-total	115	570			1,911	
RVCA	5	Embobut Multipurpose Dam Development Plan	45	190	6	48%	189	
	6	Arror Multipurpose Dam Development Plan	80	66	27.5	9%	867	
	7	Kimwarer Multipurpose Dam Development Plan	20	99	29.7	57%	937	
	8	Oletukat Multipurpose Dam Development Plan	36	164	28	52%	883	
	9	Leshota Multipurpose Dam Development Plan	54	50	20.6	11%	650	
	10	Oldorko Multipurpose Dam Development Plan	90	112	8.1	14%	255	
		Sub-total	325	681			3,781	
ACA	11	Munyu Multipurpose Dam Development Plan	40	88	100	25%	3,154	Plant Factor is assumed at 25%.
	12	Thwake Multipurpose Dam Development Plan	20	44	30	25%	946	Plant Factor is assumed at 25%.
		Sub-total	60	132			4,100	
TCA	13	High Grand Falls Multipurpose Dam Development Plan	Stage 1: 500 Stage 2: +200	1,213	500	28%	15,768	
	14	Karura Hydropower Development Project	90	187	270	24%	8,515	
		Sub-total	790	1,400			24,283	
		Total	1,381	3,065			39,389	

Source: JICA Study Team

Table 6.10.1 Present and Future Water Demands by Catchment Area

(a) Water Demands with Irrigation Development of 1.2 million ha before Water Balance Study

Catchment Area	2010							2030							2050						
	Domestic	Industrial	Irrigation	Livestock	Wildlife	Fisheries	Total	Domestic	Industrial	Irrigation	Livestock	Wildlife	Fisheries	Total	Domestic	Industrial	Irrigation	Livestock	Wildlife	Fisheries	Total
LVNCA	169	6	18	26	0	9	228	424	19	817	61	0	16	1,337	605	42	817	87	0	22	1,573
LVSCA	165	10	155	43	3	9	385	464	41	2,324	106	3	15	2,953	662	90	2,324	151	3	21	3,251
RVCA	129	10	143	70	1	4	357	264	23	1,075	123	1	8	1,494	377	50	1,075	175	1	11	1,689
ACA	519	93	498	25	3	7	1,145	941	153	3,418	59	3	12	4,586	1,344	335	3,418	85	3	17	5,202
TCA	146	5	696	34	1	9	891	343	42	7,770	69	1	16	8,241	490	92	7,770	99	1	24	8,476
ENNCA	58	1	92	57	0	4	212	125	2	2,644	79	0	7	2,857	179	4	2,644	113	0	10	2,950
Total	1,186	125	1,602	255	8	42	3,218	2,561	280	18,048	497	8	74	21,468	3,657	613	18,048	710	8	105	23,141

(b) Water Demands with Irrigation Development of 623,700 ha after Water Balance Study

Catchment Area	2010							2030						
	Domestic	Industrial	Irrigation	Livestock	Wildlife	Fisheries	Total	Domestic	Industrial	Irrigation	Livestock	Wildlife	Fisheries	Total
LVNCA	169	6	18	26	0	9	228	424	19	1,359	61	0	16	1,879
LVSCA	165	10	155	43	3	9	385	464	41	1,158	106	3	15	1,787
RVCA	129	10	143	70	1	4	357	264	23	1,393	123	1	8	1,812
ACA	519	93	498	25	3	7	1,145	941	153	917	59	3	12	2,085
TCA	146	5	696	34	1	9	891	343	42	2,697	69	1	16	3,168
ENNCA	58	1	92	57	0	4	212	125	2	539	79	0	7	752
Total	1,186	125	1,602	255	8	42	3,218	2,561	280	8,063	497	8	74	11,483

Source: JICA Study Team

Table 7.3.1 Target 137 Urban Centres for Urban Water Supply Development

No.	LVNCA	LVSCA	RVCA	ACA	TCA	ENNCA
1	Eldoret	Kisumu	Nakuru	Nairobi	Lamu	Isiolo
2	Vihiga	Rongo	Naivasha	Mombasa	Nyeri	Nanyuki
3	Kitale	Kericho	Ol Kalou	Ruiru	Kitui	Nyahururu
4	Mumias	Bomet	Molo	Kikuyu	Thika	Mandera
5	Kimilili	Kisii	Narok	Kangundo-Tala	Embu	Wajir
6	Kakamega	Migori	Gilgil	Machakos	Meru	Rumuruti
7	Kapsabet	Suneka	Njoro	Mavoko	Matuu	Moyale
8	Bungoma	Ahero	Eldama Ravine	Malindi	Makuyu	Rhamu
9	Busia	Kipkelion	Lodwar	Karuri	Chuka	Elwak
10	Luanda	Homa Bay	Mai Mahiu	Ngong	Muranga	Takaba
11	Item/Tambach	Londiani	Kakuma	Kiambu	Garissa	Maralal
12	Webuye	Nyamira	Kabarnet	Limuru	Chogoria	Marsabit
13	Kapenguria	Keroka	Lokichogio	Ukunda	Maragua	
14	Bondo	Oyugis		Kitengela	Wanguru	
15	Siaya	Muhoroni		Wundanyi	Runyenjes	
16	Yala	Awasi		Kilifi	Kerugoya/Kutus	
17	Malaba	Kehancha		Mtwapa	Maua	
18	Malakisi	Awendo		Juja	Mwingi	
19	Chwele	Kendu Bay		Ongata Rongai	Sagana	
20	Butere	Mbita Point		Taveta	Karatina	
21	Kiminini	Tabaka		Mariakani	Othaya	
22	Usenge	Litein		Voi	Madogo	
23	Moi's Bridge	Sotik		Kajiado	Msalani	
24	Nandi Hills	Nyansiongo		Kwale	Hola	
25	Lumakanda	Ogembo		Kiserian		
26	Matunda			Loitokitok		
27	Ugunja			Githunguri		
28	Port Victoria			Wote		
29	Ukwala			Watamu		
30	Nambale			Mitto Andei		
31	Burnt Forest			Masambweni		
32	Malava					
Total	32 UCs	25 UCs	13 UCs	31 UCs	24 UCs	12 UCs

Source: JICA Study Team based on Census 2009

Table 7.4.1 Target 95 Urban Centres for Sewerage System Development

No.	LVNCA	LVSCA	RVCA	ACA	TCA	ENNCA
1	Eldoret	Kisumu	Nakuru	Nairobi	Lamu	Isiolo
2	Vihiga	Rongo	Naivasha	Mombasa	Nyeri	Nanyuki
3	Kitale	Kericho	Ol Kalou	Ruiru	Kitui	Nyahururu
4	Mumias	Bomet	Molo	Kikuyu	Thika	Mandera
5	Kimilili	Kisii	Narok	Kangundo-Tala	Embu	Wajir
6	Kakamega	Migori	Gilgil	Machakos	Meru	
7	Kapsabet	Suneka	Njoro	Mavoko	Matuu	
8	Bungoma	Ahero	Eldama Ravine	Malindi	Makuyu	
9	Busia	Kipkelion	Kabarnet	Karuri	Chuka	
10	Luanda	Homa Bay		Ngong	Muranga	
11	Item/Tambach	Londiani		Kiambu	Garissa	
12	Webuye	Nyamira		Limuru	Chogoria	
13	Kapenguria	Keroka		Ukunda	Maragua	
14	Bondo	Oyugis		Kitengela	Wanguru	
15	Siaya	Muhoroni		Wundanyi	Runyenjes	
16	Malaba	Awasi		Kilifi	Kerugoya/Kutus	
17	Malakisi	Kehancha		Mtwapa	Maua	
18	Moi's Bridge	Awendo		Juja	Mwingi	
19	Matunda	Kendu Bay		Ongata Rongai		
20				Taveta		
21				Mariakani		
22				Voi		
23				Kajiado		
24				Kwale		
25				Kiserian		
Total	19 UCs	19 UCs	9 UCs	25 UCs	18 UCs	5 UCs

Source: JICA Study Team based on Census 2009

Table 7.5.1 Large Scale Irrigation Projects Proposed by Government Authorities and This Study (1/3)

a) Projects Proposed by Government Authorities

No	Name of Project	County	Irrigation Area (ha)	Type of Project*[1]	Water Source Facility*[2]	Project Status as of Oct. 2012*[3]	Executing Agency
LVNCA							
1.	Lower Nzoia Irrigation	Busia & Siaya	10,470	New	Weir	On-going	NIB
2.	Lower Sio Irrigation	Busia	6,600	New	Weir	On-going	NIB
3.	Nandikinya-Magombe-Makunda Irri.	Busia	600	New	Pumping	Proposed	LBDA
4.	Sabwani-Kapsitwet-Namanjalala Irri.	Trans Nzoia	800	Reh+Ext	Weir	Proposed	LBDA
5.	Yala Swamp Drainage & Irrigation	Siaya	4,600	New	Weir	F/S done	LBDA
	Total		23,070				
LVSCA							
1.	Ahero and West Kano Irrigation	Kisumu	1,800	Reh+Ext	Pump/Weir	F/S done	NIB
2.	Kano Plain Irrigation (Magwagwa Multi-dam)	Nyamira/Kericho	15,000	New	Multi-dam	F/S done	LBDA
3.	Kimira-Oluch Irrigation	Homa Bay	1,474	New	Weir	On-going	LBDA
4.	Lower Kuja Irrigation	Migori	7,800	New	Weir	D/D done	NIB
5.	Nandi Irrigation (Nandi Forest Multi-dam)	Vihiga/Nandi	7,272	New	Multi-dam	D/D on-going	LBDA
6.	Nyando Irrigation (Nyando Multi-dam)	Kericho	3,000	New	Multi-Dam	Proposed	LBDA
7.	South West Kano Irrigation	Kisumu	1,200	Reh	Weir	On-going	NIB
	Total		37,546				
RVCA							
1.	Ainabkoi Kamwosor Irrigation	Elgeyo Marakwet	500	New	Dam	Proposed	KVDA
2.	Arror Irrigation (Arror Multi-dam)	Elgeyo Marakwet	10,000	New+Ext	Multi-dam	F/S done	KVDA
3.	Chebaram-Kimose Irrigation	Baringo	650	New	Dam	Proposed	KVDA
4.	Chesegon Irrigation	Elgeyo Marakwet	500	New	Dam	Proposed	KVDA
5.	Chesongoch Irrigation	Elgeyo Marakwet	1,000	New	Dam	Proposed	KVDA
6.	Embobut Irrigation	Elgeyo Marakwet	2,000	Ext	Multi-dam	Proposed	KVDA
7.	Embolot Irrigation	Elgeyo Marakwet	500	New	Dam	Proposed	KVDA
8.	Embomon Irrigation	Elgeyo Marakwet	800	New	Dam	Proposed	KVDA
9.	Kakuma Irrigation	Turkana	700	New	Dam	Proposed	KVDA
10.	Katilu Irrigation	Turkana	5,060	Reh+Ext	Weir	Proposed	NIB
11.	Kimwarer Irrigation	Baringo	2,000	New	Multi-Dam	Proposed	KVDA
12.	Kipkukutia Irrigation	Baringo	600	New	Dam	Proposed	KVDA
13.	Lomut Irrigation	West Pokot	850	New	Dam	Proposed	KVDA
14.	Lower Ewaso Ng'iro Irrigation (Oletukat/Oldorko Multi-dam)	Kajiado	15,000	New	Multi-dam	F/S on-going	ENSDA
15.	Mogil Kiptunos Irrigation	Elgeyo Marakwet	500	New	Dam	Proposed	KVDA
16.	Muringa Banana Irrigation	Turkana	1,446	New	Weir	Proposed	KVDA
17.	Murung-Sebit Irrigation	West Pokot	850	New	Dam	Proposed	KVDA
18.	Namerit Irrigation	Turkana	2,000	New	Dam	Proposed	KVDA
19.	Nauwia Irrigation	Elgeyo Marakwet	500	New	Dam	Proposed	KVDA
20.	Norera Irrigation	Narok	2,000	New	Dam	F/S on-going	ENSDA
21.	Oke-Kipsaa Dam Irrigation	Baringo	1,080	New	Dam	Proposed	KVDA
22.	Oldekesi Irrigation	Narok	2,000	New	Weir	Proposed	ENSDA
23.	Olkejuado Dry Land Irrigation	Kajiado	3,000	New	Dam	Proposed	ENSDA
24.	Perkera Irrigation Extension	Baringo	3,000	Reh+Ext	Weir/Dam	F/S on-going	NIB
25.	Suswa Flood Mitigation Irrigation	Narok	4,000	New	Weir	Proposed	ENSDA
26.	Todonyang-Omo Irrigation (Gibe 3 Multi-dam in Ethiopia)	Turkana	35,000	New	Multi-dam	Proposed	KVDA
27.	Torok Irrigation	Elgeyo Marakwet	500	New	Dam	Proposed	KVDA
28.	Tunyo Irrigation	Elgeyo Marakwet	500	New	Dam	Proposed	KVDA
29.	Turkwel Irrigation	West Pokot	5,000	New	Dam (E)	F/S done	KVDA
30.	Turkwel & Kerio Valley Irrigation	Elgeyo Marakwet	30,000	New	Weir/Dam	F/S on-going	NIB
	Total		131,536				

Note: *[1]: Reh = Rehabilitation, Ext = Extension; *[2]: Multi = Multipurpose, E = Existing

*[3]: On-going = projects financed for construction, Proposed = projects having no detailed information for evaluation.

Table 7.5.1 Large Scale Irrigation Projects Proposed by Government Authorities and This Study (2/3)

a) Projects Proposed by Government Authorities (contd.)

No	Name of Project	County	Irrigation Area (ha)	Type of Project*[1]	Water Source Facility*[2]	Project Status as of Oct. 2012*[3]	Executing Agency
ACA							
1.	Burangi Irrigation	Kilifi	1,200	New	Weir	Proposed	CDA
2.	Ilchilal Irrigation	Kajiado	600	Ext	Weir	Proposed	ENSDA
3.	Kanzal Irrigation Extension	Makueni	3,500	Ext	Weir	Proposed	NIB
4.	Kavunyalalo Irrigation	Kilifi	8,240	New	Weir	F/S on-going	NIB
5.	Kayatta Irrigation Extension	Machakos	3,500	Ext	Weir	Proposed	NIB
6.	Kibwezi Irrigation Extension (Munyu Multi-dam)	Makueni	15,000	Ext	Multi-Dam	Proposed	TARDA
7.	Kibwezi Irrigation Extension (Munyu Multi-dam)	Makueni	15,000	Ext	Multi-Dam	Proposed	TARDA
8.	Kibwezi Greater Irrigation Extension (Thwake Multi-dam)	Makueni	42,000	Ext	Multi-Dam	Proposed	NIB
9.	Mt. Kilimanjaro Irrigation	Kajiado	1,500	Reh+Ext	Springs	Proposed	ENSDA
10.	Olkishunki Irrigation	Kajiado	2,000	New	Multi-Dam	Proposed	ENSDA
11.	Raare Irrigation	Kilifi	700	New	Dam	F/S on-going	CDA
12.	Rwabura Irrigation Extension	Kiambu	4,360	Ext	Weir/Dam	D/D on-going	NIB
13.	Sabaki Irrigation Extension	Kilifi	3,000	Ext	Weir	F/S on-going	NIB
14.	Sabaki Umba River Basins Integrated Irrigation	Kilifi, Kwale	80,000	New	Weir/Dam	F/S on-going	CDA
15.	Taita Taveta Irrigation	Taita Taveta	3,780	Reh+Ext	Weir	F/S on-going	TARDA
	Total		184,380				
TCA							
1.	Bura Pump Irrigation Extension	Tana river	800	Ext	Weir	On-going	NIB
2.	Bura West Irrigation Extension	Tana river	5,500	Reh+Ext	Weir	D/D done	NIB
3.	High Grand Falls Irrigation (High Grand Falls Multi-dam)	Garissa/ Tana River	106,000	New	Multi-dam	F/S done	TARDA/ NIB
4.	Hola Pump Irrigation Extension	Tana River	800	Ext	Pump	On-going	NIB
5.	Hola Irrigation Greater Extension	Tana River	3,500	Reh+Ext	Weir	D/D on-going	NIB
6.	Kaggari-Gaturi-Keini Irrigation	Embu	6,600	Ext	Dam	D/D done	NIB
7.	Kanzalu Irrigation	Machakos	4,055	New	Weir/Dam	Proposed	TARDA
8.	Kiambere Irrigation	Embu	10,000	Ext	Weir/Dam	F/S on-going	TARDA
9.	Kunati Irrigation	Meru	1,050	New	Weir	Proposed	NIB
10.	Masinga Irrigation	Machakos	10,000	New+Ext	Weir/Dam	F/S on-going	TARDA
11.	Mitunguu Irrigation Extension	Meru	10,000	Reh+Ext	Weir/Dam	F/S done	NIB
12.	Mwea Irrigation Extension (Thiba Dam)	Kirinyaga	9,485	Ext	Weir/Dam	On-going	NIB
13.	Tana Delta Irrigated Sugar	Tana River	20,000	New	Weir	D/D done	TARDA
14.	Tana Delta Irrigation Extension (Rice)	Tana River	10,000	Reh+Ext	Weir	D/D done	TARDA
15.	Thanantu Irrigation	Meru	2,500	New	Weir/Dam	Proposed	TARDA
	Total		200,290				
ENNCA							
1.	Kieni Irrigation	Nyeri	3,500	New	Weir	F/S on-going	NIB
2.	Kom (Wajir) Irrigation (Archer's Post Multi-dam)	Isiolo/Samburu	2,146	New	Multi-dam	F/S on-going	ENNDA
3.	Lorian Swamp Cotton Irrigation	Wajir	1,800	New	Weir/Dam	F/S on-going	ENNDA
	Total		7,446				

Note: *[1]: Reh = Rehabilitation, Ext = Extension; *[2]: Multi = Multipurpose, E = Existing

*[3]: On-going = projects financed for construction, Proposed = projects having no detailed information for evaluation.

Source: Information from government authorities

Table 7.5.1 Large Scale Irrigation Projects Proposed by Government Authorities and This Study (3/3)

b) Projects Proposed in This Study

No	Name of Project	County	Irrigation Area (ha)	Type of Project*[1]	Water Source Facility*[2]	Project Status as of Oct. 2012*[3]	Executing Agency
LVNCA							
1.	Upper Nzoia Irrigation (Nzoia 34B Multi-dam)	Bungoma	24,000	New	Multi-dam	Proposed	
2.	Moi's Bridge Irrigation (Moi's Bridge Multi-dam)	Bungoma	19,800	New	Multi-dam	Proposed	
3.	Kibolo Irrigation (Kibolo Multi-dam)	Kakamega	11,500	New	Multi-dam	Proposed	
	Total		55,300				
LVSCA							
1.	Lower Kuja Irrigation (Stage-2) (Katieno Multi-dam)	Migori	32,700	New	Multi-dam	Proposed	
2.	Amala Irrigation (Amala Multi-dam)	Bomet	5,000	New	Multi-dam	Proposed	
3.	Ilooiterre Irrigation (Ilooiterre Multi-dam)	Narok	3,000	New	Multi-dam	Proposed	
	Total		40,700				
TCA							
1.	Kora Irrigation (Kora Multi-dam)	Tana river	25,000	New	Multi-dam	Proposed	
	Total		25,000				
ENNCA							
1.	Kihoto Irrigation (Kihoto Multi-dam)	Laikipia	18,000	New	Multi-dam	Proposed	
	Total		18,000				

Source: JICA Study Team based on Information from government authorities

Table 7.8.1 Number of Target, Operational and Proposed Monitoring Stations of WRMA

a) Surface Water Level

Catchment Area	Target	Operational	% of Operational	Proposed Number in NWMP 2030	Difference between Target and Proposed
LVNCA	28	21	75%	24	-4
LVSCA	38	30	79%	23	-15
RVCA	41	25	61%	23	-18
ACA	31	18	58%	26	-5
TCA	45	28	62%	26	-19
ENNCA	40	24	60%	13	-27
Total	223	146	65%	135	-88

b) Surface Water Quality

Catchment Area	Target	Operational	% of Operational	Proposed Number in NWMP 2030	Difference between Target and Proposed
LVNCA	24	24	100%	24	0
LVSCA	61	47	77%	23	-38
RVCA	20	18	90%	23	3
ACA	31	26	84%	26	-5
TCA	45	18	40%	26	-19
ENNCA	40	24	60%	13	-27
Total	221	157	71%	135	-86

c) Groundwater Level

Catchment Area	Target	Operational	% of Operational	Proposed Number in NWMP 2030	Difference between Target and Proposed
LVNCA	13	9	69%	19	6
LVSCA	30	15	50%	19	-11
RVCA	37	24	65%	10	-27
ACA	71	25	35%	24	-47
TCA	41	14	34%	18	-23
ENNCA	10	5	50%	5	-5
Total	202	92	46%	95	-107

d) Groundwater Quality

Catchment Area	Target	Operational	% of Operational	Proposed Number in NWMP 2030	Difference between Target and Proposed
LVNCA	11	10	91%	19	8
LVSCA	17	13	76%	19	2
RVCA	8	8	100%	10	2
ACA	18	18	100%	24	6
TCA	41	14	34%	18	-23
ENNCA	10	3	30%	5	-5
Total	105	66	63%	95	-10

e) Rainfall

Catchment Area	Target	Operational	% of Operational	Proposed Number in NWMP 2030	Difference between Target and Proposed
LVNCA	65	52	80%	42	-23
LVSCA	65	53	82%	50	-15
RVCA	60	45	75%	47	-13
ACA	50	33	66%	38	-12
TCA	35	25	71%	47	12
ENNCA	26	8	31%	34	8
Total	301	216	72%	258	-43

Source: WRMA Performance Repport No. 1 (July 2010), JICA Study Team

Table 7.9.1 Proposed Areas Subject to Flood Disaster Management Plan

Catch-ment Area	NWMP (1992)			Flood Mitigation Strategy (MWI, June 2009)	NWCPC Strategic Plan 2010-2015	Proposed Areas Subject to NWMP 2030	
	Major Flood Area	Target Area *1	Proposed Project for Implementation*2	Areas Affected by Floods Identified in the Strategy	Identified Flood Management Project	No.	Name
LVNCA	1. Yala Swamp	O	O (by 2010)	Budalangi	Nzoia River	1.	Yala Swamp
LVSCA	2. Kano Plain	O	O (by 2000)	Kano Plains	Nyando River	2.	Kano Plain
				Nyakach Area			
	3. Sondu Rivermouth	O	–	Nyakach Area		3.	Sondu Rivermouth
				Rachuonyo			
	4. Kuja Rivermouth	O	O (by 2010)	Migori	Gucha River	4.	Kuja Rivermouth
				Urban Center of Kisumu		5.	Kisumu
RVCA	5. Middle/	O	–		Turkana	6.	Middle/Lower Turkwel
	Lower Turkwel	–	–				
	6. Lower Kerio	–	–			7.	Lower Kerio
				Urban Center of Nakuru		8.	Nakuru
					Narok	9.	Narok
					Mogotio	10.	Mogotio
ACA	7. Downmost Athi	O	–	Kilifi	Sabaki-Galana	11.	Downmost Athi
	8. Lumi Rivermouth	O	O (by 2010)		Lumi River (Taita Taveta)	12.	Lumi Rivermouth
	Nairobi City	O	O (by 2000)	Urban Center of Nairobi		13.	Nairobi City
				Kwale		14.	Kwale
				Urban Center of Mombasa		15.	Mombasa
TCA	9. Lower Tana	O	–	Tana River Basin in Coast Province	Tana River	16.	Lower Tana
				Garissa			
				Lower Parts in Tana River District			
				Ijara		17.	Ijara
ENNCA	10. Middle/	–	–			18.	Middle/Lower Ewaso Ng'iro North
	Lower Ewaso Ng'iro North	–	–				
				Wajir		19.	Wajir
					Daua River (Mandera)	20.	Mandera
					Isiolo	21.	Isiolo

Note: *1 O: Selected, –: Not selected

*2 NWMP (1992) proposes not only the above 5 projects, also:
1) 47 Urban Drainage Projects,
2) Minor Ad-hoc River Improvement Projects,
3) Long-term Improvement of Lower Tana River

Source: JICA Study Team based on NWMP (1992), Flood Mitigation Strategy (MWI, June 2009) and NWCPC Strategic Plan 2010-2015

Table 8.2.1 Water Sector Laws (1/2)

