Proposed Development Plans

Water Supply Development Plan
Urban Water Supply Development
(32 Urban Centers)
1) Rehabilitation (30 UC) 699,000 $m^3$/day
2) Expansion (29 UC) 1,542,000 $m^3$/day
3) New Construction (2 UC) 19,000 $m^3$/day
4) Service Population 17.01 million
Rural Water Supply (10 Counties)
1) Large Scale 209,000 $m^3$/day
2) Small Scale 110,000 $m^3$/day
3) Target Population 4.04 million

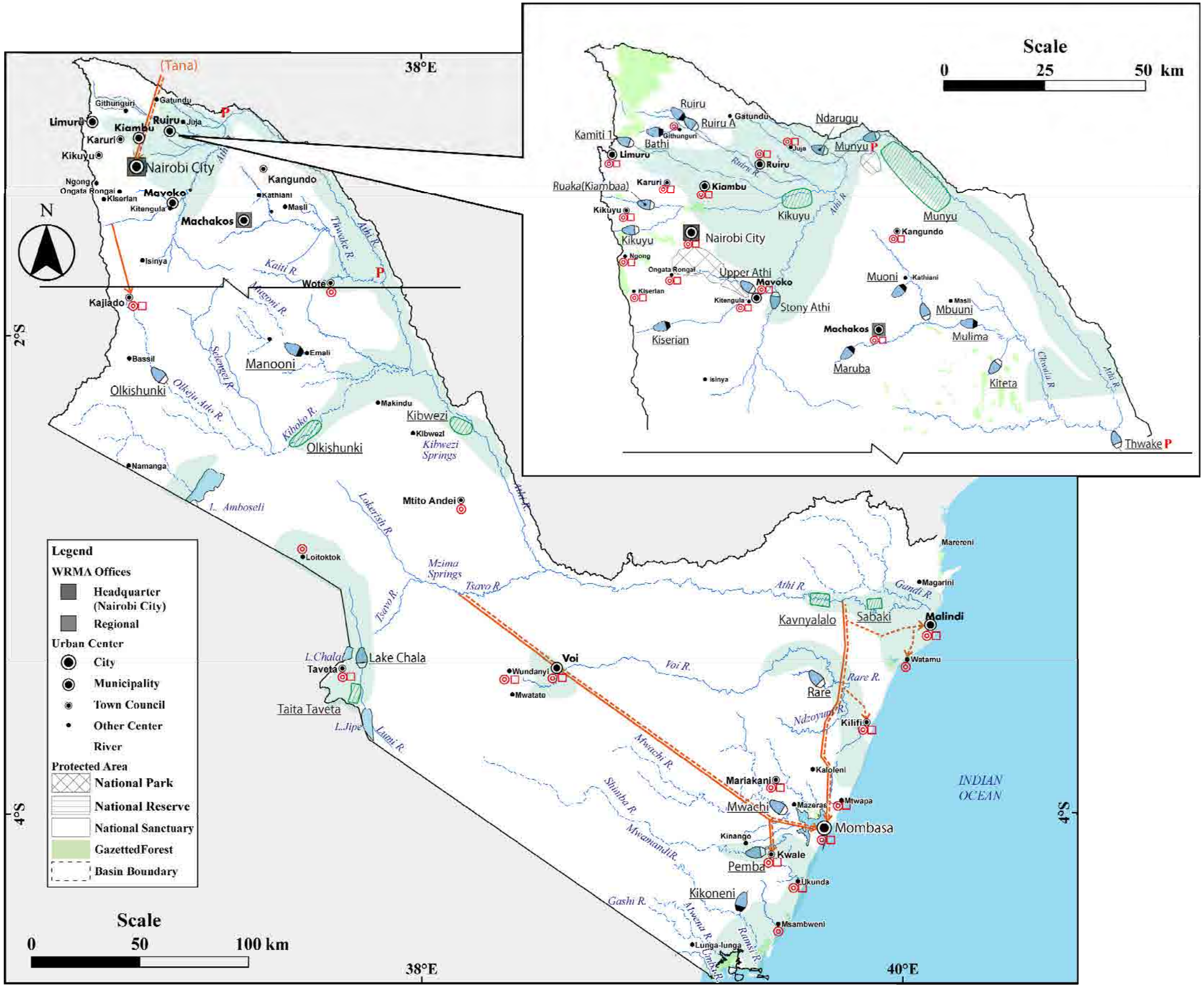
Sanitation Development Plan
Sewerage Development (25 Urban Centers)
1) Rehabilitation (6 UC) 244,000 $m^3$/day
2) Expansion (6 UC) 715,000 $m^3$/day
3) New Construction (19 UC) 430,000 $m^3$/day
4) Service Population 16.26 million
On-site Sanitation (10 Counties)
1) Installation of Proper On-site Sanitation Facilities by Individual or Communities
2) Target Population 4.28 million

Irrigation Development Plan
Large Scale Irrigation Area
1) Large Scale Irrigation 37,280 ha (4 Projects)
2) Small Scale Irrigation 6,484 ha (10 Counties)
3) Private Sector Irrigation 2,344 ha (10 Counties)

P Hydropower Development Plan
1) Munyu Multipurpose Dam Project 40MW
2) Thwake Multipurpose Dam Project 20MW

Water Resources Development Plan
1) Storage Dams 16 nos. (1,689 MCM)
2) Small Storage Dams and Pans 1,880 nos. (94 MCM)
3) Boreholes 350 nos. (35 MCM/year)
4) Inter-basin Transfer 168 MCM/year (from Tana CA to Nairobi, Ext.)
5) Intra-basin Transfer 37 MCM/year (from Mzima Spring to Mombasa/Kwale/Ukunda, Ext.)
6) Intra-basin Transfer 31 MCM/year (from Athi R. to Mombasa/ Malindi/Kilifi/Mtwapa, Ext.)
7) Desalination for Mombasa 93 MCM/year

LEGEND
Dam(Existing)
Water Transfer (Existing)
Irrigation Potential Area




| THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030 | Figure 10.1.7 Proposed Development Plans for Athi Catchment Area |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | |

Source: JICA Study Team

Proposed Management Plans

Water Resources Management Plan
1) Monitoring Networks
- Surface Water Monitoring Station 26 locations
- Rainfall Monitoring Station 38 locations
- Groundwater Monitoring Station 24 locations
- Reference Point 2 locations