National Legislation	Purpose/Salient Provision
The Constitution, 2010	
The Water Act revised in 1972	Revision of the Water Act, 1951
The Water Act, 2002 (No. 8 of 2002)	Provide for the management, conservation, use and control of water resources and the acquisition and regulation of rights to use water; Provide for the regulation and management of water supply ad sewerage services; Repeal the Water Act, 1972 (Cap 372)
The Water Resources Management Rules, 2007, Legal Notice No. 171, the Water Act (No. 8 of 2002)	The Rules made by the Minister to exercise of the powers conferred by Section 110 of the Water Act, 2002
The Agriculture Act (Cap 318) (as amended by Act No. 11 of 1993 and No.2 of 2002)	Promote agricultural development and stress the need for conservation of soil and its fertility and the development of agricultural land
The Irrigation Act	The establishment, constitution and functions of the National Irrigation Board which is responsible for the development, control and improvement of national irrigation schemes in the areas designated by the Minister
The Forest Act, 2005 (repeal of Cap 385)	Provide for the establishment, control and regulation of central forest, other forests and forest areas in Nairobi area and on unalineated Government land, and encourage conservation an maintenance of vegetative cover in all lands
The Government Lands Act (Cap 280), 1970, Revised 1984	Provide for regulation of leasing and other disposal of Government lands, and for other purposes
The Land (Group Representatives) Act (Cap 287), Revised 1970	Provides for the incorporation of representatives of groups who have been recorded as owners of land under the Land Adjudication Act and other connected purposes.
The Trust Land Act (Cap 288), 1962, Revised 1970	Act of parliament to make provision for the Trust Land on setting apart of land, exclusions, miscellaneous powers, and extinguishment of rights
The Land Acquisition Act (Cap 295), 1970, Revised 1983	Act of parliament to make provision for the compulsory acquisition of and for the public benefit
The Registered Land Act (Cap 300)	An Act of Parliament to make further and better provision for the registration of title to land, and for the regulation of dealings
The Land Control Act (Cap 302), 1981, Revised 1989	Act of parliament to provide for controlling transactions in agricultural land
The Land Planning Act (Cap 303), Revised 1970	Act of parliament to make provision for planning the use and development of land.
The Physical Planning Act, 1996 (N0.6 of 1996)	Act of parliament to make further and better provision for the registration of title to land, and for the regulation of dealings in registered land
The Environmental Management and Co-ordination Act (EMCA No.8 of 1999)	Co-ordinate the various environmental management activities being undertaken by the lead agencies integration of environmental considerations into development policies and plans.
The Lakes and Rivers Act (Cap 409), 1962, Revised 1983	Regulates dredging and the use of streams on certain lakes and rivers
The Electric Power Act	Facilitates and regulates the generation, transmission, distribution, supply and use of electric energy
The Mining Act	Provisions for mining activities licensed by the Act, including those related to soil conservation and water management
The Wildlife Act	Provide for the protection, conservation, and management of wildlife
The Local Government Act (Cap 265), 1986, Revised 1998	Provides for the establishment of authorities for local government, defining their functions and providing for other related matters
The Territorial Waters Act (Cap 371, Laws of Kenya)	Provisions for the delimitation of the territorial waters in the sea
The Kenya Ports Authority Act	Establishment of the Kenya Port Authority

Table 8.2.1 Water Sector Laws (2/2)

National Legislation	Purpose/Salient Provision
The Government Fisheries Protection Act	Prevent the depletion of certain species, for example, pearls or shellfish, beche-de-mer, etc.
The Fisheries Act (Cap 378) (Caps. 378, 379, 380 repealed)	An Act of Parliament to provide for the development, management, exploitation, utilisation and conservation of fisheries
The Public Health Act (Cap 242)	Provisions for securing and maintaining health and the importance of water from the health point of view, to define responsibility of the local authority for taking necessary measures
The Malaria Prevention Act (Cap 243)	Enables health authorities to make measures for the prevention of Malaria by drainage, etc.
The Kerio Valley Development Authority Act and The Lake Basin Development Authority Act (Cap 441)	Provide for the establishment of an authority to plan and co-ordinate the implementation of development projects in each catchment area
The Lake Basin Development Authority Act (Cap 442)	An Act of Parliament to provide for the establishment of an authority to plan and co-ordinate the implementation of development projects in the Lake Victoria catchment area and for matters connected
The Tana and Athi River Development Authority Act (Cap 443)	Provide for the establishment of an authority to advise on the institution and co-ordination of development projects in the basin
The Agricultural Development Corporation Act (Cap 444)	Act of Parliament to provide for the establishment of the Agricultural Development Corporation
The State Corporations Act (Cap 446) (KEPHIS, NTZDC)	Act of Parliament to make provision for the establishment of state corporations: for control and regulation of state corporations; and for connected purposes
The Ewaso Ng'iro South River Basin Development Act (Cap 447)	Provides for the establishment of an Authority to plan and co-ordinate the implementation of development projects in Ewaso Ngiro South River basin and its catchment areas.
The Ewaso Ng'iro North River Basin Development Act (Cap 448)	Provides for the establishment of an Authority to plan and co-ordinate the implementation of development projects in Ewaso Ngiro North River basin and its catchment areas.
The Mombasa Pipeline Board Act	Provide for the establishment of the Board, its constitution and vesting of assets, its powers and functions, price charged by Board
The National Water Conservation and Pipeline Corporation Order, 1988	Exercise of power conferred by the State Corporation Act, the establishment of the corporation (NWCPC)
The Legal Notice No. 270 of June 24, 1988	Official establishment of the NWCP

Source: JICA Study Team based on relevant government documents

Table 8.2.2 Water Sector Policies and Strategies

Policies/Strategies	Agency	Purpose and Salient Provision
National Water Policy on Water Resources Management and Development 1999 (sessional Paper Number 1 of 1999).	MWI	Provides policy direction in addressing the national challenges which include: Treating water as a social and economic good. Preservation, conservation and protection of water resources. Sustainable allocation of water resources. Supplying adequate and quality water. Ensuring save disposal of wastewater for environmental protection. Developing a sustainable financial system for the water sector.
National Policy on Irrigation and Drainage Development (June 2007).	MWI	Stimulate irrigation and drainage through targeted technical support; intensified investment in the sector; improved research and extension services; and capacity building in farmer organizations to ensure full integration of smallholder farmers in irrigation and drainage development.
National Water Storage Policy (March 2009)	MWI	Provides a guide on how water storage and its infrastructure development can be achieved and managed to meet the water demand.
National Irrigation and Drainage Policy (March 2009)	MWI	The National Irrigation and Drainage Policy presents a concise set of principles and guidelines designed to facilitate an orderly and rapid development and improved performance of the irrigation sector in Kenya.
National Water Harvesting and Storage Management Policy (May 2010)	MWI	Provides a guide for sustainable national water harvesting, storage and flood control to support livelihoods and prevent disasters, while involving the stakeholders.
National Water Resources Management Strategy 2007-2009 (January 2007)	MWI	Provides a road map for Assessing, Maintaining, Developing and Managing national water resources Sustainably, using an Integrated approach.
National Water Services Strategy 2007- 2015 (June2009)	MWI	Provides a clear, accountable and transparent road map to implement sector policy in order to improve health, jobs, and wealth for all Kenyans.
Flood Mitigation Strategy (June 2009)	MWI	Provides a guide on integrated flood interventions in the water basins while involving the stakeholders.
Catchment Management Strategy – Lake Victoria South (June 2008)	WRMA	Providing a guide for assessment, maintaining, developing and managing the water resource in the catchment through conservation, protection and sustainable use while involving stakeholders.
Catchment Management Strategy – Lake Victoria North (June 2007)	WRMA	Providing a guide for assessment, maintaining, developing and managing the water resource in the catchment through conservation, protection and sustainable use while involving stakeholders.
Catchment Management Strategy – Ewaso Ng'iro North (June 2008)	WRMA	Providing a guide for assessment, maintaining, developing and managing the water resource in the catchment through conservation, protection and sustainable use while involving stakeholders.
Catchment Management Strategy – Athi (June 2008)	WRMA	Providing a guide for assessment, maintaining, developing and managing the water resource in the catchment through conservation, protection and sustainable use while involving stakeholders.
Catchment Management Strategy – Tana (June 2007)	WRMA	Providing a guide for assessment, maintaining, developing and managing the water resource in the catchment through conservation, protection and sustainable use while involving stakeholders.
Catchment Management Strategy – Rift Valley (June 2008)	WRMA	Providing a guide for assessment, maintaining, developing and managing the water resource in the catchment through conservation, protection and sustainable use while involving stakeholders.

Note: MWI: Ministry of Water and Irrigation, WRMA: Water Resources Management Authority

Source: JICA Study Team based on relevant government documents

Table 9.3.1 Projection of Available Resources for Development Projects up to 2030

(Unit: KSh billion)

No.	Item	2011	2012	2017	2022	2030	Total	Adjusted Total
		2011/12	2012/13	2017/18	2022/23	2030/31	2013/14 - 2030/31	2013/14 - 2030/31
		Provisional	Projection					
1	GDP at 2011 constant price	3,295.0	3,492.7	5,323.3	8,573.2	16,769.3	161,197.0	
2	GOK Budget							
	Total Revenue by the Government	806.3	838.2	1,277.6	2,057.6	4,024.6	38,687.3	
	Total Expenditure by the Government	1,082.8	978.0	1,490.5	2,400.5	4,695.4	45,135.2	
	Disbursement/loan by external resources	191.5	139.7	212.9	342.9	670.8	6,447.9	
3	Gross National Saving	487.7	586.8	1,064.7	1,714.6	3,353.9	32,143.6	
	Central Government	135.1	160.7	266.2	428.7	838.5	8,072.0	
	Other	352.6	426.1	798.5	1,286.0	2,515.4	24,071.6	
4	Development Budget by Ministries for the Water Sector							
	MWI, Development Grants	13.9	16.9	25.6	41.2	80.5	774.0	
	MORDA	3.3	5.6	12.8	20.6	40.2	386.9	
	MoE		1.3	1.5	2.4	4.7	45.0	
	Total Available Resources for the Water Sector		23.7	39.8	64.1	125.4	1,205.9	
	% of GOK Budget		2.8%	3.1%	3.1%	3.1%	3.1%	
	% of GDP		0.7%	0.7%	0.7%	0.7%	0.7%	
5	Development Expenditure by Sub-Sectors							
	Water Supply		6.1	9.7	15.6	30.5	293.4	561.5
	Sewerage		0.7	1.0	1.6	3.2	30.9	30.9
	Irrigation		8.0	11.9	19.2	37.6	361.1	580.4
	Hydropower		1.3	1.5	2.4	4.7	45.0	74.0
	Water Storage*		5.2	7.5	12.0	23.5	226.2	
	Multi-purpose *		4.2	9.6	15.4	30.2	290.2	
	Total		25.5	41.2	66.3	129.7	1,246.7	1,246.7
	% of GOK Budget		3.0%	3.2%	3.2%	3.2%	3.2%	
	% of GDP		0.7%	0.8%	0.8%	0.8%	0.8%	

Note: * The estimated development expenditure in water storage and multi-purpose are integrated into other water sub-sectors in the “adjusted total” column. The calculation for available resources for multi-purpose projects was made by estimating that around 75% of the budget in Regional Development is used for multi-purpose projects, based on the projected budget for multipurpose dams (KSh 21 billion) in the total required budget of Regional Development (Ksh 28 billion) in 2013/14.

Source: GDP estimate by Kenya Vision 2030; Budget Policy Statement 2012; Data from Ministry of Water and Irrigation; General Economic, Commercial and Labour Affairs, Sector Report for the Medium Term Expenditure Framework 2013/14-2015/16

Table 10.1.1 Summary of Proposed Water Allocation Plans for Water Demands in 2030

(Unit: MCM/year)

Catchment Area	LVNCA			LVSCA			RVCA		
Water Demand Category	Water Demand	Water Source		Water Demand	Water Source		Water Demand	Water Source	
		Surface	Groundwater		Surface	Groundwater		Surface	Groundwater
Domestic	424	363	61	464	374	90	264	213	51
Industrial	19	10	9	41	21	20	23	12	11
Irrigation	1,359	1,332	27	1,158	1,107	51	1,393	1,377	16
Livestock	61	61	0	106	106	0	123	123	0
Wildlife	0	0	0	3	3	0	1	1	0
Fisheries	16	16	0	15	15	0	8	8	0
Total	1,879	1,782	97	1,787	1,626	161	1,812	1,734	78
Available Water Resources	5,077	4,969	108	5,937	5,749	188	3,147	3,045	102
Ratio of Water Demands	37.0%	35.9%	89.8%	30.1%	28.3%	85.6%	57.6%	56.9%	76.5%

Catchment Area	ACA			TCA			ENNCA		
Water Demand Category	Water Demand	Water Source		Water Demand	Water Source		Water Demand	Water Source	
		Surface	Groundwater		Surface	Groundwater		Surface	Groundwater
Domestic	941	819	122	343	303	40	125	42	83
Industrial	153	77	76	42	21	21	2	1	1
Irrigation	917	882	35	2,697	2,546	151	539	432	107
Livestock	59	59	0	69	69	0	79	79	0
Wildlife	3	3	0	1	1	0	0	0	0
Fisheries	12	12	0	16	16	0	7	7	0
Total	2,085	1,852	233	3,168	2,956	212	752	561	191
Available Water Resources (*)	1,634	1,334	300	7,828	7,261	567	3,011	2,536	475
Ratio of Water Demands	127.6%	138.8%	77.7%	40.5%	40.7%	37.4%	25.0%	22.1%	40.2%

Total				Present Water Sources**		
Water Demand Category	Water Demand	Water Source		Water Demand	Water Source	
		Surface	Groundwater		Surface	Groundwater
Domestic	2,561	2,114	447	1,186	724	462
Industrial	280	142	138	125	62	63
Irrigation	8,063	7,676	387	1,602	1,602	n.a.
Livestock	497	497	0	255	255	n.a.
Wildlife	8	8	0	8	8	0
Fisheries	74	74	0	42	42	0
Total	11,483	10,511	972	3,218	2,693	525
Available Water Resources (*)	26,634	24,894	1,740	30,452	24,894	5,558
Ratio of Water Demands	43.1%	42.2%	55.9%	10.6%	10.8%	9.4%

Note: * Deficit of Athi Catchment Area is to be met by 472 MCM/year of inter-basin transfer and 93 MCM/year of desalination.

** The data on groundwater use for irrigation and livestock are not available.

Source: JICA Study Team

Table 10.1.2 Summary of Proposed Water Supply Development Plans

Catchment Area		LVNCA			LVSCA			RVCA		
Type of Project		Target Area	Required Capacity (m^3/day)	Service Population (million persons)	Target Area	Required Capacity (m^3/day)	Service Population (million persons)	Target Area	Required Capacity (m^3/day)	Service Population (million persons)
Urban Water Supply	Rehabilitation	20 UCs	135,000		21 UCs	120,000		10 UCs	129,000	
	Expansion	20 UCs	556,000		21 UCs	571,000		10 UCs	254,000	
	New Construction	12 UCs	91,000	6.57	4 UCs	94,000	6.26	3 UCs	15,000	3.34
	Total	32 UCs	782,000 (135,000)		25 UCs	785,000 (120,000)		13 UCs	398,000 (129,000)	
Rural Water Supply	LSRWSS	11 Counties	184,000 (10,000)		14 Counties	277,000 (26,000)		18 Counties	178,000 (7,000)	
	SSRWSS	11 Counties	220,000 (144,000)	5.79	14 Counties	208,000 (150,000)	6.46	18 Counties	120,000 (78,000)	4.11
	Total	11 Counties	404,000 (154,000)		14 Counties	485,000 (176,000)		18 Counties	298,000 (85,000)	

Catchment Area		ACA			TCA			ENNCA		
Type of Project		Target Area	Required Capacity (m^3/day)	Service Population (million persons)	Target Area	Required Capacity (m^3/day)	Service Population (million persons)	Target Area	Required Capacity (m^3/day)	Service Population (million persons)
Urban Water Supply	Rehabilitation	30 UCs	699,000		15 UCs	106,000		6 UCs	32,000	
	Expansion	29 UCs	1,542,000		14 UCs	349,000		6 UCs	61,000	
	New Construction	2 UCs	19,000	17.01	8 UCs	88,000	4.90	6 UCs	31,000	1.04
	Total	32 UCs	2,260,000 (699,000)		23 UCs	543,000 (106,000)		12 UCs	124,000 (32,000)	
Rural Water Supply	LSRWSS	10 Counties	209,000 (100,000)		16 Counties	211,000 (149,000)		14 Counties	119,000 (7,000)	
	SSRWSS	10 Counties	110,000 (108,000)	4.04	16 Counties	145,000 (72,000)	4.96	14 Counties	101,000 (77,000)	3.36
	Total	10 Counties	319,000 (208,000)		16 Counties	356,000 (221,000)		14 Counties	220,000 (84,000)	

Total				
Type of Project		Target Area	Required Capacity (m^3/day)	Service Population (million persons)
Urban Water Supply	Rehabilitation	102 Ucs	1,221,000	
	Expansion	100 UCs	3,333,000	
	New Construction	35 UCs	338,000	39.12
	Total	137 UCs	4,892,000 (1,221,000)	
Rural Water Supply	LSRWSS	47 Counties	1,178,000 (299,000)	
	SSRWSS	47 Counties	904,000 (629,000)	28.72
	Total	47 Counties	2,082,000 (928,000)	

Source: JICA Study Team

Note:
1) LSRWSS: large scale rural water supply system, SSRWSS: small scale rural water supply system
2) For Urban Water Supply and LSRWSS, the figures in parentheses indicate the total capacities of existing water supply systems (including systems under construction)
3) For SSRWSS, the figures in parentheses indicate estimate of water consumption, by applying unit rate of 50 L/p/day.

Table 10.1.3 Summary of Proposed Sanitation Development Plans

Catchment Area		LVNCA			LVSCA			RVCA		
Type of Project		Target Area	Required Capacity (m^3/day)	Service Population (million persons)	Target Area	Required Capacity (m^3/day)	Service Population (million persons)	Target Area	Required Capacity (m^3/day)	Service Population (million persons)
Sewerage	Rehabilitation	7 UCs	21,000	6.03	3 UCs	22,000	6.02	3 UCs	18,000	3.16
	Expansion	7 UCs	230,000		3 UCs	171,000		3 UCs	150,000	
	New Construction	12 UCs	209,000		16 UCs	291,000		6 UCs	72,000	
	Total	19 UCs	460,000 (21,000)		19 UCs	484,000 (22,000)		9 UCs	240,000 (18,000)	
On-site Treatment Facilities		11 Counties	--	6.33	14 Counties	--	6.70	18 Counties	--	4.29

Catchment Area		ACA			TCA			ENNCA		
Type of Project		Target Area	Required Capacity (m^3/day)	Service Population (million persons)	Target Area	Required Capacity (m^3/day)	Service Population (million persons)	Target Area	Required Capacity (m^3/day)	Service Population (million persons)
Sewerage	Rehabilitation	6 UCs	244,000	16.26	6 UCs	32,000	5.24	2 UCs	5,000	0.82
	Expansion	6 UCs	715,000		6 UCs	118,000		2 UCs	27,000	
	New Construction	19 UCs	430,000		12 UCs	248,000		3 UCs	30,000	
	Total	25 UCs	1,389,000 (244,000)		18 UCs	398,000 (32,000)		5 UCs	62,000 (5,000)	
On-site Treatment Facilities		10 Counties	--	4.28	16 Counties	--	5.13	14 Counties	--	3.58

Total				
Type of Project		Target Area	Required Capacity (m^3/day)	Service Population (million persons)
Sewerage	Rehabilitation	27 UCs	342,000	37.53
	Expansion	27 UCs	1,411,000	
	New Construction	68 UCs	1,280,000	
	Total	95 UCs	3,033,000 (342,000)	
On-site Treatment Facilities		47 Counties	--	30.31

Note: The figures in parentheses indicate the total capacities of existing sewerage systems (including systems under construction).
Source: JICA Study Team

Table 10.1.4 Summary of Proposed Irrigation Development Plans

Type of Project	LVNCA			LVSCA			RVCA		
	Large Scale Irrigation Projects (nos)	Target Counties (nos)	Irrigation Area (ha)	Large Scale Irrigation Projects (nos)	Target Counties (nos)	Irrigation Area (ha)	Large Scale Irrigation Projects (nos)	Target Counties (nos)	Irrigation Area (ha)
Large Scale Irrigation	6		78,370	8		75,572	9		78,850
Small Scale Irrigation		11	47,122		12	22,501		14	9,271
Private Irrigation		11	43,421		12	15,133		14	4,045
Total	6	11	168,913	8	12	113,206	9	14	92,166

Type of Project	ACA			TCA			ENNCA		
	Large Scale Irrigation Projects (nos)	Target Counties (nos)	Irrigation Area (ha)	Large Scale Irrigation Projects (nos)	County (nos)	Irrigation Area (ha)	Large Scale Irrigation Projects (nos)	Target Counties (nos)	Irrigation Area (ha)
Large Scale Irrigation	4		37,280	4		135,961	3		26,202
Small Scale Irrigation		10	6,484		15	15,784		10	8,116
Private Irrigation		10	2,344		15	10,054		10	7,165
Total	4	10	46,108	4	15	161,799	3	10	41,483

Type of Project	Total			Existing Irrigation Area		
	Large Scale Irrigation Projects (nos)	Target Counties (nos)*	Irrigation Area (ha)	Large Scale Irrigation Projects (nos)	Relevant Counties (nos)	Irrigation Area (ha)
Large Scale Irrigation	34		432,235	9		14,137
Small Scale Irrigation		47	109,278		7	51,923
Private Irrigation		47	82,162		7	75,840
Total	34	47	623,675	9	7	141,900

Note: * One county belongs to plural catchment areas, but total number of counties in Kenya is 47.

Source: JICA Study Team

Table 10.1.5 Summary of Proposed Hydropower Development Plans

LVNCA						LVNCA						LVNCA					
No.	Name of Plan	Type of Plan	River	Installed Capacity	Purpose	No.	Name of Plan	Type of Plan	River	Installed Capacity	Purpose	No.	Name of Plan	Type of Plan	River	Installed Capacity	Purpose
1	Nzoia (34B) Multipurpose Dam Development Plan	M	Nzoia River	16 MW	Water Supply, Irrigation, Flood Control, Hydropower	1	Magwagwa Multipurpose Dam Development Plan	M	Sondu River	115 MW	Water Supply, Irrigation, Hydropower	1	Embobut Multipurpose Dam Development Plan	M	Turkwel River	45 MW	Water Supply, Irrigation, Hydropower
2	Nzoia (42A) Multipurpose Dam Development Plan	M	Nzoia River	25 MW	Flood Control, Hydropower							2	Arror Multipurpose Dam Development Plan	M	Arror River	80 MW	Water Supply, Irrigation, Hydropower
3	Nandi Forest Multipurpose Dam Development Plan	M	Yala River	50 MW	Water Supply, Irrigation, Hydropower							3	Kimwarer Multipurpose Dam Development Plan	M	Kerio River	20 MW	Water Supply, Irrigation, Hydropower
												4	Oletukat Multipurpose Dam Development Plan	M	Ewaso Ng'iro South River	36 MW	Water Supply, Hydropower
												5	Leshota Multipurpose Dam Development Plan	M	Ewaso Ng'iro South River	54 MW	Water Supply, Hydropower
												6	Oldorko Multipurpose Dam Development Plan	M	Ewaso Ng'iro South River	90 MW	Water Supply, Irrigation, Hydropower
			Sub-total	91 MW					Sub-total	115 MW					Sub-total	325 MW	

ACA						TCA						ENNCA					
No.	Name of Plan	Type of Plan	River	Installed Capacity	Purpose	No.	Name of Plan	Type of Plan	River	Installed Capacity	Purpose	No.	Name of Plan	Type of Plan	River	Installed Capacity	Purpose
11	Munyu Multipurpose Dam Development Plan	M	Athi River	40 MW	Irrigation, Hydropower	13	High Grand Falls Multipurpose Dam Development Plan	M, L	Tana River	Stage 1: 500 MW	Water Supply, Irrigation, Hydropower						
12	Thwake Multipurpose Dam Development Plan	M	Athi River	20 MW	Water Supply, Irrigation, Hydropower					Stage 2: +200 MW							
						14	Karura Hydropower Development Project	O	Tana River	90 MW	Hydropower						
			Sub-total	60 MW					Sub-total	790 MW							

Total	
No. of Plans	Total Installed Capacity
14 plans	1,381 MW

Note: Type of Plan

M: Hydropower Component of Multipurpose Dam Development L: Proposed Project in Least Cost Power Development Plan (LCPDP) O: Others (Proposed by Private Company etc.)

Source: JICA Study Team, based on information from MORDA, LBDA and KenGen.

Table 10.1.6 Summary of Proposed Water Resources Development Plans

Catchment Area	LVNCA			LVSCA			RVCA		
Facilities	Quantity	Total Volume/Yield	Remarks	Quantity	Total Volume/Yield	Remarks	Quantity	Total Volume/Yield	Remarks
Dam	7 nos	1,080 MCM		10 nos	1,000 MCM		10 nos	659 MCM	
Small Dam and Water Pan	3,620 nos	181 MCM		3,880 nos	194 MCM		3,640 nos	182 MCM	
Inter-basin Water Transfer	1 no	189 MCM/year	From Nandi Forest Dam to LVSCA	2 nos	123 MCM/year	From Itare & Londiani Dams to RVCA, and from Amala Dam to RVCA (From Nandi Forest Dam)	-	-	(From Itare, Londiani and Amala Dams)
Intra-basin Water Transfer	1 no	5 MCM/year	From Moiben Dam to Eldoret	-	-		-	-	
Borehole	560 nos	56 MCM/year		1,250 nos	125 MCM/year		160 nos	16 MCM/year	
Desalination	-	-		-	-		-	-	

Catchment Area	ACA			TCA			ENNCA		
Facilities	Quantity	Total Volume/Yield	Remarks	Quantity	Total Volume/Yield	Remarks	Quantity	Total Volume/Yield	Remarks
Dam	16 nos	1,689 MCM		11 nos	5,729 MCM		5 nos	522 MCM	
Small Dam and Water Pan	1,880 nos	94 MCM		3,020 nos	151 MCM		1,820 nos	91 MCM	
Inter-basin Water Transfer	-	-	(From TCA)	1 no	168 MCM/year	From TCA to Nairobi	-	-	
Intra-basin Water Transfer	2 nos	68 MCM/year	From Mzima Springs & Athi River	3 nos	94 MCM/year	From Masinga Dam to Kitui, from Kiambere Dam to Mwingi, and from High Grand Falls Dam to Lamu	-	-	
Borehole	350 nos	35 MCM		1,440 nos	144 MCM/year		1,560 nos	156 MCM/year	
Desalination	1 no	93 MCM/year	Mombasa	-	-		-	-	

Total			Existing Facilities		
Facilities	Quantity	Total Volume/Yield	Facilities	Quantity	Total Volume/Yield
Dam	59 nos	10,679 MCM	Dam	26 nos	3,906 MCM
Small Dam and Water Pan	17,860 nos	893 MCM	Small Dam and Water Pan	4,037 nos	74 MCM
Inter-basin Water Transfer	4 nos	480 MCM/year	Inter-basin Water Transfer	5 nos	185 MCM/year
Intra-basin Water Transfer	6 nos	167 MCM/year	Intra-basin Water Transfer	10 nos	74 MCM/year
Borehole	5,320 nos	532 MCM/year	Borehole	13,758 nos	525 MCM/year
Desalination	1 no	93 MCM/year	Desalination	-	-

Source: JICA Study Team

Table 10.1.7 Summary of Proposed Water Resources Management Plans

Catchment Area	LVNCA	LVSCA	RVCA
1) Monitoring Networks - Surface Water Monitoring - Rainfall Monitoring Stations - Groundwater Monitoring Stations - Reference Point	 24 locations 42 locations 19 locations 2 locations	 23 locations 50 locations 19 locations 5 locations	 23 locations 47 locations 10 locations 4 locations
2) Evaluation of Water Resources	a) Formulation of water resources evaluation team in LVN Regional office b) Enhance evaluation of water quality in water quality test laboratory in Kakamega.	a) Formulation of water resources evaluation team in LVS Regional office b) Enhance evaluation of water quality in water quality test laboratory in Kisumu.	a) Formulation of water resources evaluation team in RV Regional office b) Establishment of additional water quality test laboratories in Lodwar and Kapenguria for timely analysis of water quality c) Enhance evaluation of water quality in water quality test laboratories in Nakuru, Lodwar and Kapenguria.
3) Improvement of Water Permit Issuance and Control	a) Maintenance of the latest version of issued permits b) Revision of standards such as water allocation guidelines based on future demand and water resources c) Increase of water right officers from the current five to seven.	a) Maintenance of the latest version of issued permits b) Revision of standards such as water allocation guidelines based on future demand and water resources c) Increase of water right officers from the current four to seven.	a) Maintenance of the latest version of issued permits b) Revision of standards such as water allocation guidelines based on future demand and water resources c) Increase of water right officers from the current six to 15.
4) Watershed Conservation (Forestation, Small Water Sources Conservation and Soil Erosion Control)	a) Forestation of 234,000 ha to achieve Kenya Vision 2030 target forest recovery of 10%. b) Soil Erosion Control	a) Forestation of 412,000 ha to achieve Kenya Vision 2030 target forest recovery of 10%. b) Small Water Sources Conservation c) Soil Erosion Control	a) Forestation of 1,006,000 ha to achieve Kenya Vision 2030 target forest recovery of 10%. b) Soil Erosion Control
Catchment Area	ACA	TCA	ENNCA
1) Monitoring Networks - Surface Water Monitoring - Rainfall Monitoring Stations - Groundwater Monitoring Stations - Reference Point	 26 locations 38 locations 24 locations 2 locations	 26 locations 47 locations 18 locations 3 locations	 13 locations 34 locations 5 locations 1 locations
2) Evaluation of Water Resources	a) Formulation of water resources evaluation team in Athi Regional office b) Establishment of additional water quality test laboratory in Mombasa for timely analysis of water quality c) Enhance evaluation of water quality in water quality test laboratories in Machakos and Mombasa.	a) Formulation of water resources evaluation team in Tana Regional office b) Establishment of additional water quality test laboratory in Garissa for timely analysis of water quality c) Enhance evaluation of water quality in water quality test laboratories in Embu and Garissa.	a) Formulation of water resources evaluation team in ENN Regional office b) Establishment of additional water quality test laboratories in Marsabit and Wajir for timely analysis of water quality c) Enhance evaluation of water quality in water quality test laboratories in Nyeri, Marsabit and Wajir.
3) Improvement of Water Permit Issuance and Control	a) Maintenance of the latest version of issued permits b) Revision of standards such as water allocation guidelines based on future demand and water resources c) Increase of water right officers from the current six to 16.	a) Maintenance of the latest version of issued permits b) Revision of standards such as water allocation guidelines based on future demand and water resources c) Increase of water right officers from the current seven to 15.	a) Maintenance of the latest version of issued permits b) Revision of standards such as water allocation guidelines based on future demand and water resources c) Increase of water right officers from the current eight to 12.
4) Watershed Conservation (Forestation, Small Water Sources Conservation and Soil Erosion Control)	a) Forestation of 868,000 ha to achieve Kenya Vision 2030 target forest recovery of 10%. b) Small Water Sources Conservation	a) Forestation of 1,366,000 ha to achieve Kenya Vision 2030 target forest recovery of 10%. b) Soil Erosion Control	a) Forestation of 592,000 ha to achieve Kenya Vision 2030 target forest recovery of 10%. b) Small Water Sources Conservation c) Soil Erosion Control

Catchment Area	Total
1) Monitoring Networks - Surface Water Monitoring - Rainfall Monitoring Stations - Groundwater Monitoring Stations - Reference Point	 135 locations 258 locations 95 locations 17 locations
2) Evaluation of Water Resources	a) Formulation of water resources evaluation team in each regional offices of WRMA. b) Establishment of additional six water quality test laboratories in total in RVCA, ACA, TCA and ENNCA.
3) Improvement of Water Permit Issuance and Control	a) Maintenance of the latest version of issued permits b) Revision of standards such as water allocation guidelines based on future demand and water resources c) Increase of water right officers from the current 36 to 72.
4) Watershed Conservation (Forestation and Soil Erosion Control)	a) Forestation of 4,478,000 ha to achieve Kenya Vision 2030 target forest recovery of 10%. b) Small Water Sources Conservation c) Soil Erosion Control

Source: JICA Study Team

Table 10.1.8 Summary of Proposed Flood and Drought Disaster Management Plans

Catchment Area	LVNCA	LVSCA	RVCA
Flood Management Plan	a) Nzoia R. Basin: Flood control by dams, dikes and river improvement b) Nzoia R. Basin: Operation of early flood forecasting and warning system c) Nzoia and Yala R. Basins: Preparation of flood fighting plans for dikes	a) Kano Plain: Flood control by dams, dikes and river improvement b) Kano Plain: Establishment of early flood forecasting and warning system c) Nyando R.: Preparation of flood fighting plan for dikes d) Mouth areas of Sondu and Kuja Rivers: Community-based disaster management e) Kisumu City: Provision of urban drainage measures	a) Narok: Flood control by river improvement and dam, and preparation of flood hazard map and evacuation plan b) Mogotio: Flood control by river improvement and preparation of hazard map c) Narok: Provision of urban drainage measures d) Nakuru: Provision of urban drainage measures
	Target Area *: 1. Yala Swamp (a/b/c)	Target Area *: 2. Kano Plain (a/b/c), 3. Sondu Rivermouth (d), 4. Kuja Rivermouth (d), 5. Kisumu (e)	Target Area *: 8. Nakuru (d), 9. Narok (a/c), 10. Mogotio (b)
Drought Management Plan	a) Monitoring reference water levels which correspond to reserve or normal discharge (as a part of WRM plan) b) Establishment of 2 Basin Drought Conciliation Councils c) Early Drought Forecasting based on long-term rainfall prediction d) Water Use Restriction Rule for Reservoirs (Existing 5 dams and proposed 7 dams)	a) Monitoring reference water levels which correspond to reserve or normal discharge (as a part of WRM plan) b) Establishment of 5 Basin Drought Conciliation Councils c) Early Drought Forecasting based on long-term rainfall prediction d) Water Use Restriction Rule for Reservoirs (Existing 2 dams and proposed 10 dams)	a) Monitoring reference water levels which correspond to reserve or normal discharge (as a part of WRM plan) b) Establishment of 7 Basin Drought Conciliation Councils c) Early Drought Forecasting based on long-term rainfall prediction d) Water Use Restriction Rule for Reservoirs (Existing 5 dams and proposed 10 dams)
Catchment Area	ACA	TCA	ENNCA
Flood Management Plan	a) Kilifi (Downmost Athi): Community-based disaster management b) Taveta (Lumi Rivermouth): Community-based disaster management c) Kwale (Vanga): Flood control by river training and preparation of hazard map d) Nairobi: Provision of urban drainage measures e) Mombasa: Provision of urban drainage measures	a) Garissa: Flood control by river structure and dam, and preparation of flood hazard map and evacuation plan b) Lower Tana: Community-based disaster management c) Kiambere Dam: Improvement of discharge warning system	a) Mandera: Flood control by river structures, and preparation of flood hazard map and evacuation plan b) Isiolo: Flood control by river structures and preparation of flood hazard map c) Isiolo: Provision of urban drainage measures
	Target Area *: 11. Downmost Athi (a), 12. Lumi Rivermouth (b), 13. Nairobi City (d), 14. Kwale (c), 15. Mombasa (e)	Target Area *: 16. Lower Tana (a/b/c), 17. Ijara (a/b/c)	Target Area *: 20. Mandera (a), 21. Isiolo (b/c)
Drought Management Plan	a) Monitoring reference water levels which correspond to reserve or normal discharge (as a part of WRM plan) b) Establishment of 6 Basin Drought Conciliation Councils c) Early Drought Forecasting based on long-term rainfall prediction d) Water Use Restriction Rule for Reservoirs (Existing 8 dams and proposed 16 dams)	a) Monitoring reference water levels which correspond to reserve or normal discharge (as a part of WRM plan) b) Establishment of 1 Basin Drought Conciliation Council c) Early Drought Forecasting based on long-term rainfall prediction d) Water Use Restriction Rule for Reservoirs (Existing 8 dams and proposed 11 dams)	a) Monitoring reference water levels which correspond to reserve or normal discharge (as a part of WRM plan) b) Establishment of 1 Basin Drought Conciliation Council c) Early Drought Forecasting based on long-term rainfall prediction d) Water Use Restriction Rule for Reservoirs (Existing 1 dam and proposed 5 dams)

Plan	Total
Flood Management Plan	17 areas
Drought Management Plan	d) Water Use Restriction Rule for Reservoirs (Existing 29 dams and proposed 59 dams)

Note: * The underlined numbers that are provided to each target area name correspond to the table "Proposed Areas Subject to Flood Disaster Management Plan" shown in Section 6.9 (2) e).

Source: JICA Study Team

Table 10.1.9 Summary of Proposed Environmental Management Plans (1/2)

Catch-ment Area	Target	Proposed Setting Point			Reserve[*1] (m^3/s)	Monitoring Point of WRM [*2]
LVNCA	Nzoia River	Environmental flow rate	1	Lower reaches of the Nzoia River : LVN-F1	34.1	1EE01
			2	Reference point (Webuye Town) : LVN-F2	15.9	1DA02
			3	Moi's Bridge Town : LVN-F3	2.5	1BB01
		Environmental monitoring	4	Lower reaches of the Nzoia River : LVN-M1	34.1	1EE01
			5	Reference point (Webuye Town) : LVN-M2	15.9	1DA02
	Yala River	Environmental flow rate	1	Reference point (Yala Town) : LVN-F4	6.7	1FG01
			2	Downstream of Nandi Forest Dam: LVN-F5	5.1	1FE02
		Environmental monitoring	3	Yala Swamp : LVN-M3	-	1FG03
	Lake Victoria	Environmental monitoring	1	Near river mouth of the Nzoia River : LVN-M4	-	-
			2	Near river mouth of the Yala River : LVN-M5	-	-
LVSCA	Nyando River	Environmental flow rate	1	Reference point (Ahero Town) : LVS-F1	1.7	1GD03
			2	Near Muhoroni Town : LVS-F2	1.9	1GD07
		Environmental monitoring	3	Reference point (Ahero Town): LVS-M1	1.7	1GD03
			4	Near Muhoroni Town : LVS-M2	1.9	1GD07
	Sondu River	Environmental flow rate	1	Reference point (Upstream of the Sondu Dam) : LVS-F3	10.5	1JG05
			2	Confluence point with the Itare River : LVS-F4	3.7	1JF08
		Environmental monitoring	3	Reference point (Upstream of the Sondu Dam) : LVS-M3	10.5	1JG05
			4	Confluence point with the Itare River : LVS-M4	3.7	1JF08
	Gucha - Migori River	Environmental flow rate	1	Confluence point of both rivers : LVS-F5	2.4	1KB05
			2	Reference point (Gucha River) : LVS-F6	0.4	1KB03
			3	Reference point (Migori River) : LVS-F7	1.5	1KC03
		Environmental monitoring	4	Confluence point of both rivers : LVS-M5	2.4	1KB05
			5	Reference point (Gucha River) : LVS-M6	0.4	1KB03
			6	Reference point (Migori River) : LVS-M7	1.5	1KC03
	Mara River	Environmental flow rate	1	Reference point (Upstream of the Masai-Mara National Park) : LVS-F8	4.3	1LA04
		Environmental monitoring	1	Reference point (Upstream of the Masai-Mara National Park) : LVS-M8	4.3	1LA04
	Lake Victoria	Environmental monitoring	1	Near river mouth of the Nyando River : LVS-M9	-	-
			2	Near river mouth of the Sondu River : LVS-M10	-	-
			3	Near river mouth of the Gucha River : LVS-M11	-	-
	Kisumu City and Homa Bay Town	Environmental monitoring	1	Kisumu City (Main discharge point: Lower reaches of the Kibos River): LVS-M12	-	-
			2	Homa Bay Town (Major discharge point) : LVS-M13	-	-
RVCA	Turkwel River	Environmental flow rate	1	Reference point (Lodwar Town) : RV-F1	0.0	2B21
			2	Confluence point with the Suam River (Downstream of the Turkwel Dam) : RV-F2	0.0	-
		Environmental monitoring	3	Reference point (Lodwar Town) : RV-M1	0.0	2B21
			4	Confluence point with the Suam River (Downstream of the Turkwel Dam) : RV-M2	0.0	-
	Kerio River	Environmental flow rate	1	Reference point (Downstream of confluence with the Arror River) : RV-F3	0.0	2C16
		Environmental monitoring	2	Downstream of the South Turkana National Reserve : RV-M3	-	-
			3	Reference point (Downstream of confluence with the Arror River) : RV-M4	0.0	2C16
	Ewaso Ng'iro South River	Environmental flow rate	1	Reference point (Narok Town) : RV-F4	0.0	2K06
		Environmental monitoring	2	Lower reaches of the Ewaso Ng'iro South River: RV-M5	0.0	2K04
	Lake Turkana	Environmental flow rate	1	Representative point : RV-F5	-	2B13
		Environmental monitoring	2	Representative point : RV-M6	-	2B13
	Lake Baringo	Environmental flow rate	1	Representative point : RV-F6	-	2EH1
		Environmental monitoring	2	Representative point : RV-M7	-	2EH1
	Lake Bogoria	Environmental flow rate	1	Representative point : RV-F7	-	2EB10
		Environmental monitoring	2	Representative point : RV-M8	-	2EB10
	Lake Nakuru	Environmental flow rate	1	Representative point : RV-F8	-	2FC04
		Environmental monitoring	2	Representative point : RV-M9	-	2FC04
	Lake Elementaita	Environmental flow rate	1	Representative point : RV-F9	-	2FA08
		Environmental monitoring	2	Representative point : RV-M10	-	2FA08

Table 10.1.9 Summary of Proposed Environmental Management Plans (2/2)

Catch-ment Area	Target	Proposed Setting Point			Reserve*1 (m^3/s)	Monitoring Point of WRM *2
RVCA (Contd.)	Lake Naivasha	Environmental flow rate	1	Representative point : RV-F10	-	2GD06
		Environmental monitoring	2	Representative point : RV-M11	-	2GD06
	Lake Magadi	Environmental flow rate	1	Representative point : RV-F11	-	New
		Environmental monitoring	2	Representative point : RV-M12	-	New
	Nakuru and Naivasha towns	Environmental monitoring	1	Nakuru Town (Main discharge channel) : RV-M13	-	-
			2	Naivasha Town (Main discharge channel) : RV-M14	-	-
ACA	Athi River	Environmental flow rate	1	Reference point (Confluence point with the Tsavo River) : ACA-F1	8.9	3HA12
			2	Upstream of Tsavo national parks : ACA-F2	9.8	3F09
			3	Reference point (Kangundo Town) : ACA-F3	8.6	3DB01
		Environmental monitoring	4	Reference point (Confluence point with the Tsavo River) : ACA-M1	8.9	3HA12
			5	Upstream of Tsavo national parks : ACA-M2	9.8	3F09
			6	Reference point (Kangundo Town) : ACA-M3	8.6	3DB01
	Lumi River	Environmental flow rate	1	Reference point : ACA-F4	0.0	3J15
		Environmental monitoring	2	Reference point : ACA-M4	0.0	3J15
	Nairobi River	Environmental monitoring	1	Downstream of Nairobi City : ACA-M5	1.1	3BA29
	Lake Chala	Environmental flow rate	1	Representative point : ACA-F5	-	3J12
		Environmental monitoring	2	Representative point : ACA-M6	-	3J12
	Lake Jipe	Environmental flow rate	1	Representative point : ACA-F6	-	3J02
		Environmental monitoring	2	Representative point : ACA-M7	-	3J02
	Lake Amboseli	Environmental monitoring	1	Representative point : ACA-M8	-	-
	Nairobi and Mombasa cities	Environmental monitoring	1	Nairobi City (Main discharge point): ACA-M9	-	-
			2	Mombasa City (Main discharge point) : ACA-M10	-	-
TCA	Tana River	Environmental flow rate	1	Reference point (Downstream of Garissa Town) : TCA-F1	53.5	4G01
			2	Upper reaches of the Meru National Park : TCA-F2	52.1	4F13
			3	Reference point(Upstream of Masinga Dam) : TCA-F3	1.5	4BE01
		Environmental monitoring	4	Tana Delta : TCA-M1	42.7	4G02
			5	Upstream of the Tana River Primate National Reserve : TCA-M2	-	-
			6	Reference point (Downstream of Garissa Town) : TCA-M3	53.5	4G01
			7	Upstream of the Meru National Park : TCA-M4	52.1	4F13
			8	Reference point (Upstream of Masinga Dam) : TCA-M5	1.5	4BE01
	Chania River	Environmental flow rate	1	Reference point (Downstream of Thika Town) : TCA-F4	8.5	4CC03
		Environmental monitoring	2	Reference point (Downstream of Thika Town): TCA-M6	8.5	4CC03
ENNCA	Ewaso Ng'iro North River	Environmental flow rate	1	Reference point (Archers' Post Town) : ENN-F1	0.0	5ED01
			2	Downstream of confluence point with the Ewaso Narok River: ENN-F2	1.3	5DC02
		Environmental monitoring	3	Reference point (Archers' Post Town) : ENN-M1	0.0	5ED01
			4	Downstream of confluence point with the Ewaso Narok River: ENN-M2	1.3	5DC02
Total		Environmental flow rate	36 points		-	
		Environmental monitoring	50 points		-	

Note: *1 Reserve includes the water for ecological needs and basic human needs as mentioned in WRMA Guidelines for Water Allocation.

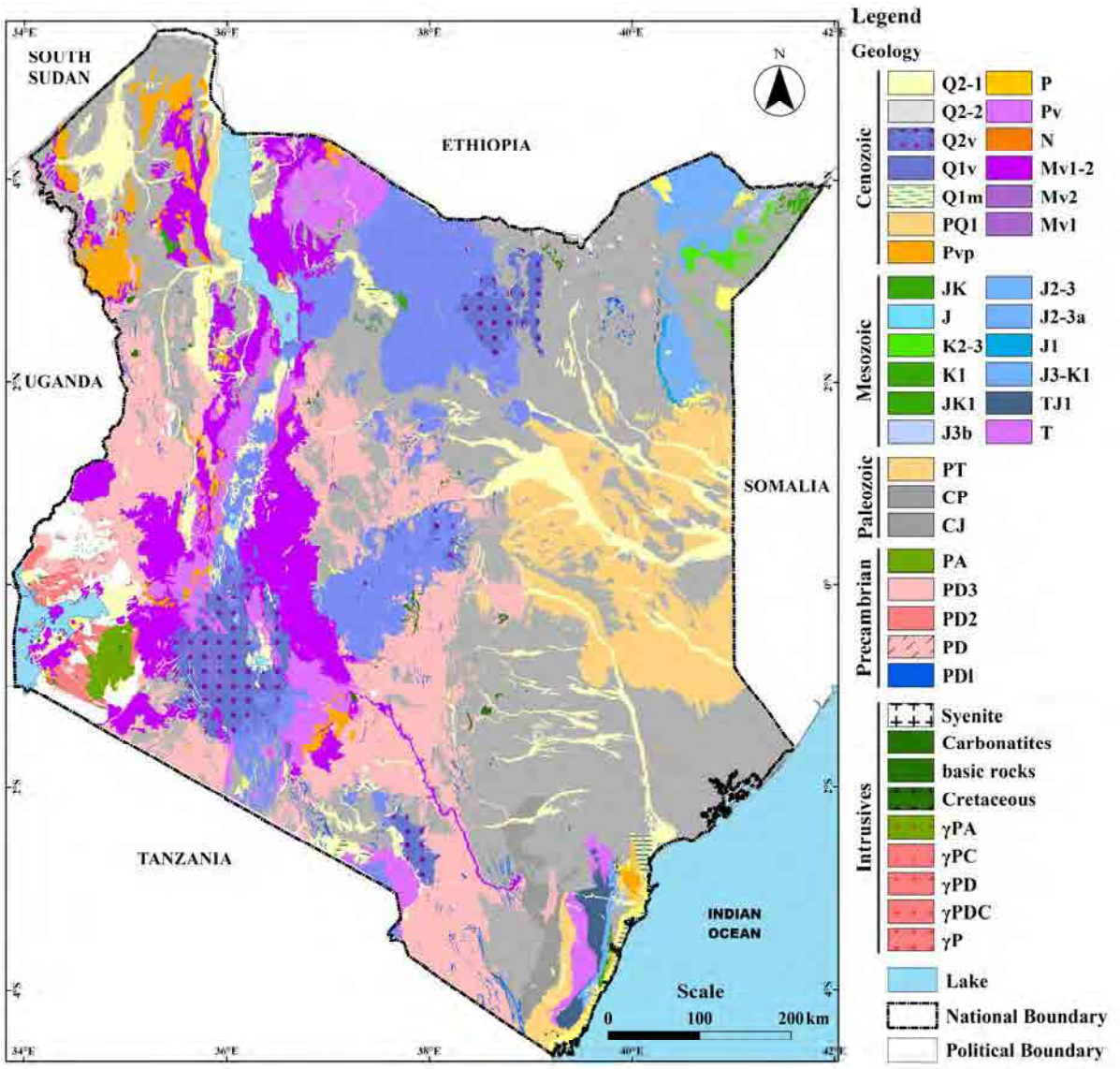
*2 WRM = Water Resource Management

Source: JICA Study Team referring to existing water resources monitoring points.

Figures

Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 1.3.1 Catchment Areas of WRMA**
JAPAN INTERNATIONAL COOPERATION AGENCY	

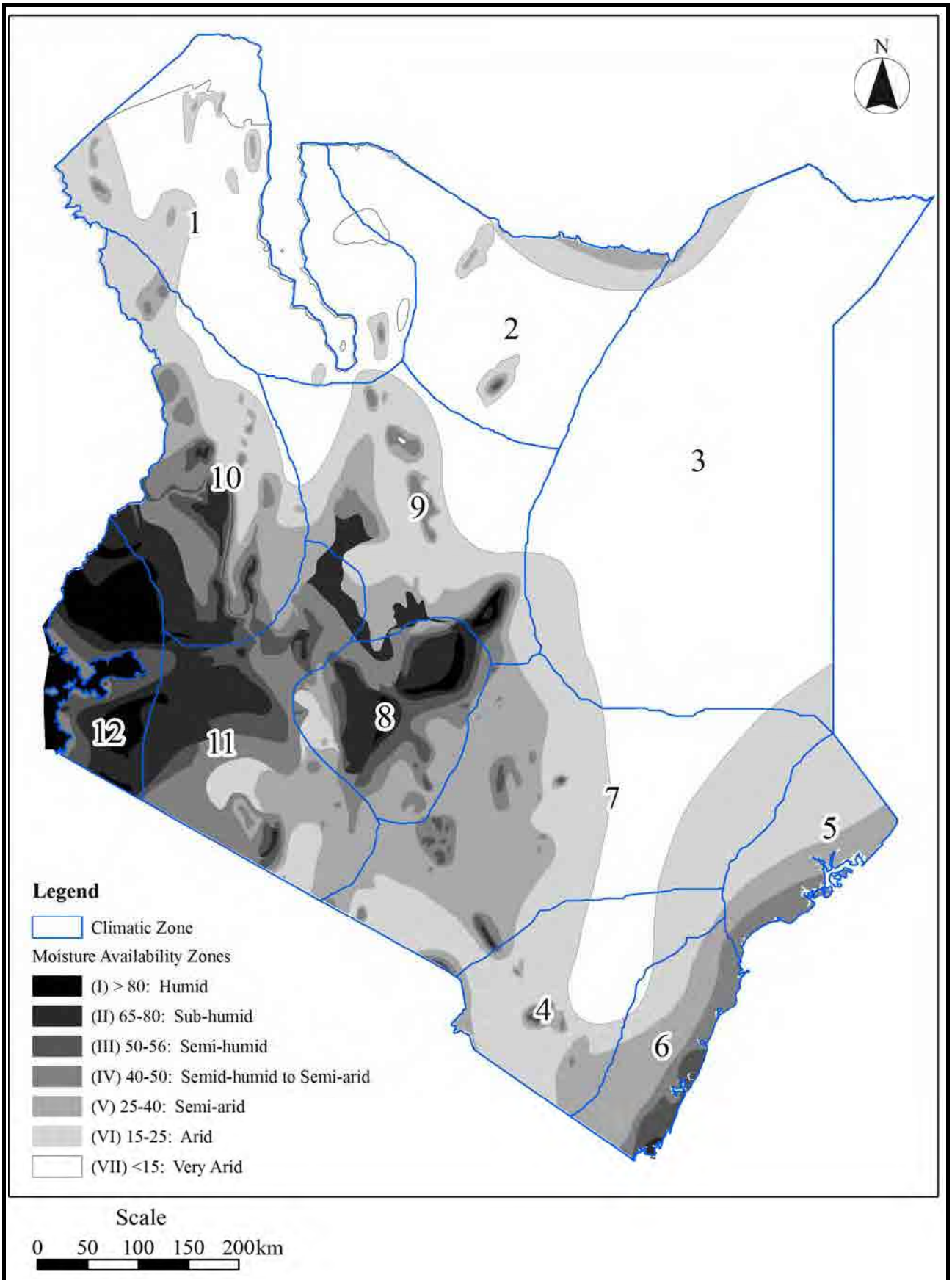


Period	Geology	Description
Cenozoic	Q_{2-1}	Holocene. Alluvium
	Q_{2-2}	Holocene. Colluvial deposits, pebble sheets and red soils
	Q_{2v}	Holocene. Basalt flows, pyroclastics, volcanic soils
	Q_{1v}	Pleistocene. Trachytes, basalts and pyroclastics
	Q_{1m}	Pleistocene. Sands, marine deposits
	PQ_1	Plio-Pleistocene. Sediments of Turkana area
	Pvp	Pliocene. Trachytes, phonolites, basalts, rhyorites
	P	Pliocene. Sandstones, sands
	Pv	Pliocene. Trachyte, phonolite, basalts
	N	Neogene. Undifferentiated sediments, interbedded in volcanic, sands, shales, tuffs
	M_{v1}, M_{v2}	Miocene Phonolites, trachytes and olivine basalts
Mesozoic	JK	Jurassic-Cretaceous. Turkana Grits
	J	Jurassic. Condensate undifferentiated sequence of sandstones, limestones
	K_{2-1}	Cenomanian to Maastrichtian. Marehan series. Sandstones, shales with marine limestones
	K_1	Neocomian. Shales and limestone
	JK_1	Tithonian to Neocomian. Mandera Series. Dolomites, shales, sandstones
	J_{3b}	Kimmeridgian-Tithonian. Dense limestone with an intermediate shale member
	J_{2-3}	Bajocian-Upper Jurassic. Posidona shales and Kambe oolitic limestone

Period	Geology	Description
Mesozoic	J_{2-3a}	Bajocian to Oxfordian. Mainly limestones oolitic or not with shale sans sandstones
	J_1	Toarcian. Didimtu. Non oolitic limestone
	TJ_1	Upper Triassic-Lower Lias. Coarse grained sandstones
	T	Triassic. Mariakani. Sandstones, shales
Paleozoic	PT	Permian-Lower Triassic. Maji-ya-Chumvi. Shales, siltstones
	CP	Upper Carboniferous-Lower Permian. Taru Grits. Tillites, grits, shales
	CJ	Duruma Series of undifferentiated Karoo
Precambrian	PA	Precambrian A. Bukoban. Quartzites and volcanics
	PD_3	Precambrian D_3. Kavirondian, Embu. Grits and mudstones
	PD_2	Precambrian D_2. Nyanzian. Rhyolites, andesites, basalts and greywackes
	PD	Precambrian D. Mozambique belt. Quartzites, micaschists, biotite and hornblende gneiss, granitoid gneiss, amphilibolites, migmatites, syntetonic granites
	PD_1	Crystalline limestones, intercalations in PD
Intrusive	γPA	Precambrian A
	γPC	Precambrian C
	γPD	Precambrian D
	γPDC	Precambrian DC
	γP	Undifferentiated Precambrian

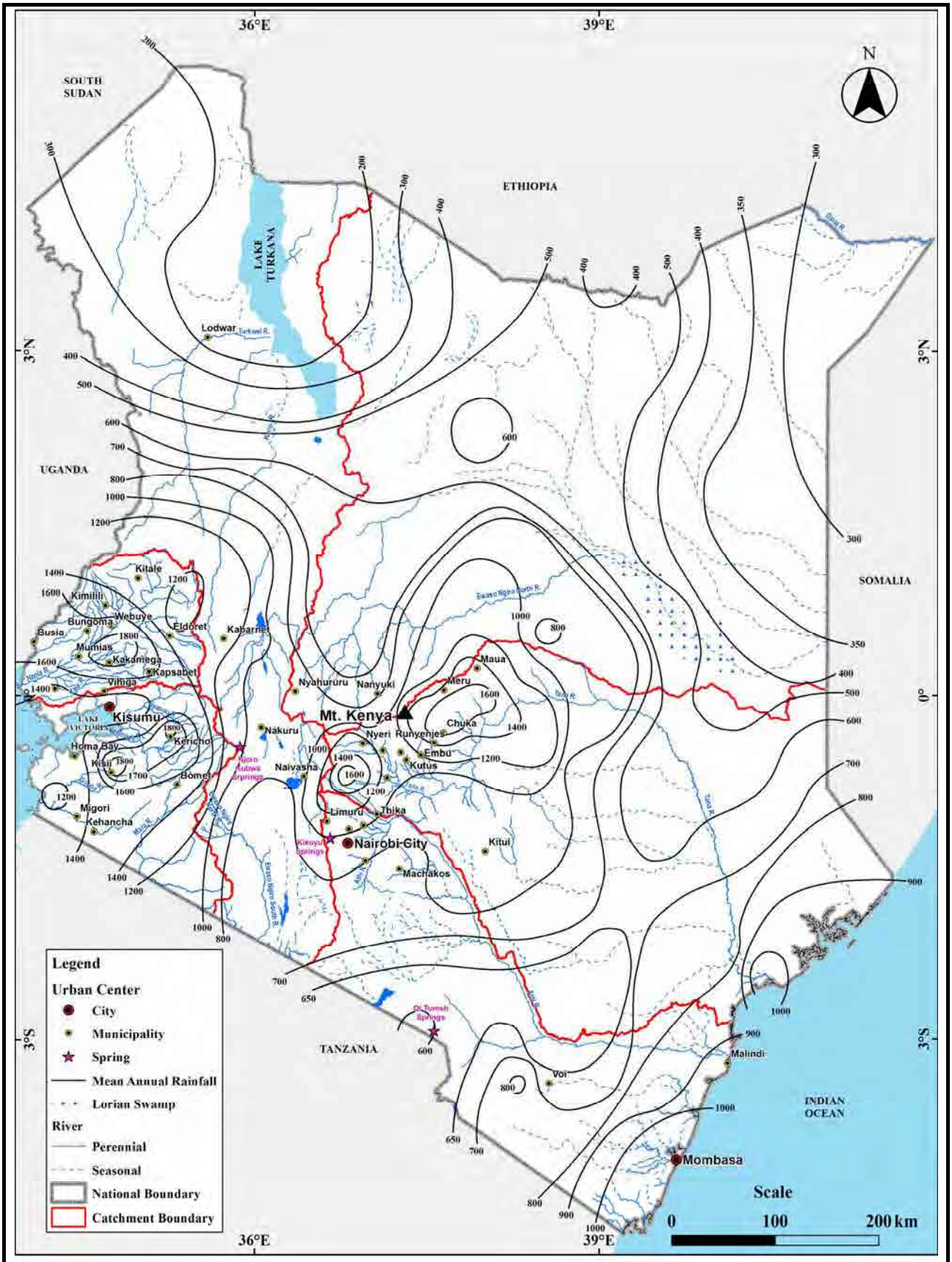
Source: Ministry of Energy and Regional Development

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 2.2.1 Geological Map of Kenya**
JAPAN INTERNATIONAL COOPERATION AGENCY	



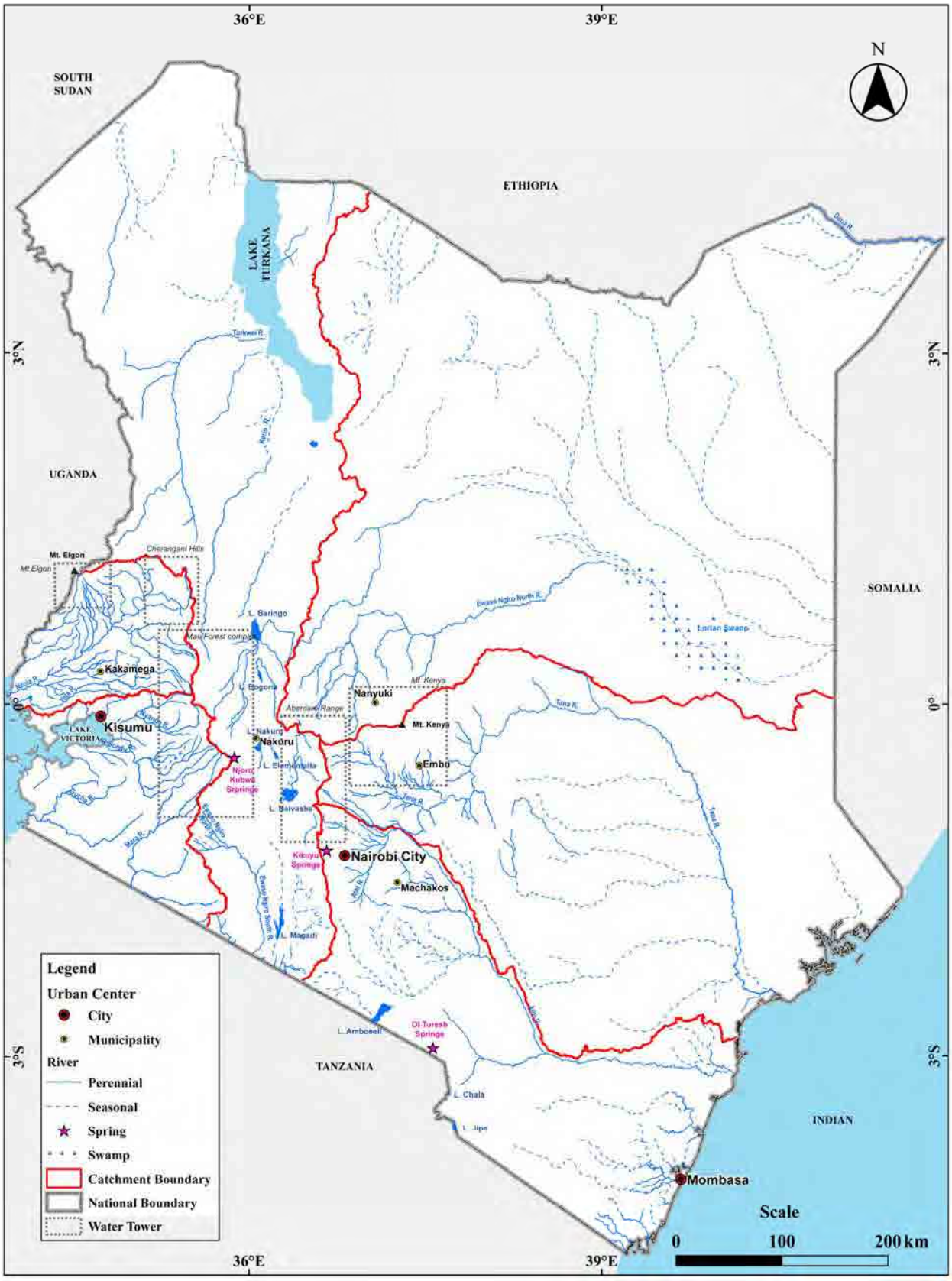
Source: UNEP/GRID database derived from the Exploratory Soil Survey Report number E1, Kenya Soil survey, Nairobi 1982

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 2.3.1 Climatic Zones**
JAPAN INTERNATIONAL COOPERATION AGENCY	



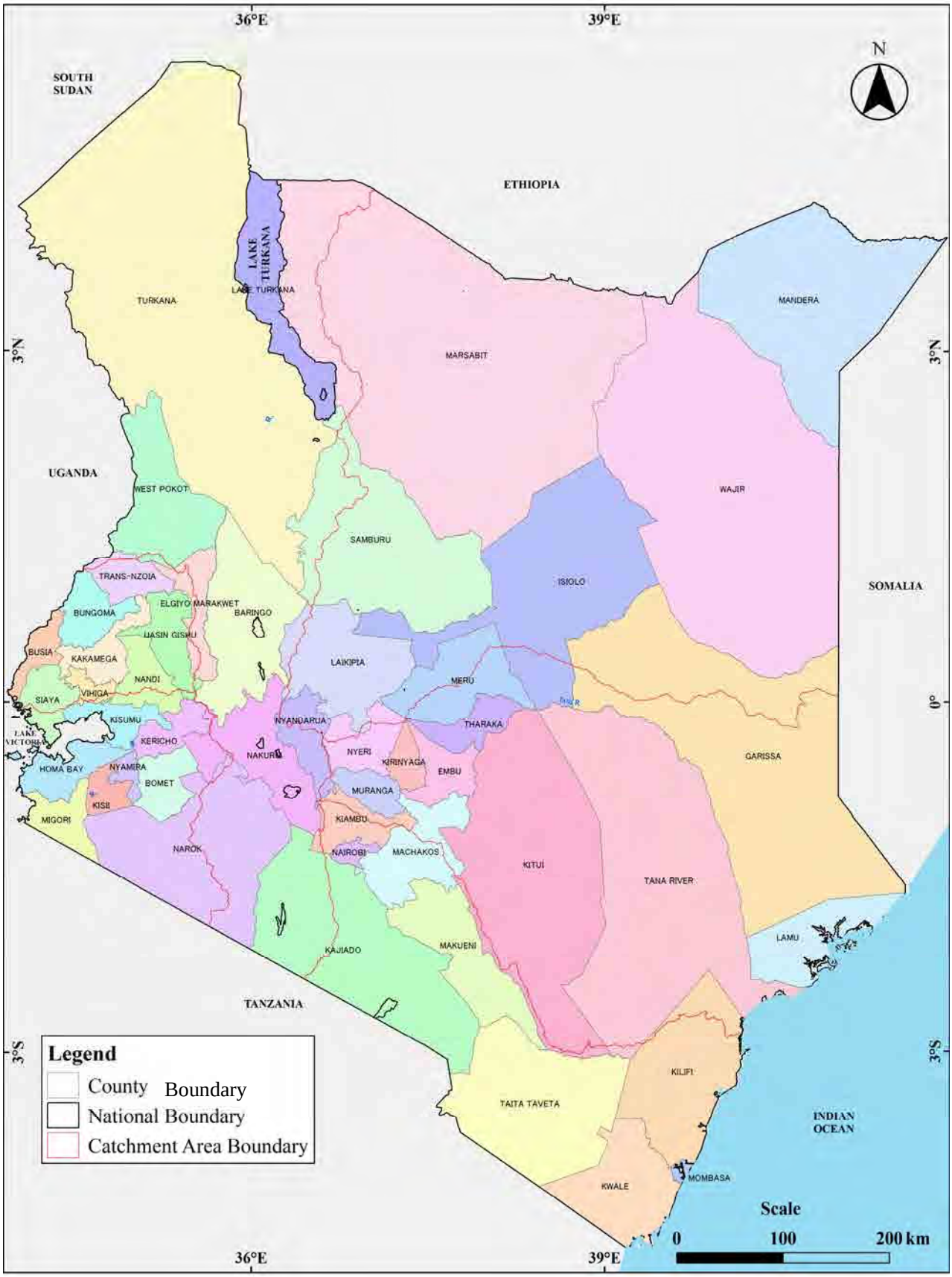
Source: JICA Study Team based on data from WRMA

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 2.3.2 Isohyetal Map of Mean Annual Rainfall for 1981 to 2010**
JAPAN INTERNATIONAL COOPERATION AGENCY	



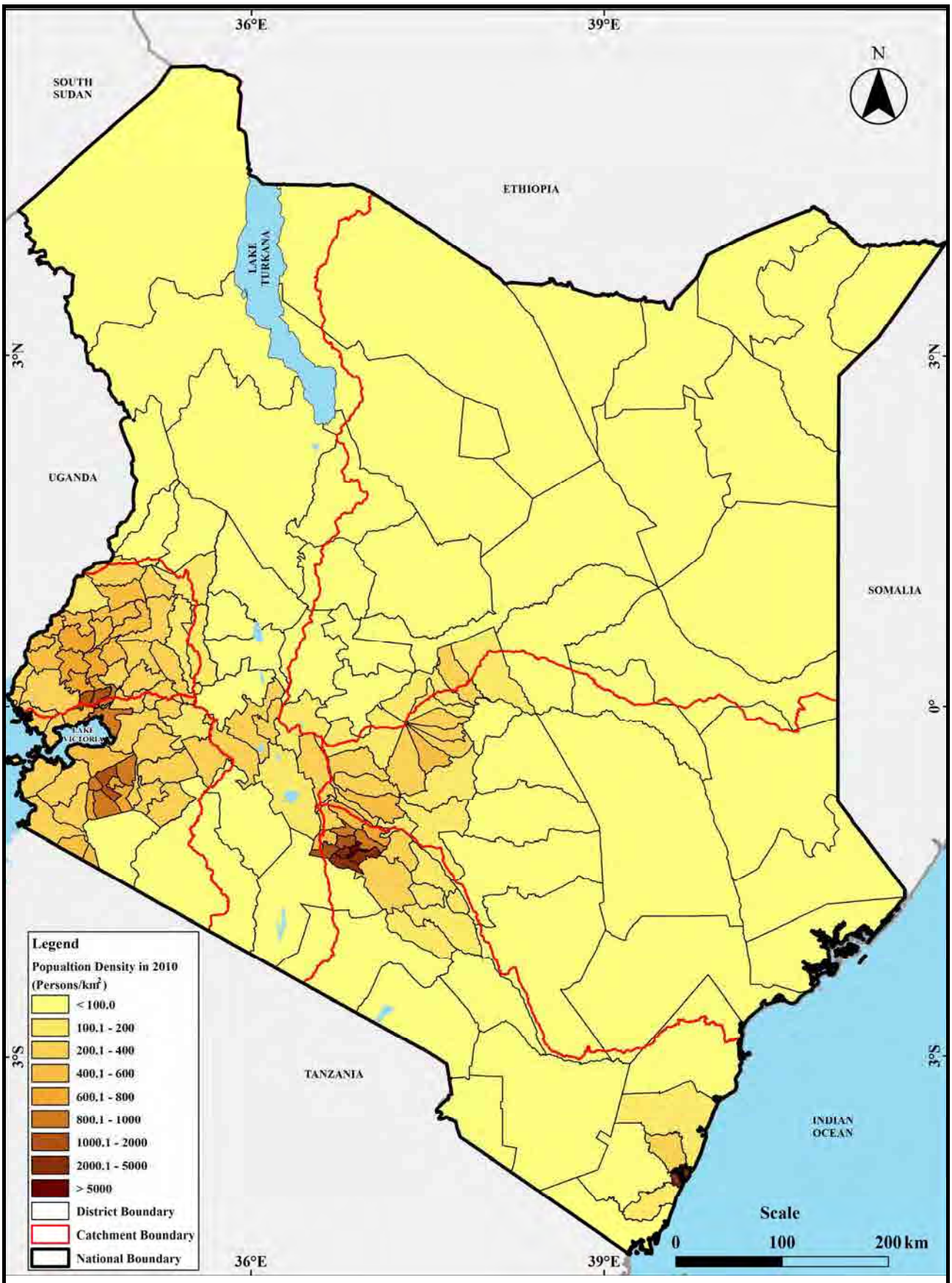
Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 2.4.1 Major Rivers, Lakes and Springs in Kenya**
JAPAN INTERNATIONAL COOPERATION AGENCY	



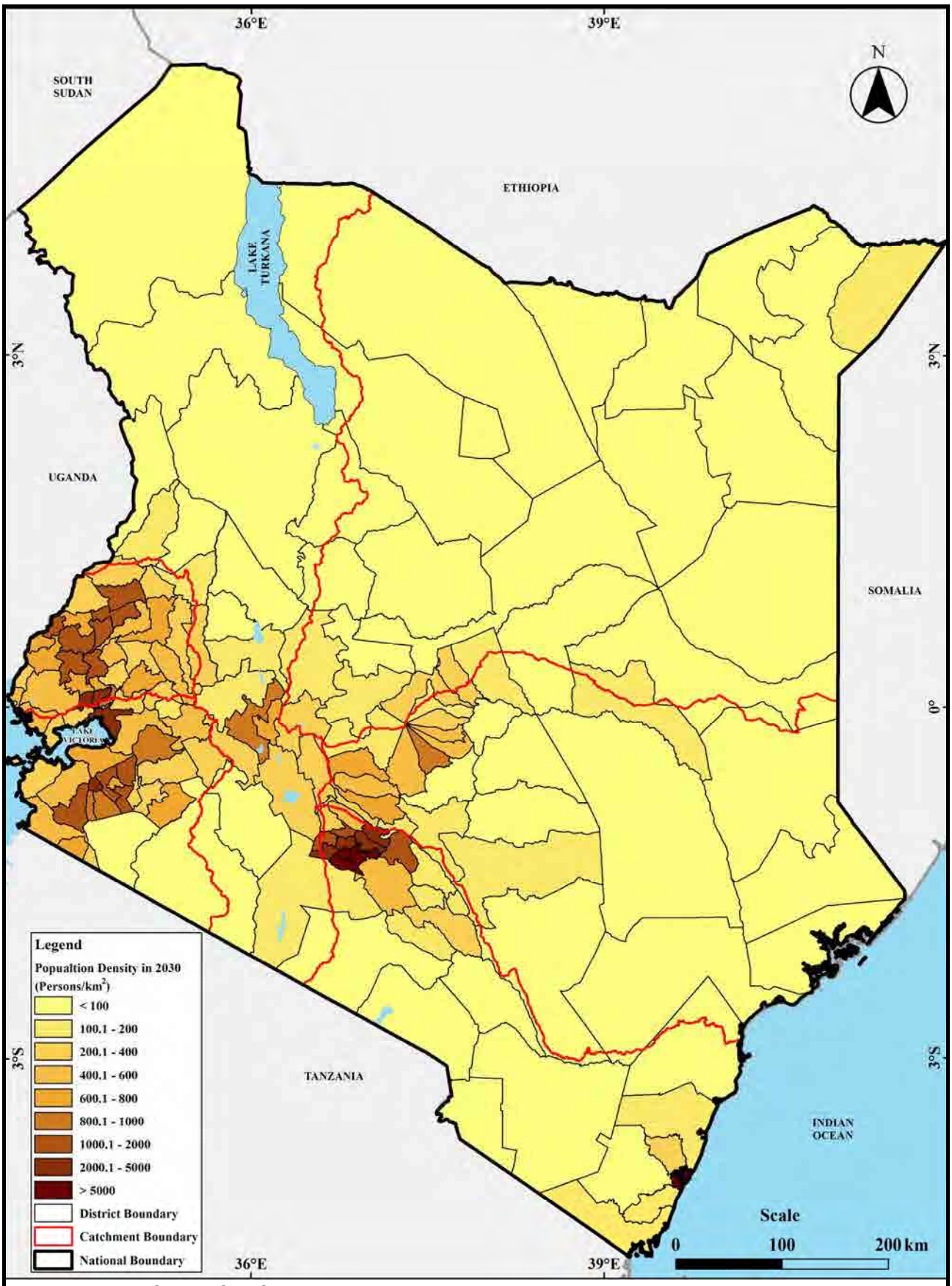
Source: JICA Study Team based on GIS data from Kenya National Bureau of Statistics

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 3.1.1 County and Catchment Area Boundaries**
JAPAN INTERNATIONAL COOPERATION AGENCY	



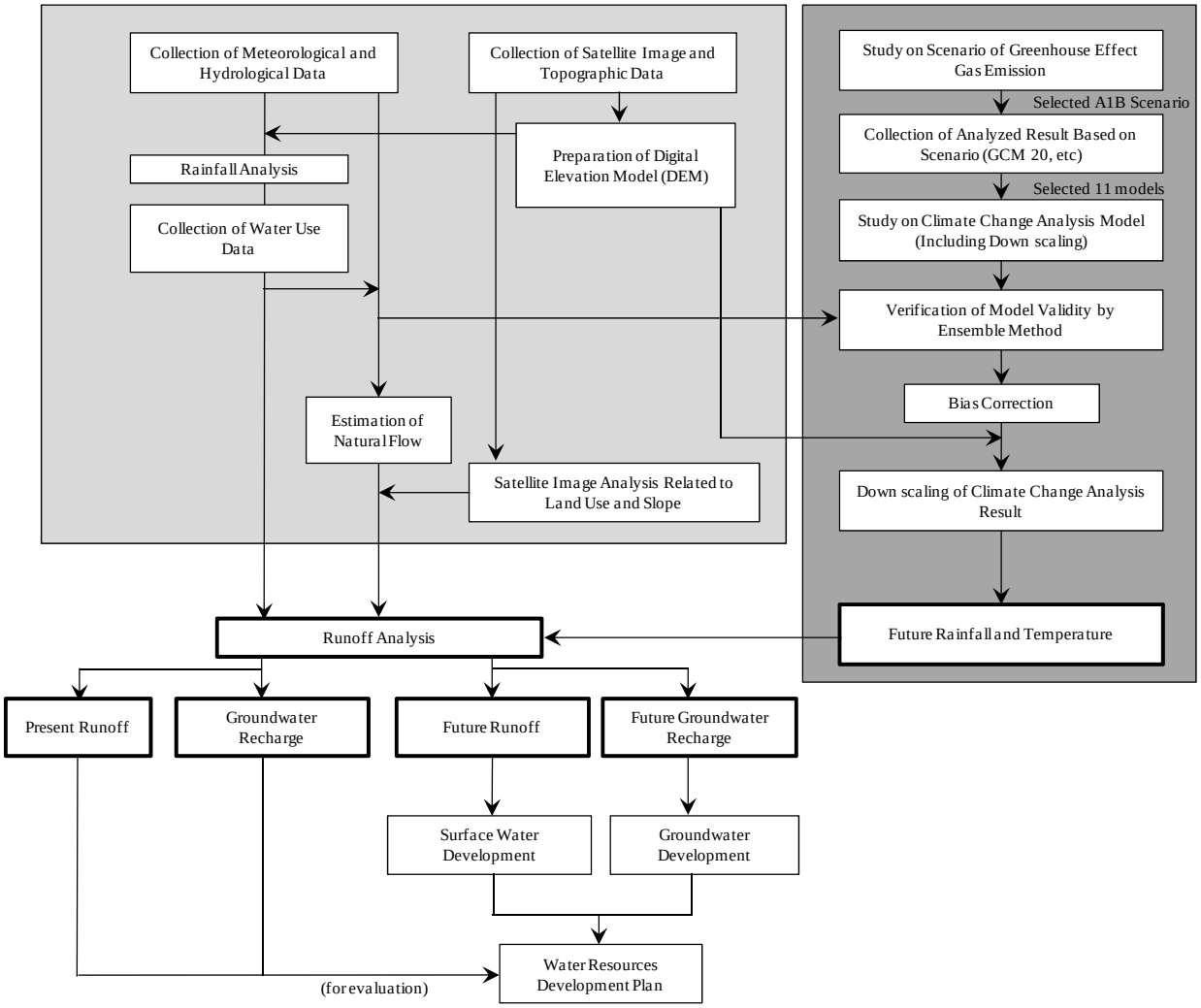
Source: JICA Study Team based on Statistical Abstract 2011

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 3.2.1 Population Density in 2010**
JAPAN INTERNATIONAL COOPERATION AGENCY	



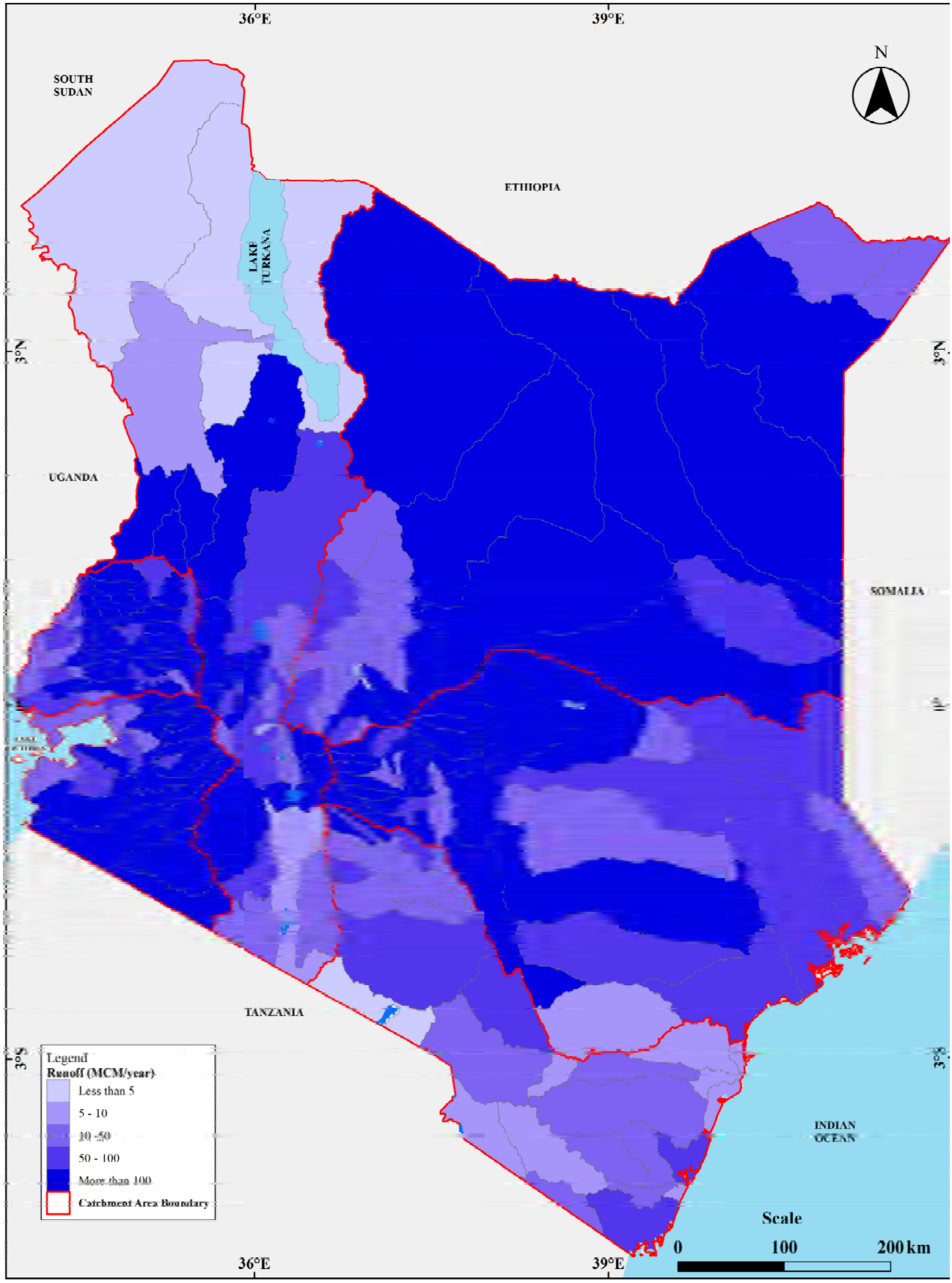
Source: JICA Study Team based on Kenya Vision 2030

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 3.2.2 Population Density in 2030**
JAPAN INTERNATIONAL COOPERATION AGENCY	



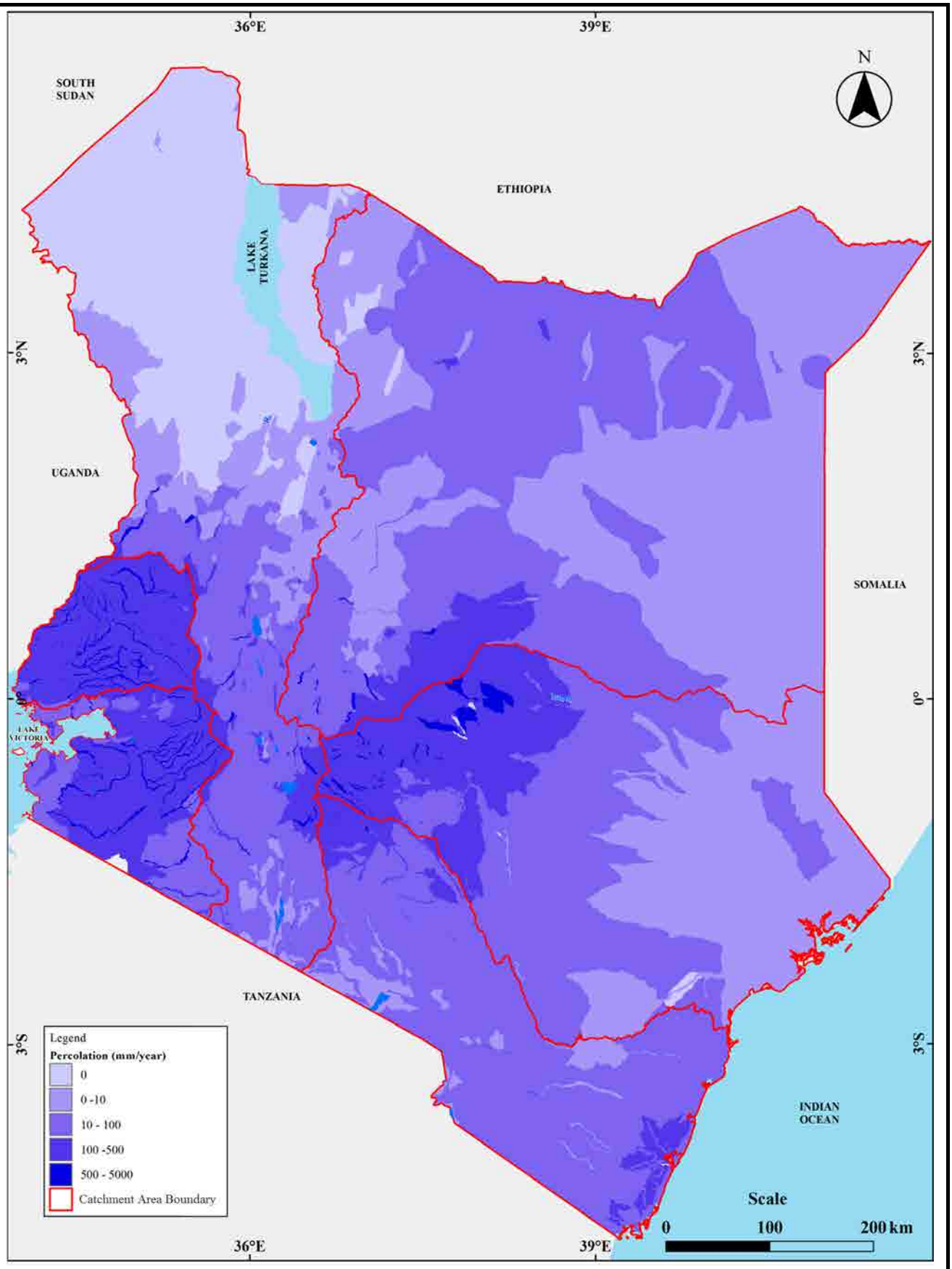
Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 5.1.1 Flowchart for Projection on Effects of Future Climate Change and Formulation of Water Resources Development Plan**
JAPAN INTERNATIONAL COOPERATION AGENCY	



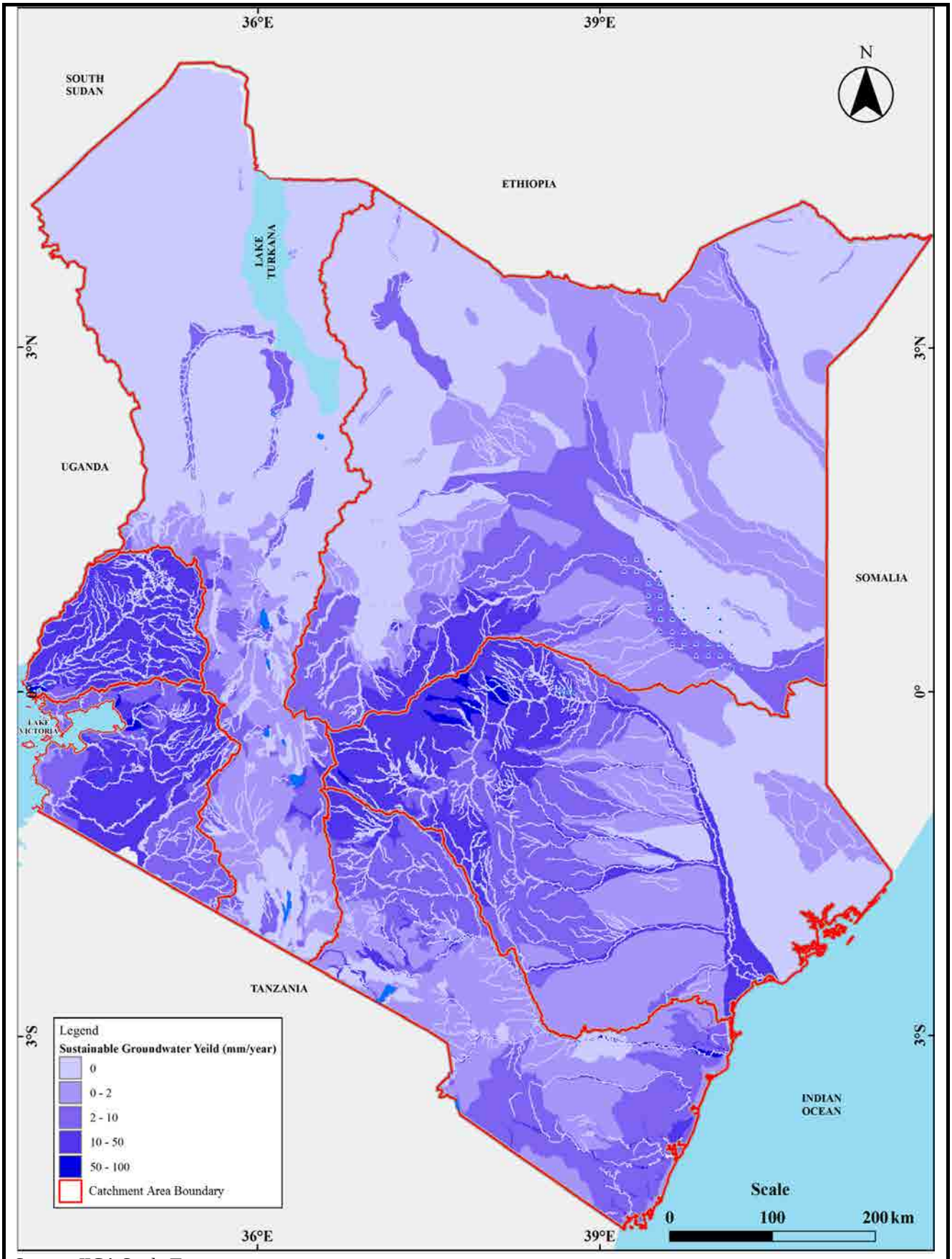
Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 5.2.1 Distribution of Surface Water Runoff**
JAPAN INTERNATIONAL COOPERATION AGENCY	



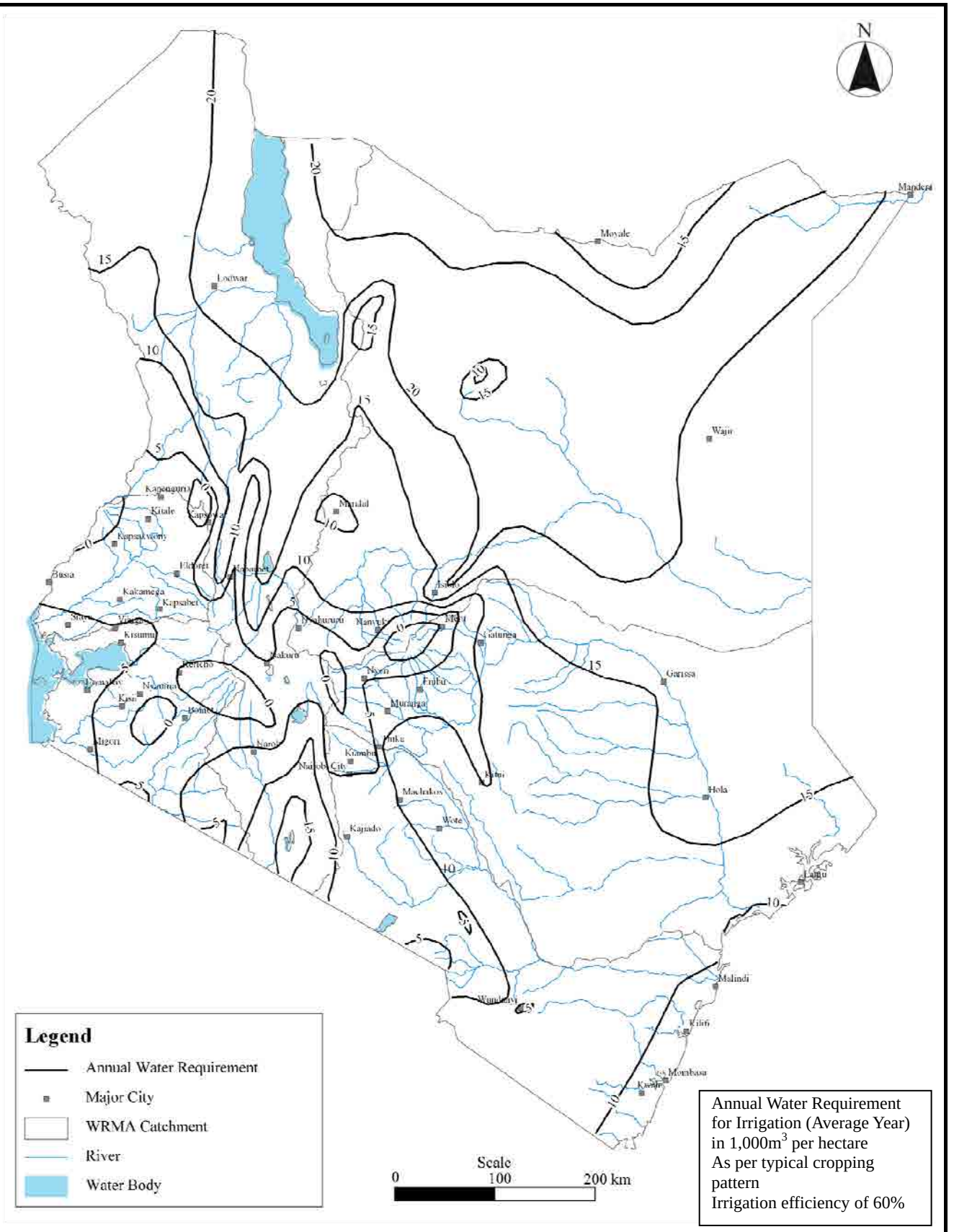
Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 5.2.2 Distribution of Groundwater Recharge (Percolation)**
JAPAN INTERNATIONAL COOPERATION AGENCY	



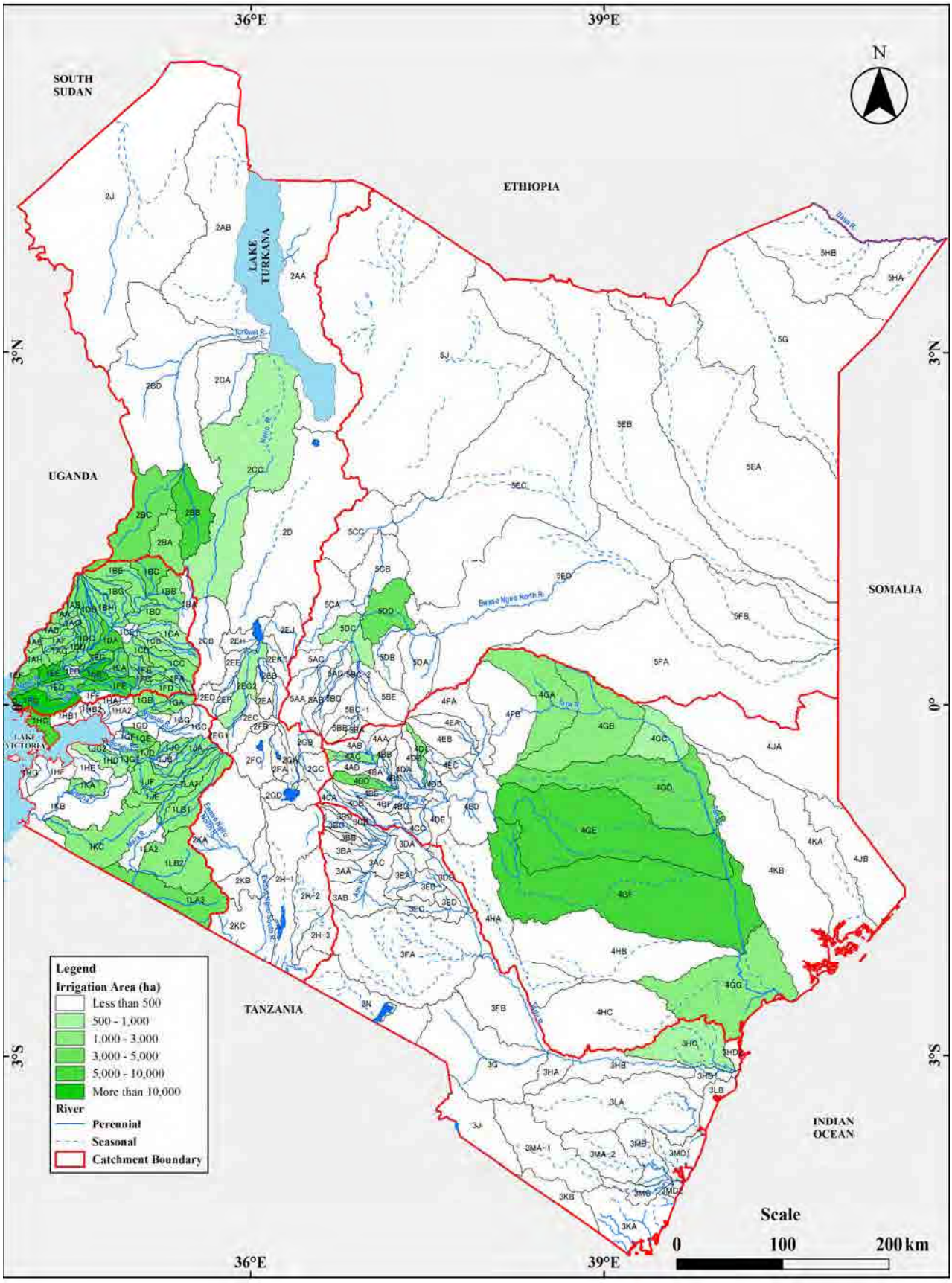
Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 5.2.3 Distribution of Sustainable Groundwater Yields**
JAPAN INTERNATIONAL COOPERATION AGENCY	



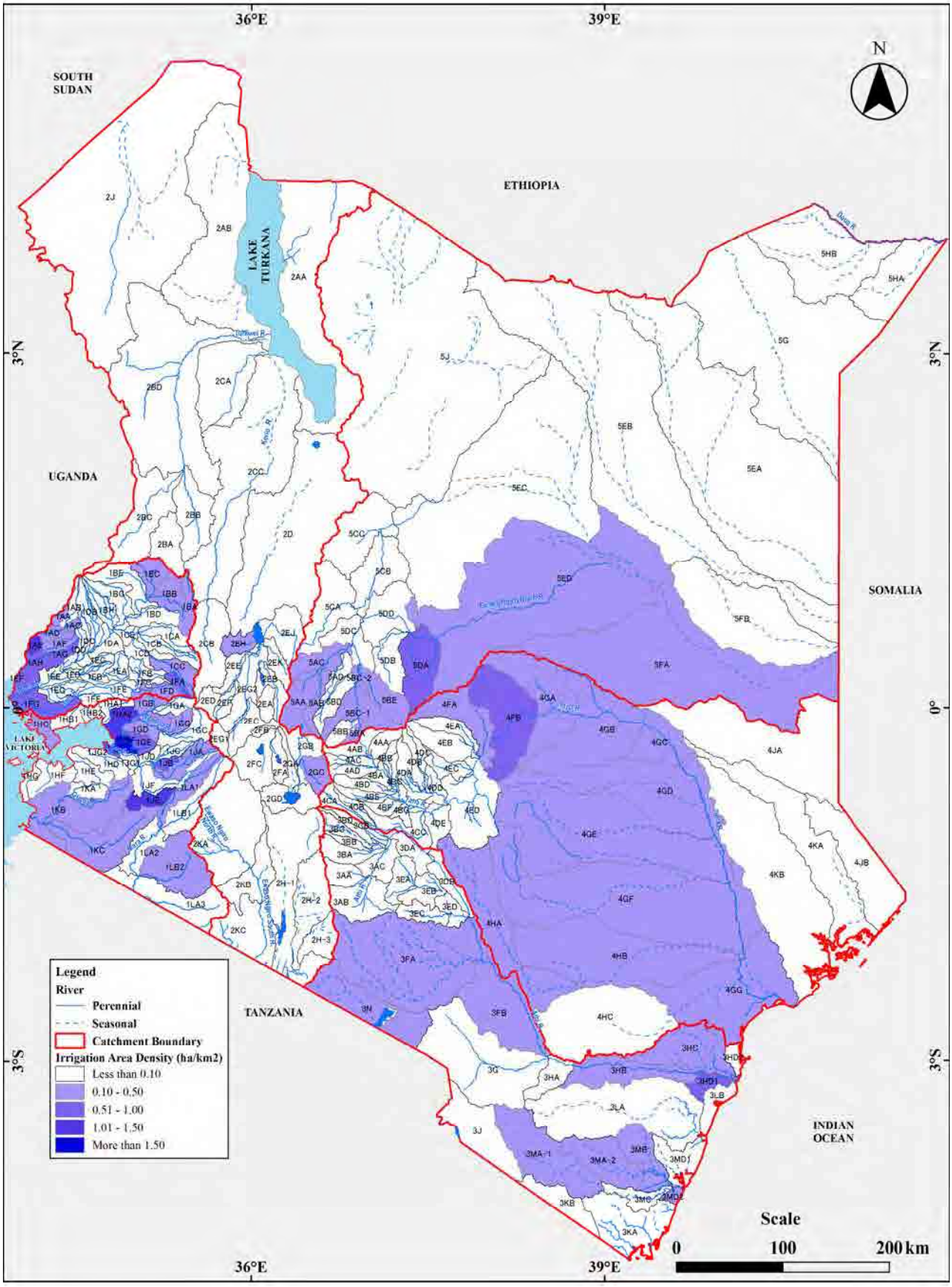
Source: Water Requirement for Irrigation in Kenya, Ministry of Water Development, Sep. 1985

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 6.5.1 Iso-annual Irrigation Water Requirement**
JAPAN INTERNATIONAL COOPERATION AGENCY	



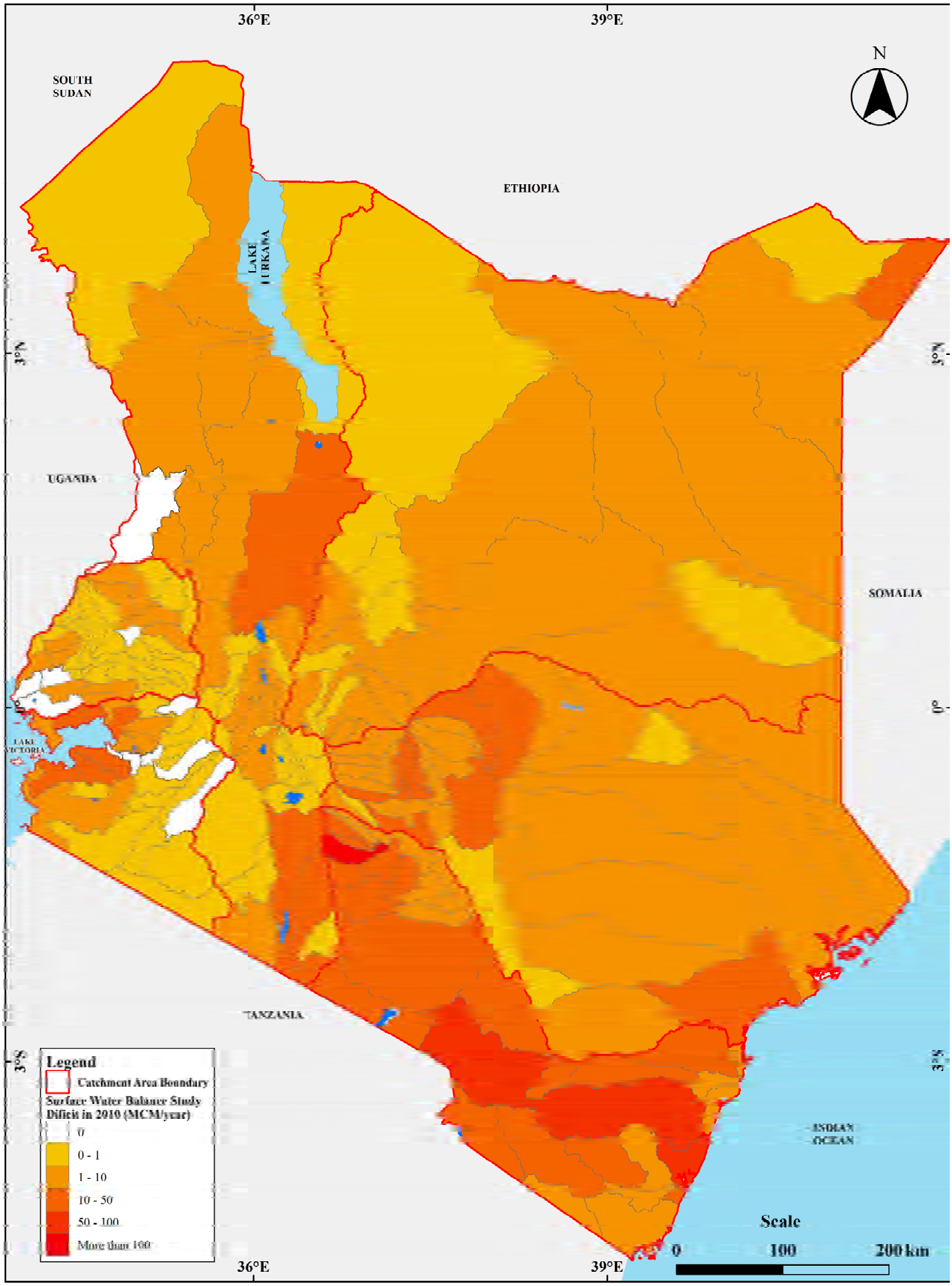
Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 6.5.2 Possible Surface Water Irrigation Area by Sub-basin in 2030**
JAPAN INTERNATIONAL COOPERATION AGENCY	



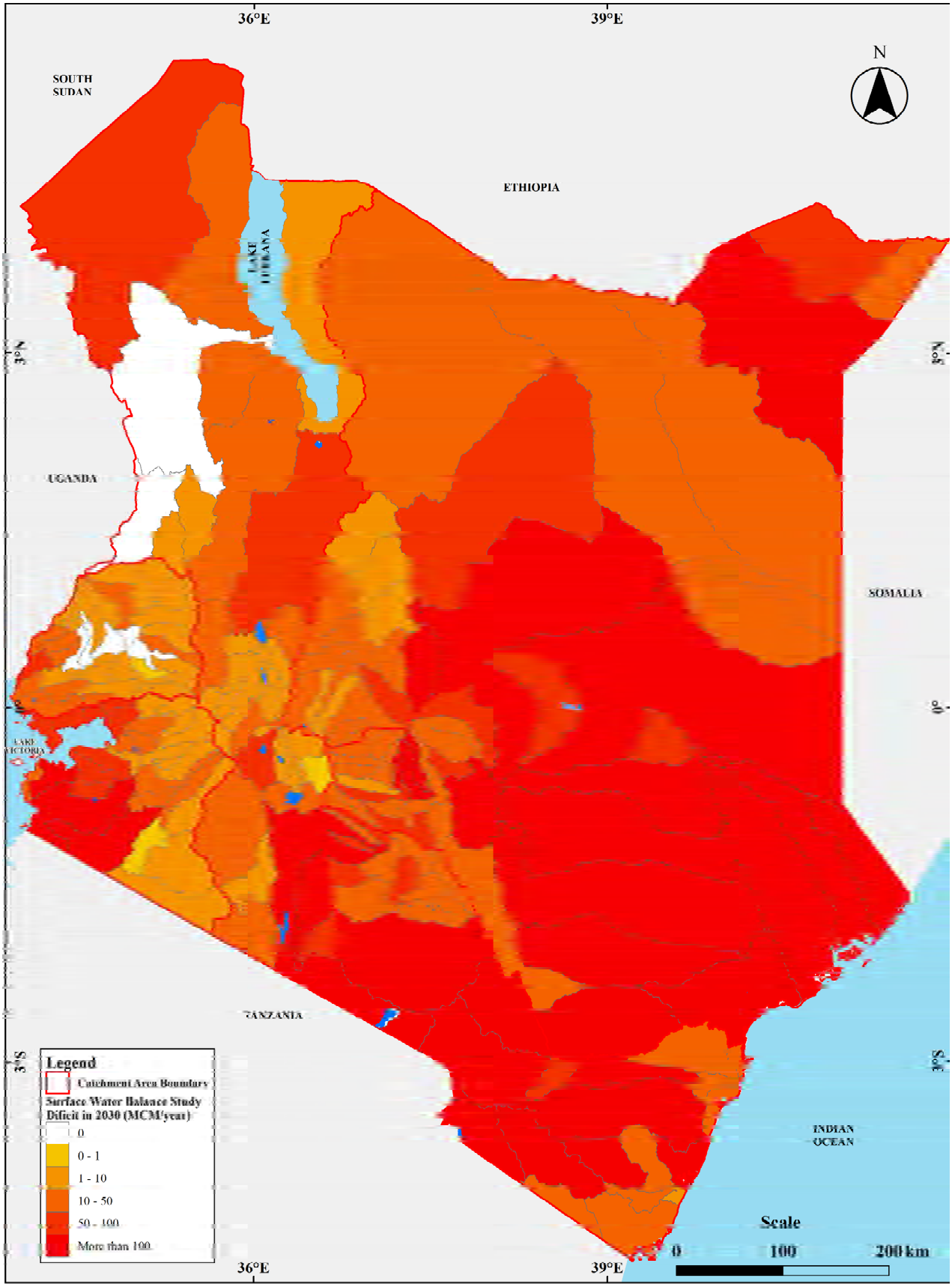
Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 6.5.3 Possible Groundwater Irrigation Area by Sub-basin in 2030**
JAPAN INTERNATIONAL COOPERATION AGENCY	



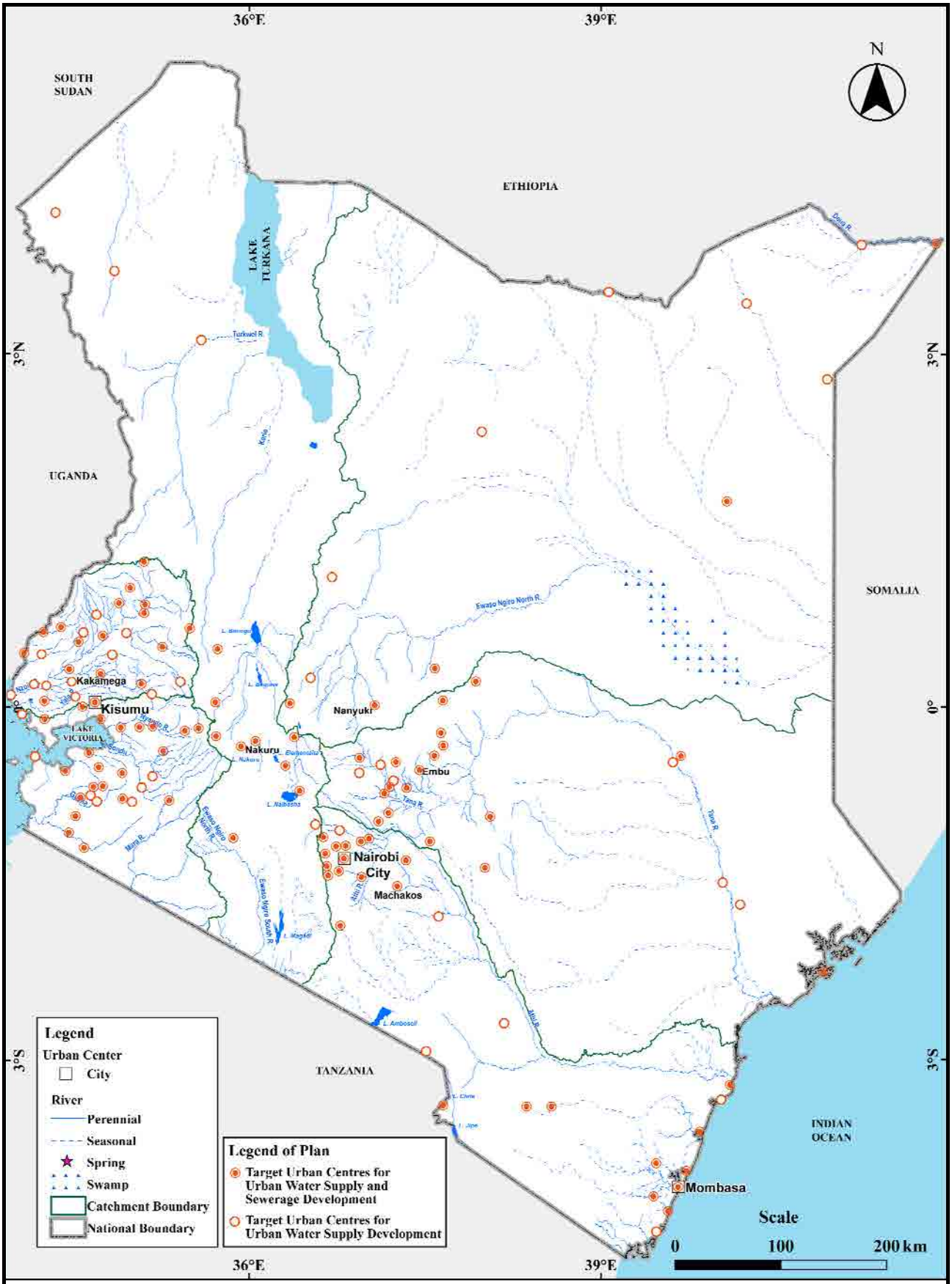
Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 6.11.1 Annual Deficit for 10-Year Probable Drought under Present (2010) Water Demand Condition**
JAPAN INTERNATIONAL COOPERATION AGENCY	



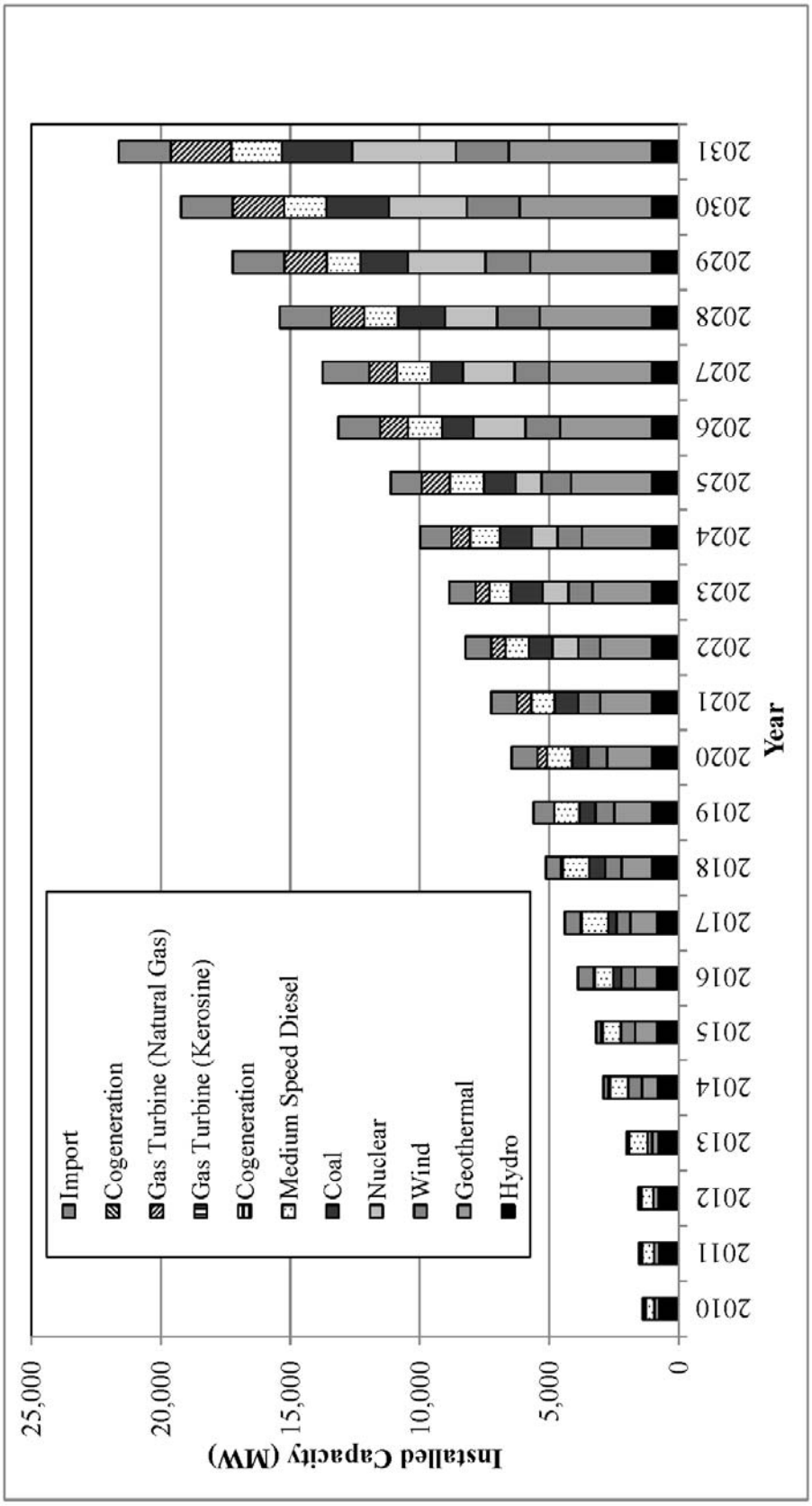
Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 6.11.2** **Annual Deficit for 10-Year Probable Drought under Future (2030) Water Demand Condition**
JAPAN INTERNATIONAL COOPERATION AGENCY	



Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 7.3.1 Target Urban Centres for Urban Water Supply and Sewerage System Development**
JAPAN INTERNATIONAL COOPERATION AGENCY	

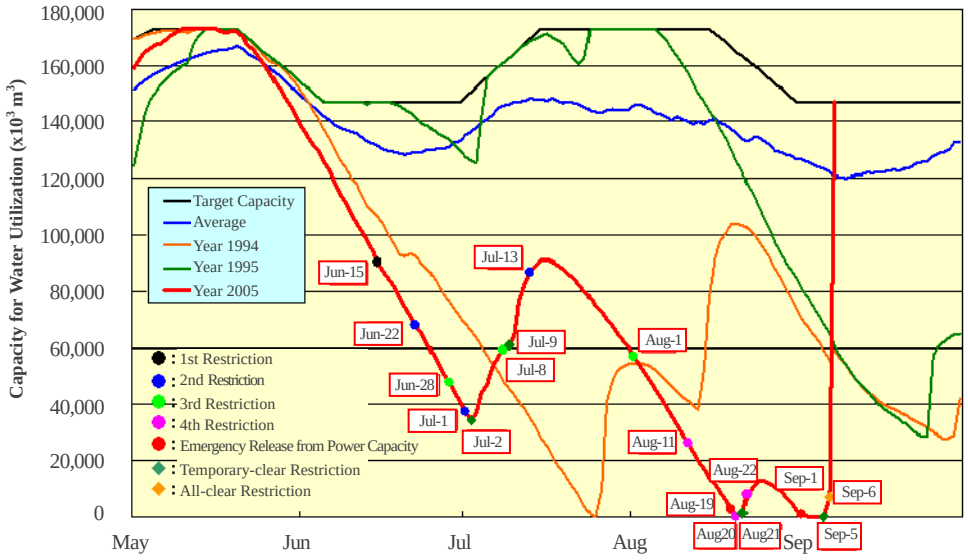


Source: LCPDP 2011-2031

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 7.6.1 Power Development Plan by Type of Energy**
JAPAN INTERNATIONAL COOPERATION AGENCY	

Flow of Water Use Restriction of the Sameura Dam in 2005 Drought

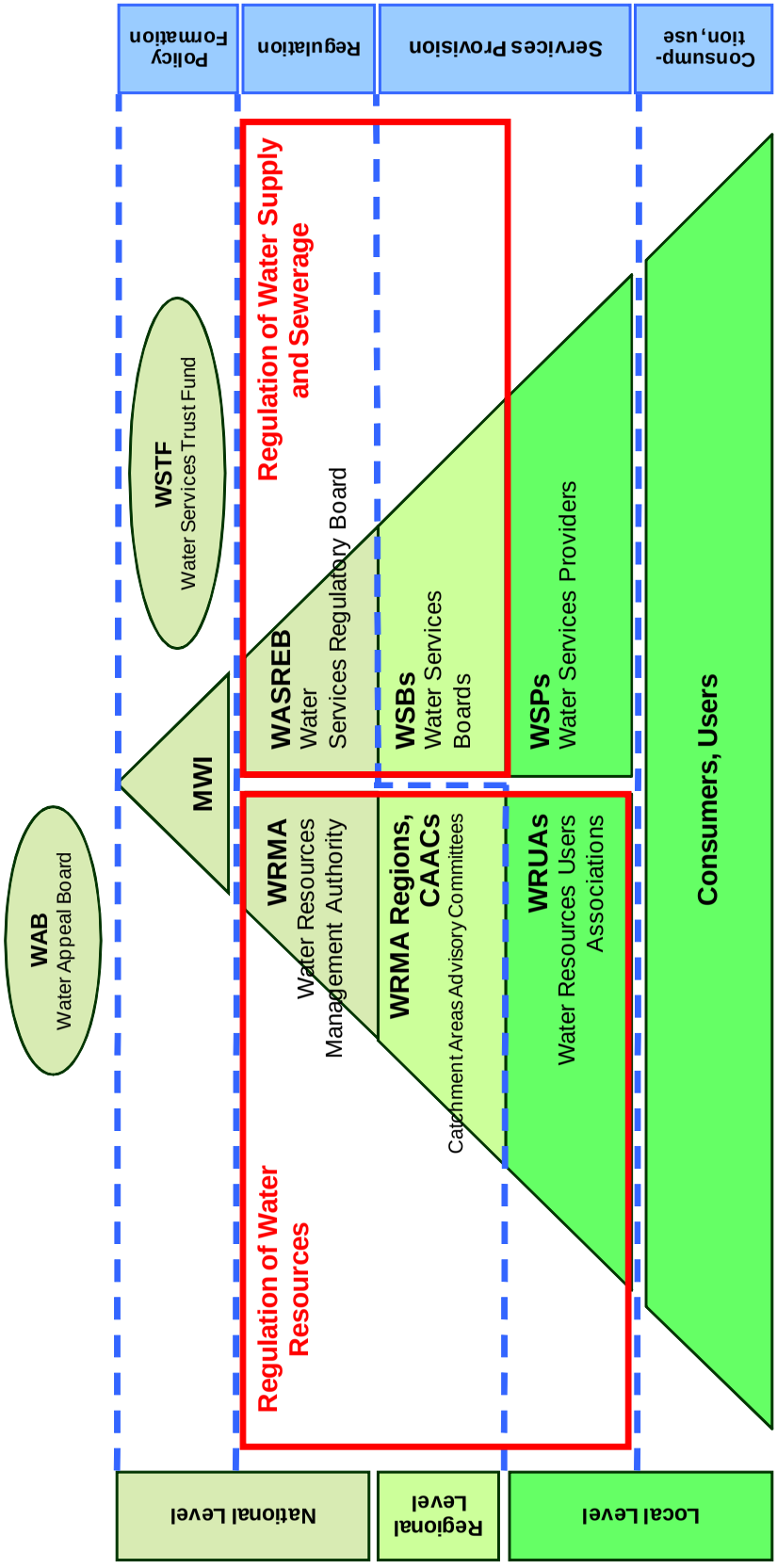
Date	Reserve	Water Use Restriction	Organizational Arrangement
May 26	96.40%		15:00 Setting up a head office of special task force for water restriction in Shikoku Regional Development Bureau (a) 15:00 Setting up a branch office of special task force for water restriction in Integrated Management Office of Dams in Yoshino River (b)
Jun 13	66.60%	0:00 Voluntary water-saving [Tokushima 5.9%]	
Jun 15	61.20%	9:00 The first water restriction [Tokushima 14.1% (new 20%), Kagawa 20%]	9:00 Setting up a branch office of special task force for water restriction in Tokushima River and National Highway Office (c)
Jun 22	46.00%	9:00 The second water restriction [Tokushima 15.9% (new 35%), Kagawa 35%]	
Jun 28	32.40%	9:00 The third water restriction [Tokushima 17.6% (new 50%), Kagawa 50%]	
Jul 1	25.10%	22:00 Ease the second water restriction [Tokushima 17.2% (new 35%), Kagawa 35%]	
Jul 2	22.80%	6:00 Temporary-clear water restriction	
Jul 8	36.80%	0:00 The third water restriction [Tokushima 19.0% (new 50%), Kagawa 50%]	
Jul 9	37.50%	15:00 Temporary-clear water restriction	
Jul 13	51.20%	18:00 The second water restriction [Tokushima 17.2% (new 35%), Kagawa 35%]	
Aug 1	32.90%	9:00 The third water restriction [Tokushima 19.0% (new 50%), Kagawa 50%]	
Aug 11	15.10%	9:00 The forth water restriction [Tokushima 22.0% (new 75%), Kagawa 75%]	9:00 Setting up a head office of emergency task force for extraordinary drought in Shikoku Region (d)
Aug 19 (20:00)	1.5% (0.0%)	20:00 Start emergency release from power generation capacity [Tokushima 1.85 m^3/s, Kagawa 1.81 m^3/s]	
Aug 20	0.00%	22:00 Temporary ease the forth water restriction [Tokushima 22.0% (new 75%), Kagawa 75%] Stop emergency release from power generation capacity	
Aug 21	1.10%	11:00 Temporary-clear water restriction	
Aug 22	4.90%	22:00 Restart the forth water restriction [Tokushima 22.4% (new 75%), Kagawa 75%]	
Sep 1 (8:00)	0.5% (0.0%)	8:00 Start emergency release from power generation capacity [Tokushima 1.85m^3/s, Kagawa 1.81m^3/s]	
Sep 5	0.00%	5:00 Stop emergency release from power generation capacity 9:00 Temporary-clear water restriction	
Sep 6 (20:00)	4.6% (100%)	18:00 All-clear water restriction	18:00 Breaking up the office (a) 18:00 Breaking up the office (d) 18:00 Breaking up the office (c) 20:00 Breaking up the office (b)



Time Series Graph of Water Use Capacity of the Sameura Dam and Restriction Actions in 2005 Drought

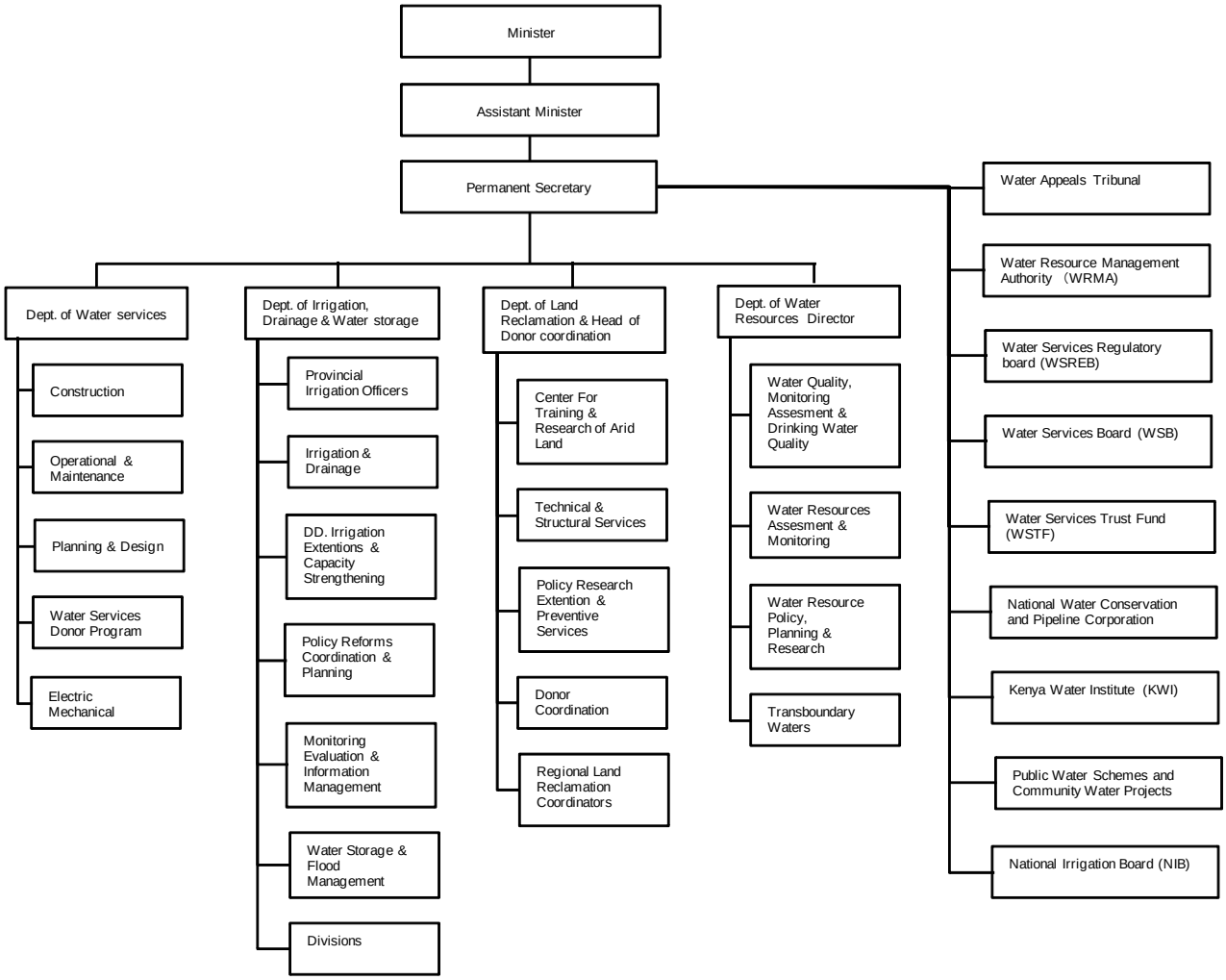
Source: Shikoku Regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism, Japan

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 7.9.1 Example for Water Use Restriction of Sameura Dam in 2005 Drought**
JAPAN INTERNATIONAL COOPERATION AGENCY	



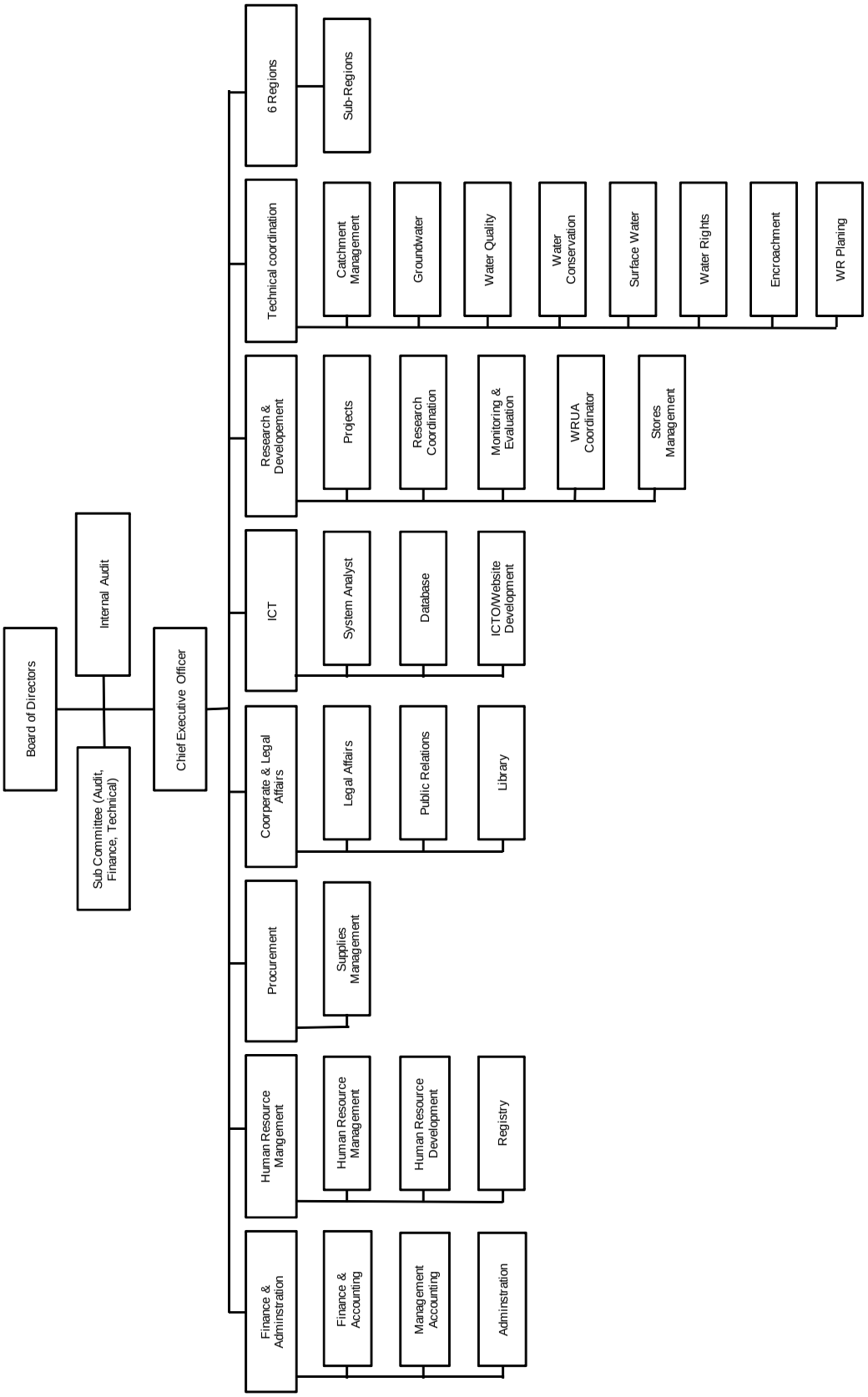
Source: WRMA with notes by JICA Study Team (as of November 2012)

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030 JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure 8.2.1** **Existing Representation of Institutional Framework of Water Sector under MWI**



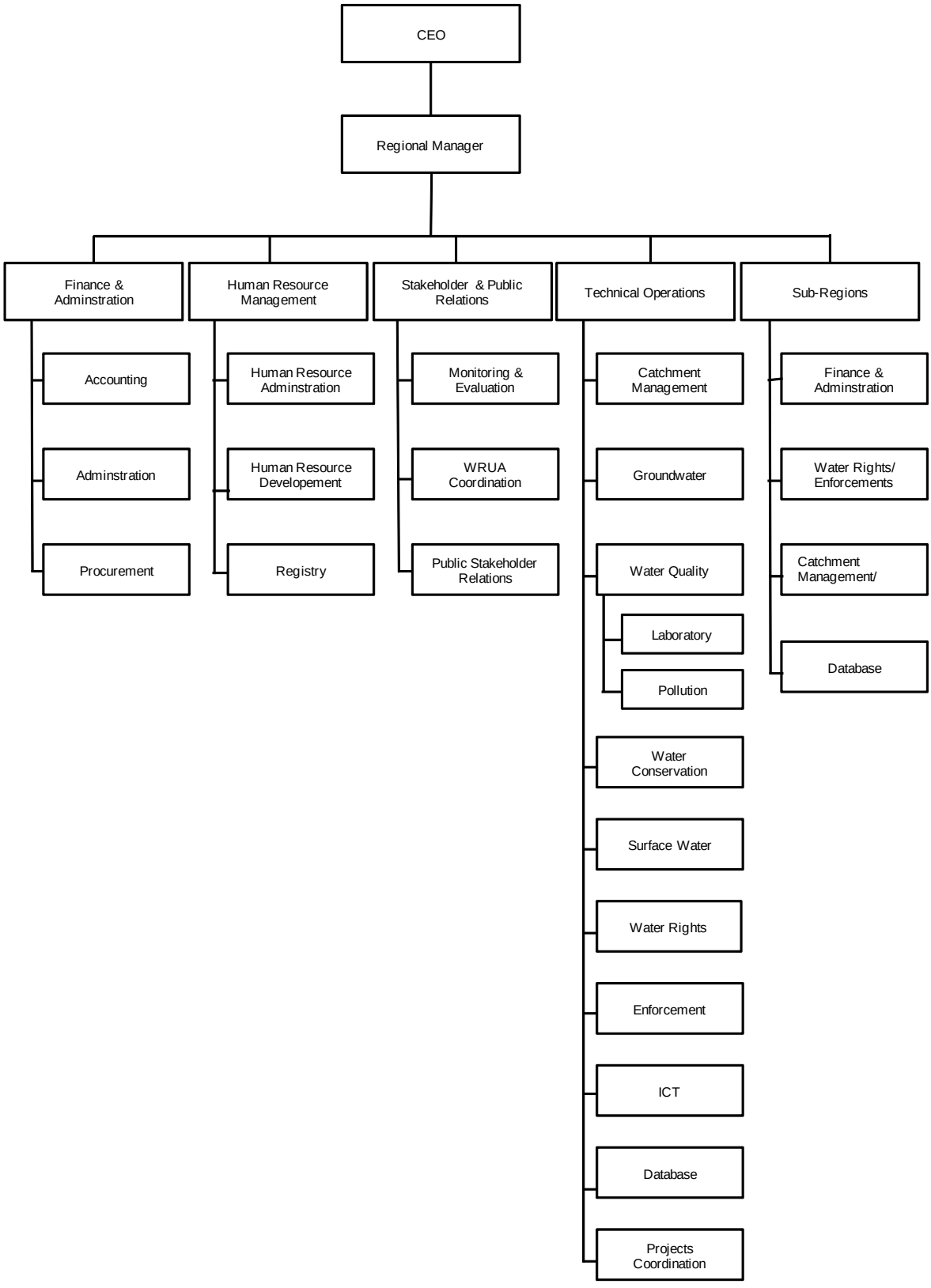
Source: MWI (as of November 2012)

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 8.2.2 Organogram of Ministry of Water and Irrigation**
JAPAN INTERNATIONAL COOPERATION AGENCY	



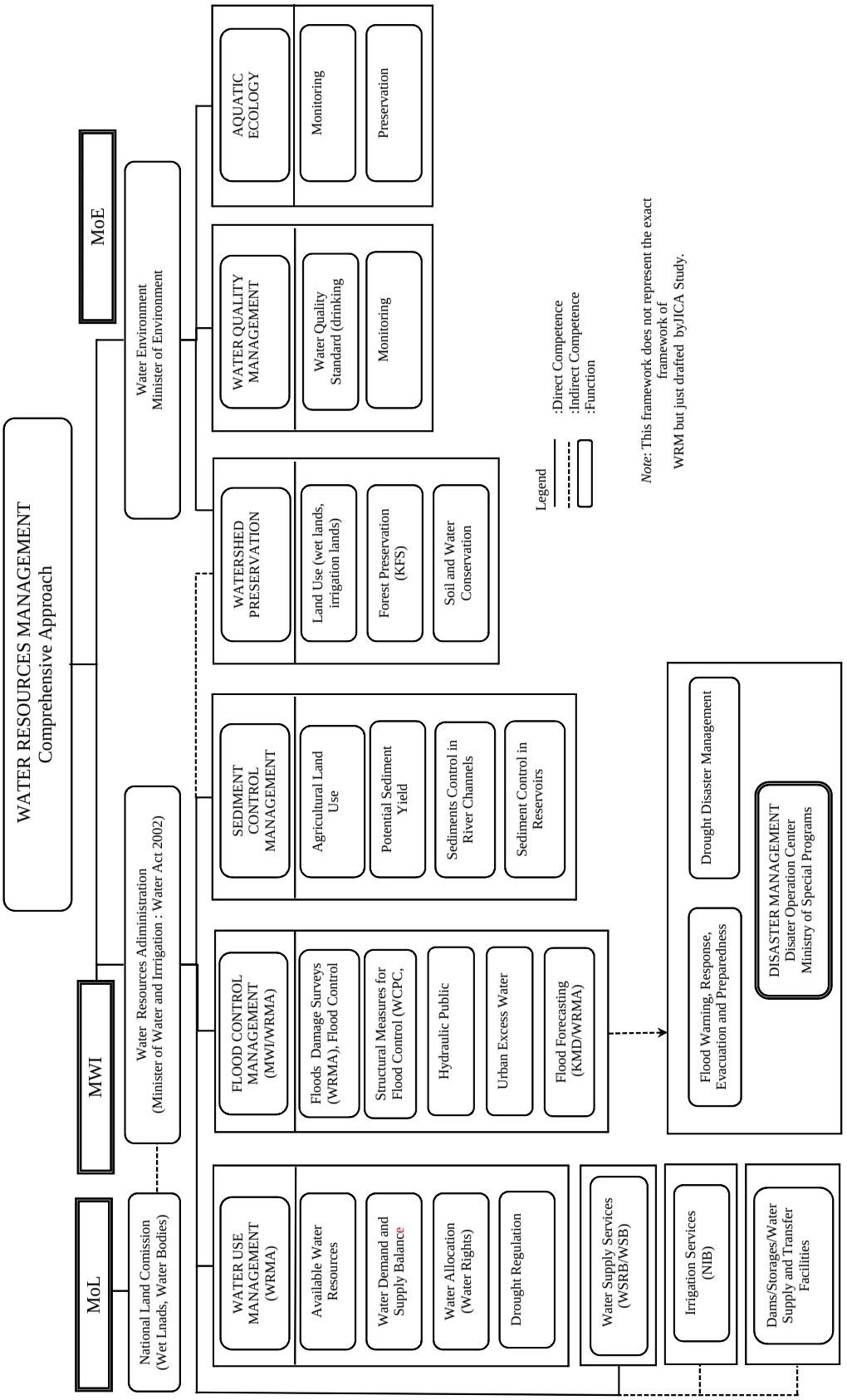
Source: WRMA (as of November 2012)

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 8.2.3 Functional Organization Structure of WRMA**
JAPAN INTERNATIONAL COOPERATION AGENCY	



Source: WRMA (as of November 2012)

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 8.2.4 Functional Organization Structure of WRMA at Regional Level**
JAPAN INTERNATIONAL COOPERATION AGENCY	

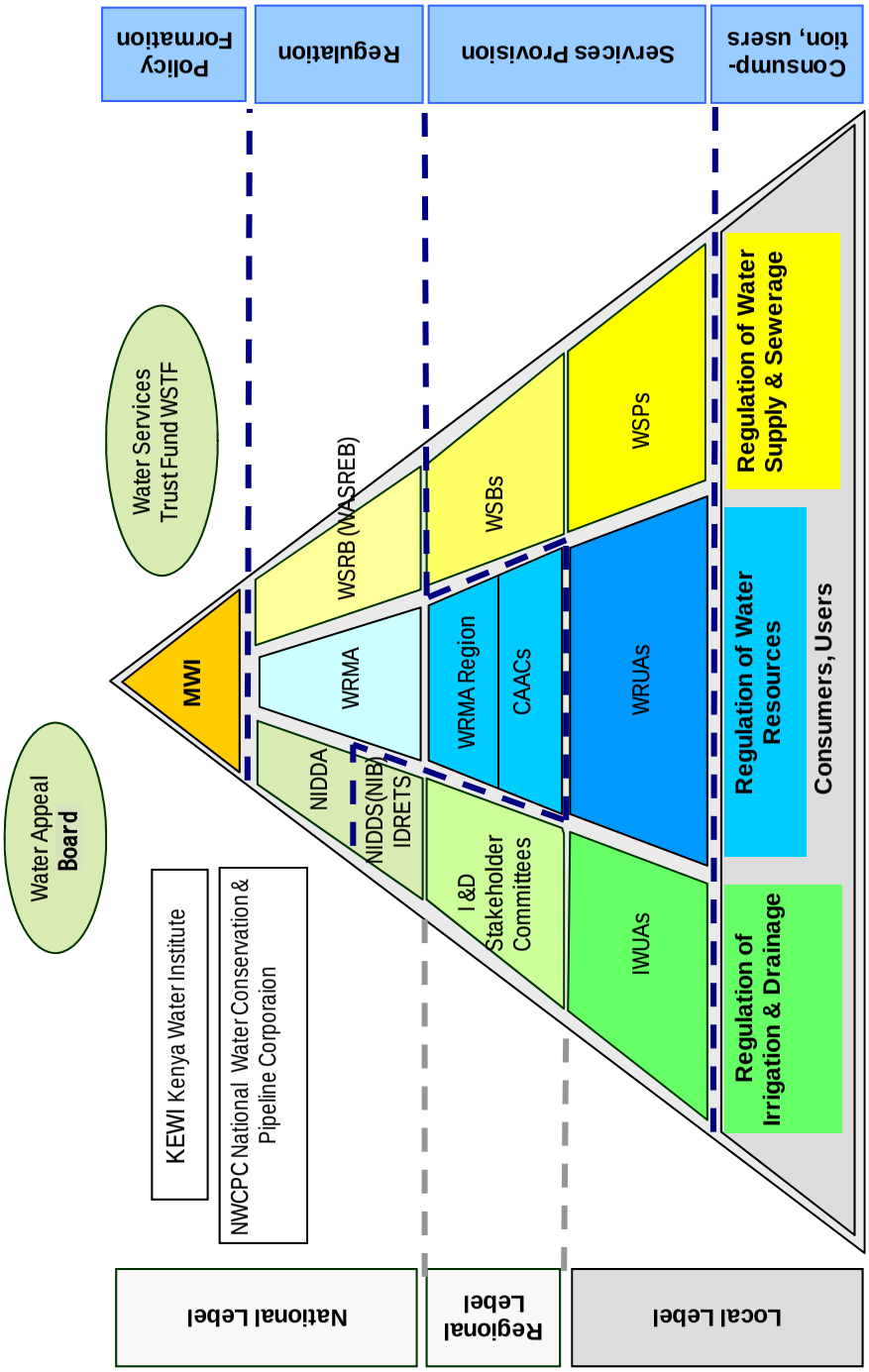


Note: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 8.2.5
Existing Sector Framework of Water Resources Management in Kenya



Note 1: NIDDA: National Irrigation and Drainage Authority
NIDDS: National Irrigation and Drainage Development Services
NIB: National Irrigation Board
IDRETS: Irrigation and Drainage Research, Extension and Training Service
I&D: Irrigation and Drainage

Note 2: The Draft Water Bill 2012 (version of March 2012) transfers the existing functions; from WRMA to Water Resources Regulatory Authority (WRRA), from WRMA Regional Offices to Basin Water Resources Boards (BWRBs), from NWCPC to National Water Storage Authority, from WSRB to Water Services Regulatory Commission, WSBs to Water Works Development Boards, from WSPs to County or Cross-County Water Service Providers, from Water Appeal Board to Water Tribunal, from WSTF to Water Sector Trust fund Authority.

Source: Transboundary Water Policy (Draft)

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 8.4.1 Actual Institutional Set-up of Ministry of Water and Irrigation**
JAPAN INTERNATIONAL COOPERATION AGENCY	

Proposed Development Plans

Water Supply Development Plan

Urban Water Supply Development (32 Urban Centers)

1)	Rehabilitation (20 UC)	135,000 m^3/day
2)	Expansion (20 UC)	556,000 m^3/day
3)	New Construction (12 UC)	91,000 m^3/day
4)	Service Population	6.57 million

Rural Water Supply (11 Counties)

1)	Large Scale	184,000 m^3/day
2)	Small Scale	220,000 m^3/day
3)	Target Population	5.79 million

Sanitation Development Plan

Sewerage Development (19 Urban Centers)

1)	Rehabilitation (7 UC)	21,000 m^3/day
2)	Expansion (7 UC)	230,000 m^3/day
3)	New Construction (12 UC)	209,000 m^3/day
4)	Service Population	6.03 million

On-site Sanitation (11 Counties)

1)	Installation of Proper On-site Sanitation Facilities by Individual or Communities	
2)	Target Population	6.33 million

Irrigation Development Plan

Large Scale Irrigation Area

1)	Large Scale Irrigation	78,370 ha (6 Projects)
2)	Small Scale Irrigation	47,122 ha (11 Counties)
3)	Private Sector Irrigation	43,421 ha (11 Counties)

Hydropower Development Plan

Hydropower Development

1)	Nzoia(34B) Multipurpose Dam Project	16 MW
2)	Nzoia(42A) Multipurpose Dam Project	25 MW
3)	Nandi Forest Multipurpose Dam Project	50 MW

Water Resources Development Plan

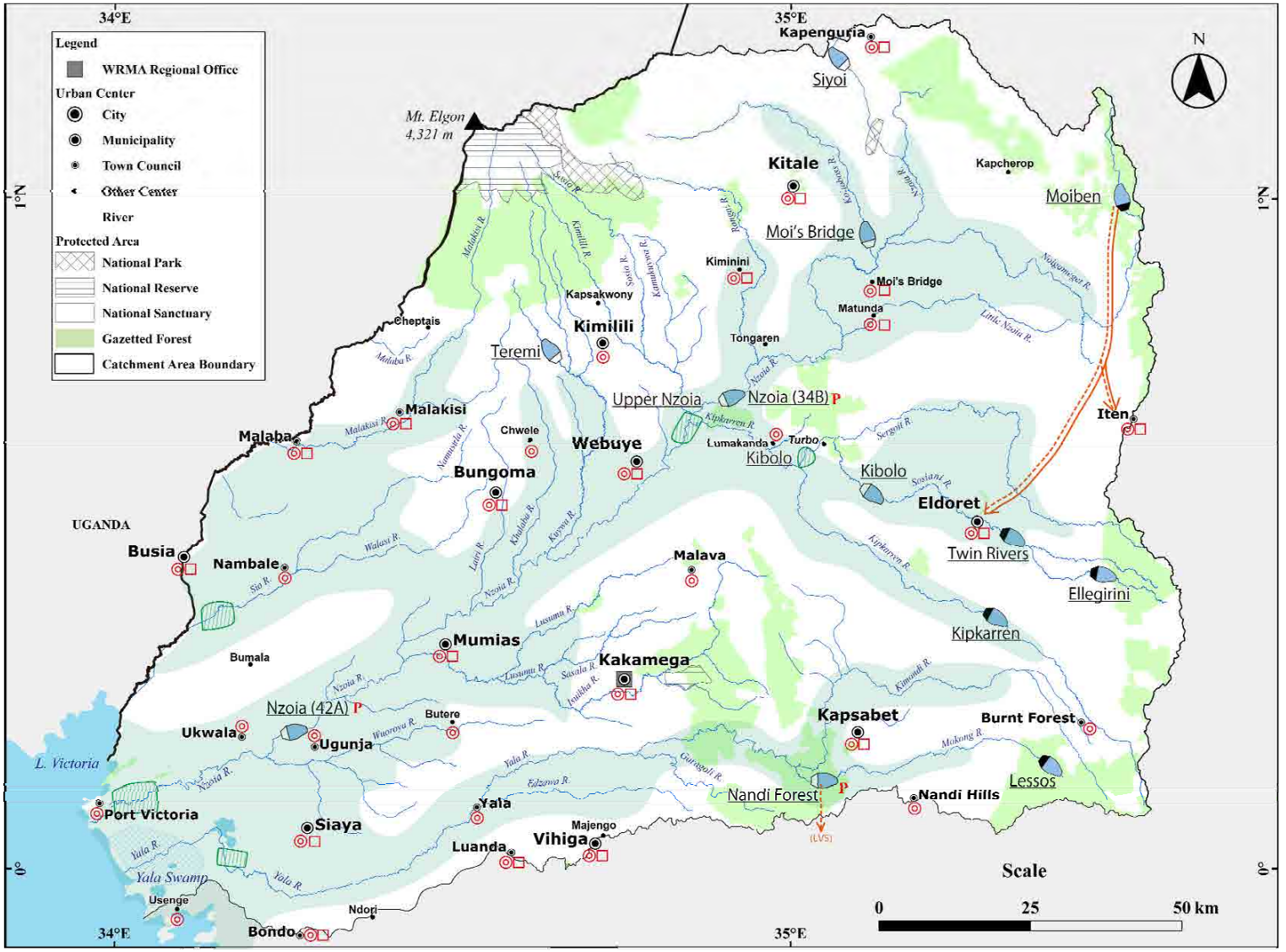
1)	Storage Dams	7 nos. (1,080 MCM)
2)	Small Storage Dams and Pans	3,620 nos. (181 MCM)
3)	Boreholes:	560 nos. (56 MCM/year)
4)	Inter-basin Transfer (from Nandi Forest Dam to LVS CA)	189 MCM/year
5)	Intra-basin Transfer (from Moiben Dam to Eldoret, Ext.)	5 MCM/year

LEGEND

Dam(Existing)

Water Transfer (Existing)

Irrigation Potential Area



THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 10.1.1** **Proposed Development Plans for Lake Victoria North Catchment Area**
JAPAN INTERNATIONAL COOPERATION AGENCY	

Source: JICA Study Team

Proposed Management Plans

Water Resources Management Plan

1) Monitoring Networks

Surface Water Monitoring Station	24 locations
Rainfall Monitoring Station	42 locations
Groundwater Monitoring Station	19 locations
Reference Point	2 locations

2) Evaluation of Water Resources
3) Improvement of Water Permit Issue and Management System
4) Watershed Conservation (Forestation and Soil Erosion Control)

Flood and Drought Disaster Management Plan

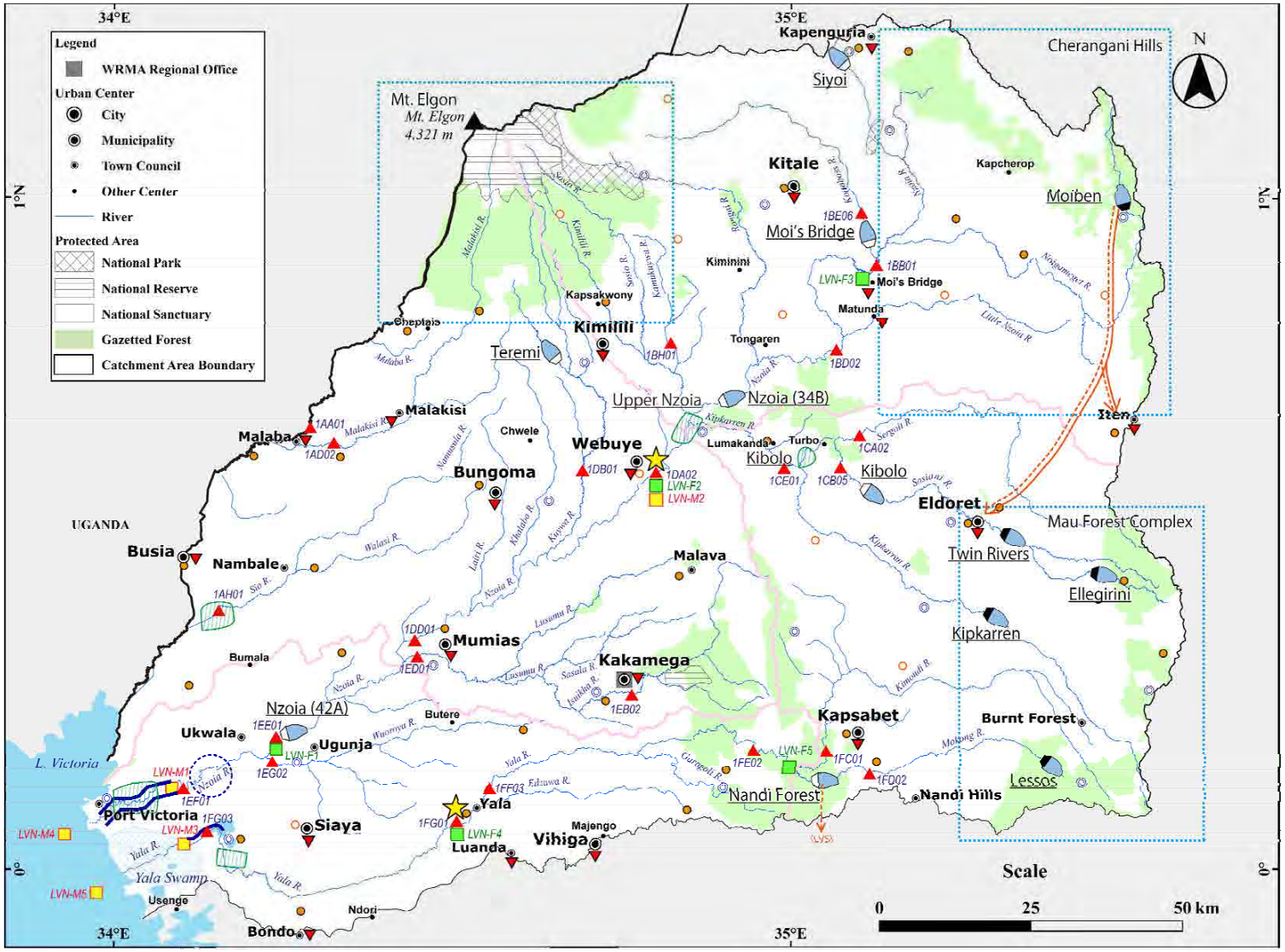
1) Flood Management
   a) Nzoia R. Basin: flood control by dams, dikes and river improvement
   b) Nzoia R. Basin: operation of early flood forecasting and warning system
   c) Nzoia and Yala R. Basins: preparation of flood fighting plans for dikes
2) Drought Management
   a) Establishment of Basin Drought Conciliation Councils
   b) Early Drought Forecasting based on long-term rainfall prediction
   c) Water Use Restriction Rule for Reservoirs (Existing 5 dams and proposed 7 dams)

Environmental Management Plan

1) Setting of Environmental Flow Rate	5 locations
2) Environmental Monitoring	5 locations

LEGEND

- Dam(Existing)
- Dam (Proposed)
- Water Transfer (Existing)
- Water Transfer (Proposed)
- Sub-regional Boundary



Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 10.1.2** **Proposed Management Plans for Lake Victoria North Catchment Area**
JAPAN INTERNATIONAL COOPERATION AGENCY	

Proposed Development Plans

Water Supply Development Plan

Urban Water Supply Development
(25 Urban Centers)

1)	Rehabilitation (21 UC)	120,000 m^3/day
2)	Expansion (21 UC)	570,000 m^3/day
3)	New Construction (4 UC)	94,000 m^3/day
4)	Service Population	6.26 million

Rural Water Supply (14 Counties)

1)	Large Scale (14 Counties)	277,000 m^3/day
2)	Small Scale (14 Counties)	208,000 m^3/day
3)	Target Population	6.46 million

Sanitation Development Plan

Sewerage Development (19 Urban Centers)

1)	Rehabilitation (3 UC)	22,000 m^3/day
2)	Expansion (3 UC)	171,000 m^3/day
3)	New Construction (16 UC)	291,000 m^3/day
4)	Service Population	6.02 million

On-site Sanitation (14 Counties)

1)	Installation of Proper On-site Sanitation Facilities by Individual or Communities	
2)	Target Population	6.70 million

Irrigation Development Plan

Large Scale Irrigation Area

1)	Large Scale Irrigation	75,572 ha (7 Projects)
2)	Small Scale Irrigation	22,501 ha (12 Counties)
3)	Private Sector Irrigation	15,133 ha (12 Counties)

Hydropower Development Plan

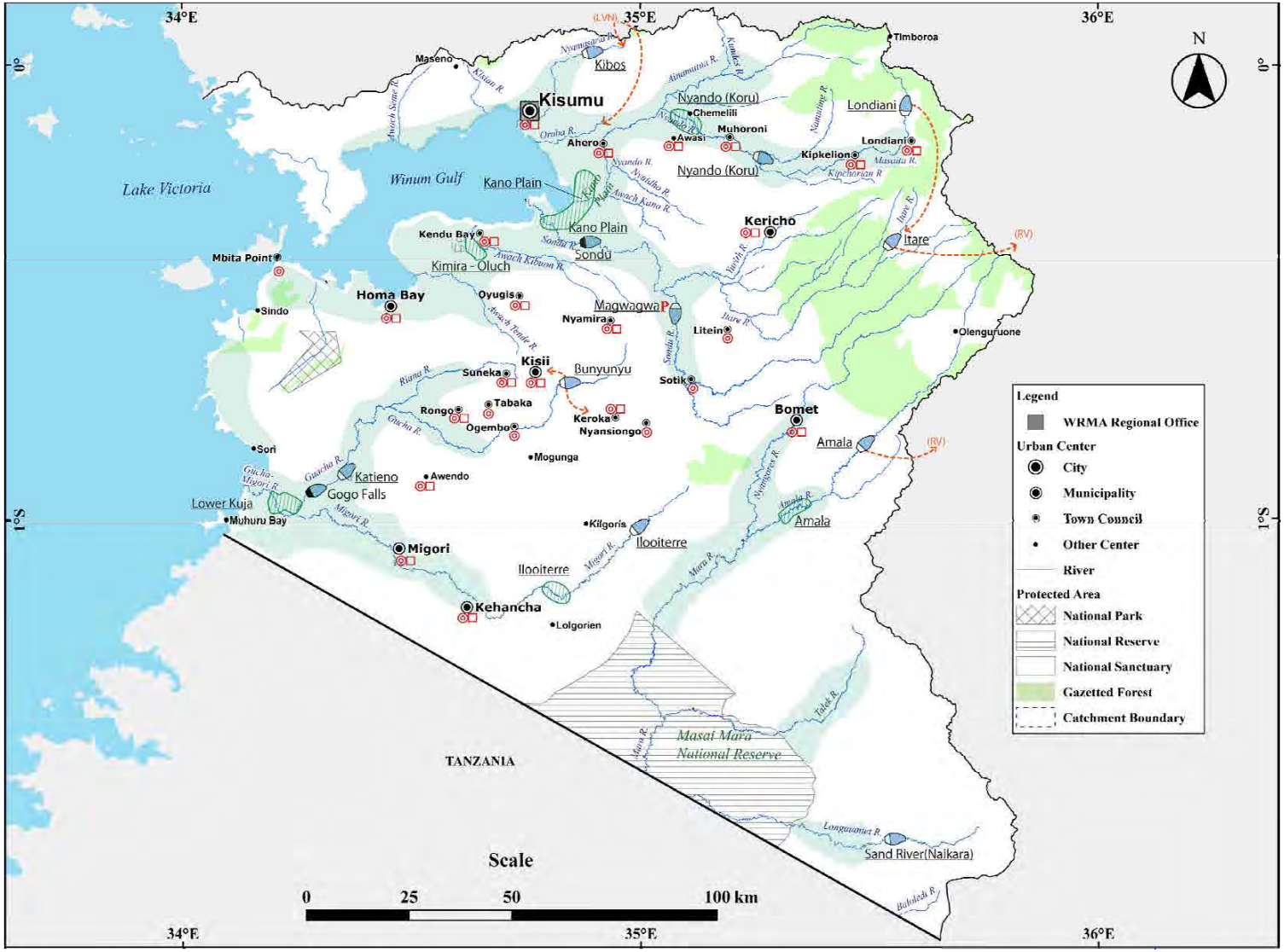
Hydropower Development

1)	Magwagwa Multipurpose Dam Project	115 MW

Water Resources Development Plan

1)	Storage Dams	10 nos. (1,000 MCM)
2)	Small Storage Dams and Pans	3,880 nos. (194 MCM)
3)	Boreholes:	1,250 nos. (125 MCM/year)
4)	Inter-basin Transfer (from Itare and Londiani Dams to Nakuru)	41 MCM/year
5)	Inter-basin Transfer (from Amala Dam to Ewaso Ng'iro South River)	82 MCM/year
6)	Inter-basin Transfer (from Nandi Forest Dam (LVNCA))	189 MCM/year

LEGEND
Dam(Existing)
Water Transfer (Existing)
Irrigation Potential Area



Source: JICA Study Team

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 10.1.3
Proposed Development Plans for Lake Victoria South Catchment Area

Proposed Management Plans

Water Resources Management Plan

1) Monitoring Networks
   - Surface Water Monitoring Station 23 locations
   - Rainfall Monitoring Station 50 locations
   - Groundwater Monitoring Station 19 locations
   - Reference Point 5 locations
2) Evaluation of Water Resources
3) Improvement of Water Permit Issue and Management System
4) Watershed Conservation (Forestation, Small Water Sources Conservation and Soil Erosion Control)

Flood and Drought Disaster Management Plan

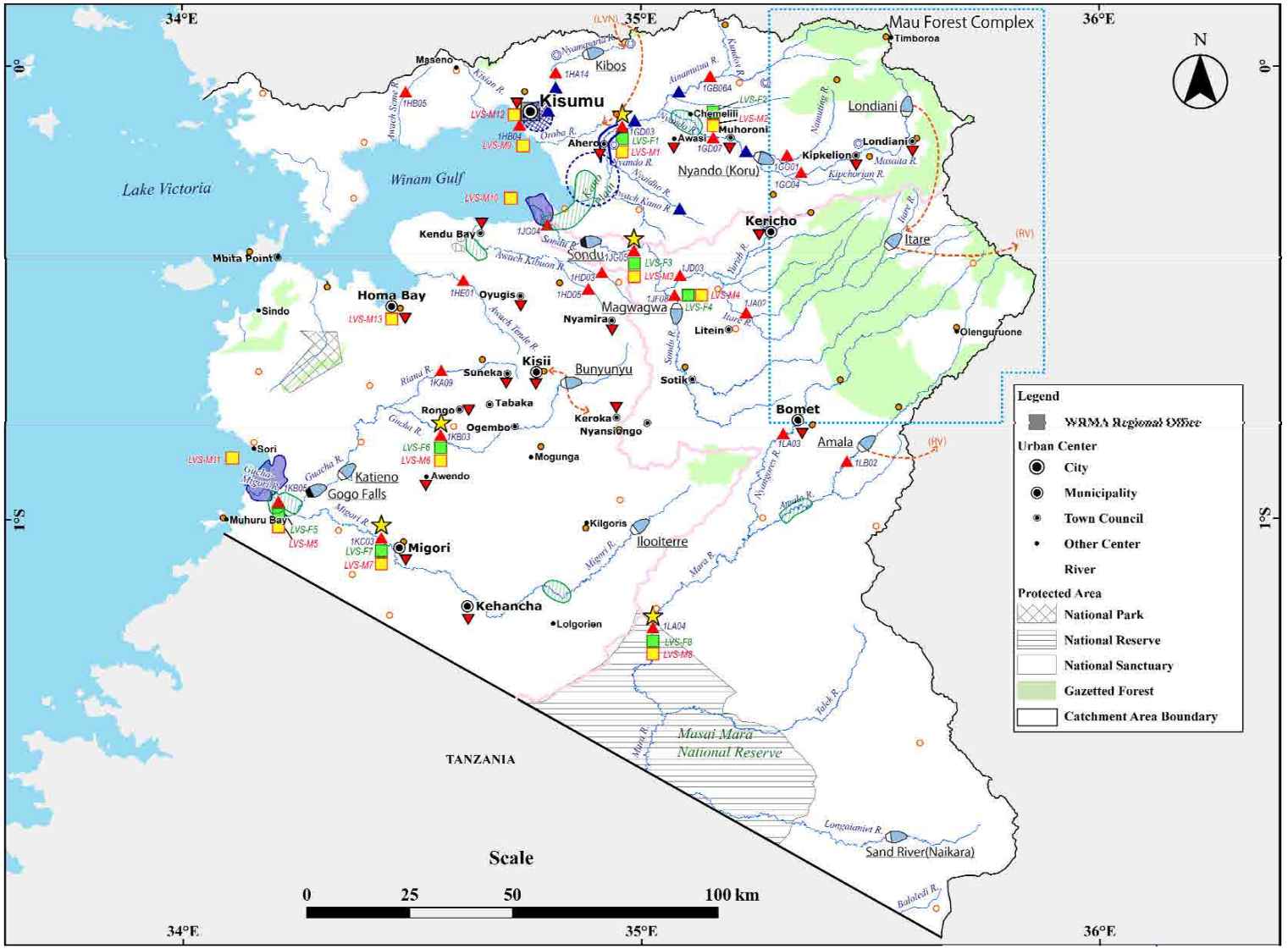
1) Flood Management
   a) Kano Plain: flood control by dams, dikes and river improvement
   b) Kano Plain: establishment of early flood forecasting and warning system
   c) Nyando R.: preparation of flood fighting plan for dikes
   d) Mouth areas of Sondu and Kuja Rivers : community-based disaster management
   e) Kisumu City: provision of urban drainage measures
2) Drought Management
   a) Establishment of Basin Drought Conciliation Councils
   b) Early Drought Forecasting based on long-term rainfall prediction
   c) Water Use Restriction Rule for Reservoirs (Existing 2 dams and proposed 10 dams)

Environmental Management Plan

1) Setting of Environmental Flow Rate 8 locations
2) Environmental Monitoring 13 locations

LEGEND

- Dam(Existing)
- Dam (Proposed)
- Water Transfer (Existing)
- Water Transfer (Proposed)
- Sub-regional Boundary



Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 10.1.4** Proposed Management Plans for Lake Victoria South Catchment Area
JAPAN INTERNATIONAL COOPERATION AGENCY	

Proposed Development Plans

Water Supply Development Plan

Urban Water Supply Development (13 Urban Centers)

1) Rehabilitation (10 UC)	129,000 m^3/day
2) Expansion (10 UC)	254,000 m^3/day
3) New Construction (3 UC)	15,000 m^3/day
4) Service Population	3.34 million

Rural Water Supply (18 Counties)

1) Large Scale	178,000 m^3/day
2) Small Scale	120,000 m^3/day
3) Target Population	4.11 million

Sanitation Development Plan

Sewerage Development (9 Urban Centers)

1) Rehabilitation (3 UC)	18,000 m^3/day
2) Expansion (3 UC)	150,000 m^3/day
3) New Construction (6 UC)	72,000 m^3/day
4) Service Population	3.16 million

On-site Sanitation (18 Counties)

1) Installation of Proper On-site Sanitation Facilities by Individual or Communities	
2) Target Population	4.29 million

Irrigation Development Plan

Large Scale Irrigation Area

1) Large Scale Irrigation	78,850 ha (9 Projects)
2) Small Scale Irrigation	9,271 ha (14 Counties)
3) Private Sector Irrigation	4,045 ha (14 Counties)

Hydropower Development Plan

Hydropower Development

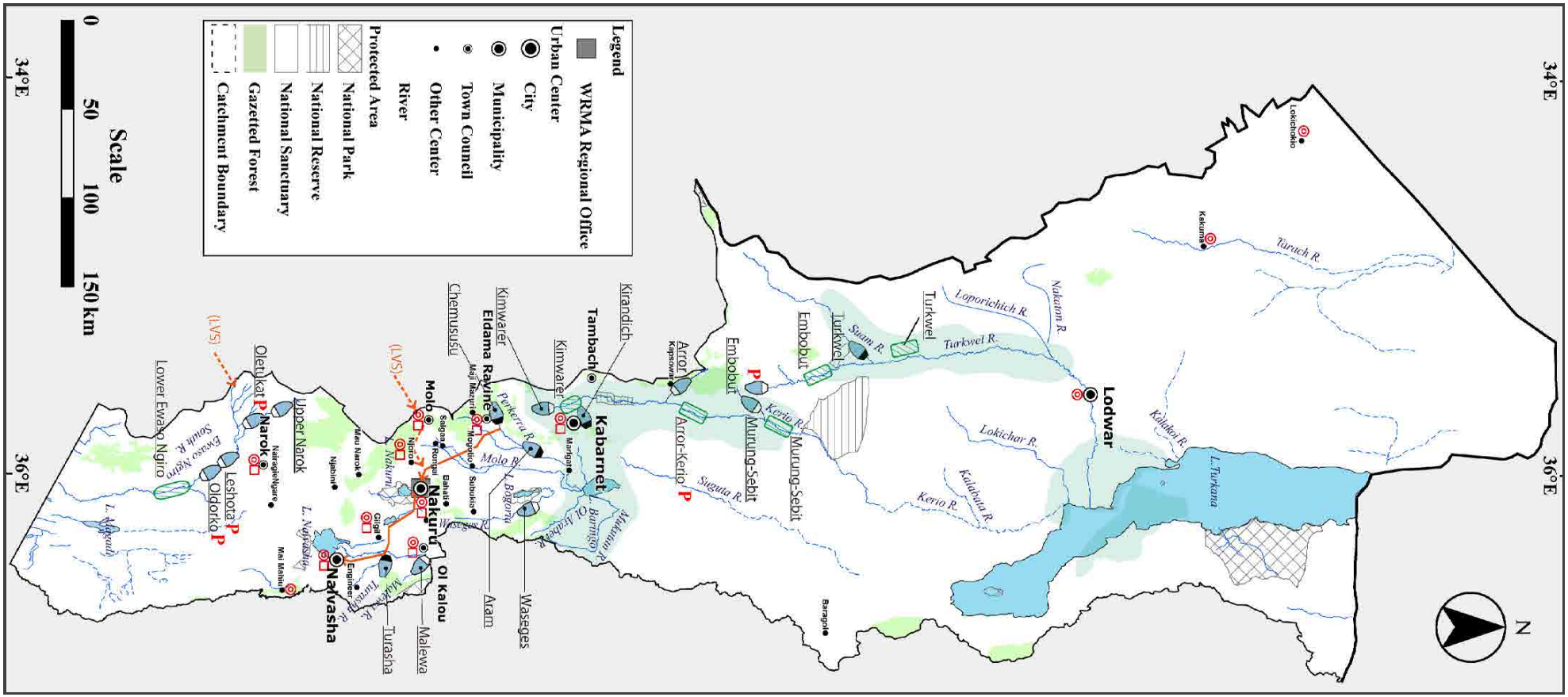
1) Arror	Multipurpose Dam Project	80 MW
2) Embobut	Multipurpose Dam Project	45 MW
3) Kimwarer	Multipurpose Dam Project	20 MW
4) Oletukat	Multipurpose Dam Project	36 MW
5) Leshota	Multipurpose Dam Project	54 MW
6) Oldorko	Multipurpose Dam Project	90 MW

Water Resources Development Plan

1) Storage Dams	10 nos. (659 MCM)
2) Small Storage Dams and Pans	3,640 nos. (182 MCM)
3) Boreholes:	160 nos. (16 MCM/year)
4) Inter-basin Transfer (from Itare and Londiani Dams to Nakuru)	41 MCM/year
5) Inter-basin Transfer (from Amala Dam to Ewaso Ng'iro South River)	82 MCM/year

LEGEND

Irrigation Potential Area
Water Transfer (Existing)
Dam(Existing)



Note: See a close-up view shown in Figure 19.1.13
Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030

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Figure 10.1.5
Proposed Development Plans for Rift Valley Catchment Area

Proposed Management Plans

Water Resources Management Plan

1) Monitoring Networks
   - Surface Water Monitoring Station 23 locations
   - Rainfall Monitoring Station 47 locations
   - Groundwater Monitoring Station 10 locations
   - Reference Point 4 locations
2) Evaluation of Water Resources
3) Improvement of Water Permit Issue and Management System
4) Watershed Conservation (Forestation and Small Water Sources Conservation)

Flood and Drought Disaster Management Plan

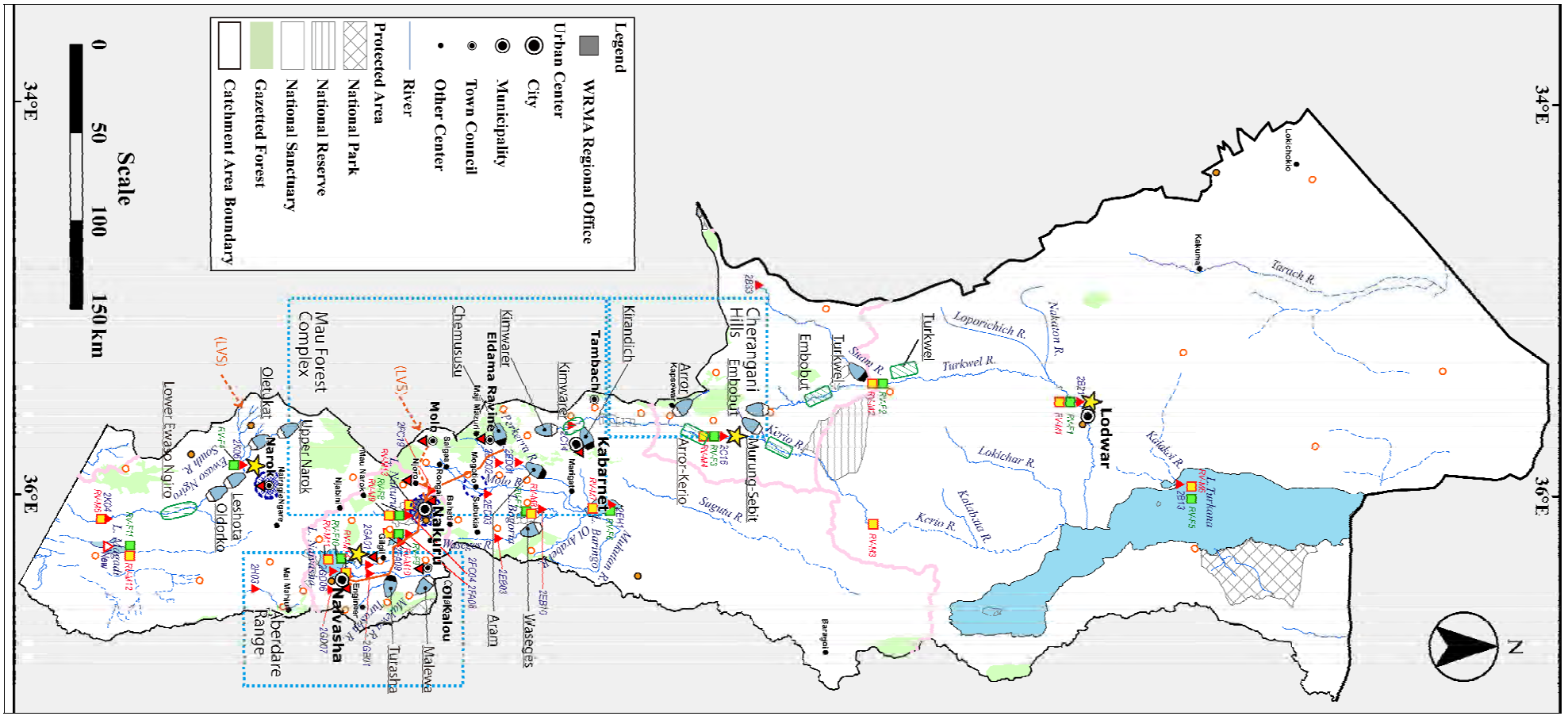
1) Flood Management
   a) Narok: flood control by river improvement and dam, and preparation of flood hazard map and evacuation plan
   b) Mogotio: flood control by river improvement and preparation of hazard map
   c) Narok: provision of urban drainage measures
   d) Nakuru: provision of urban drainage measures
2) Drought Management
   a) Establishment of Basin Drought Conciliation Councils
   b) Early Drought Forecasting based on long-term rainfall prediction
   c) Water Use Restriction Rule for Reservoirs (Existing 5 dams and proposed 10 dams)

Environmental Management Plan

1) Setting of Environmental Flow Rate 12 locations
2) Environmental Monitoring 14 locations

LEGEND

- Dam(Existing)
- Dam (Proposed)
- Water Transfer (Existing)
- Water Transfer (Proposed)
- Sub-regional Boundary



Note: See a close-up view shown in Figure 19.1.13
Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 10.1.6** **Proposed Management Plans for Rift Valley Catchment Area**
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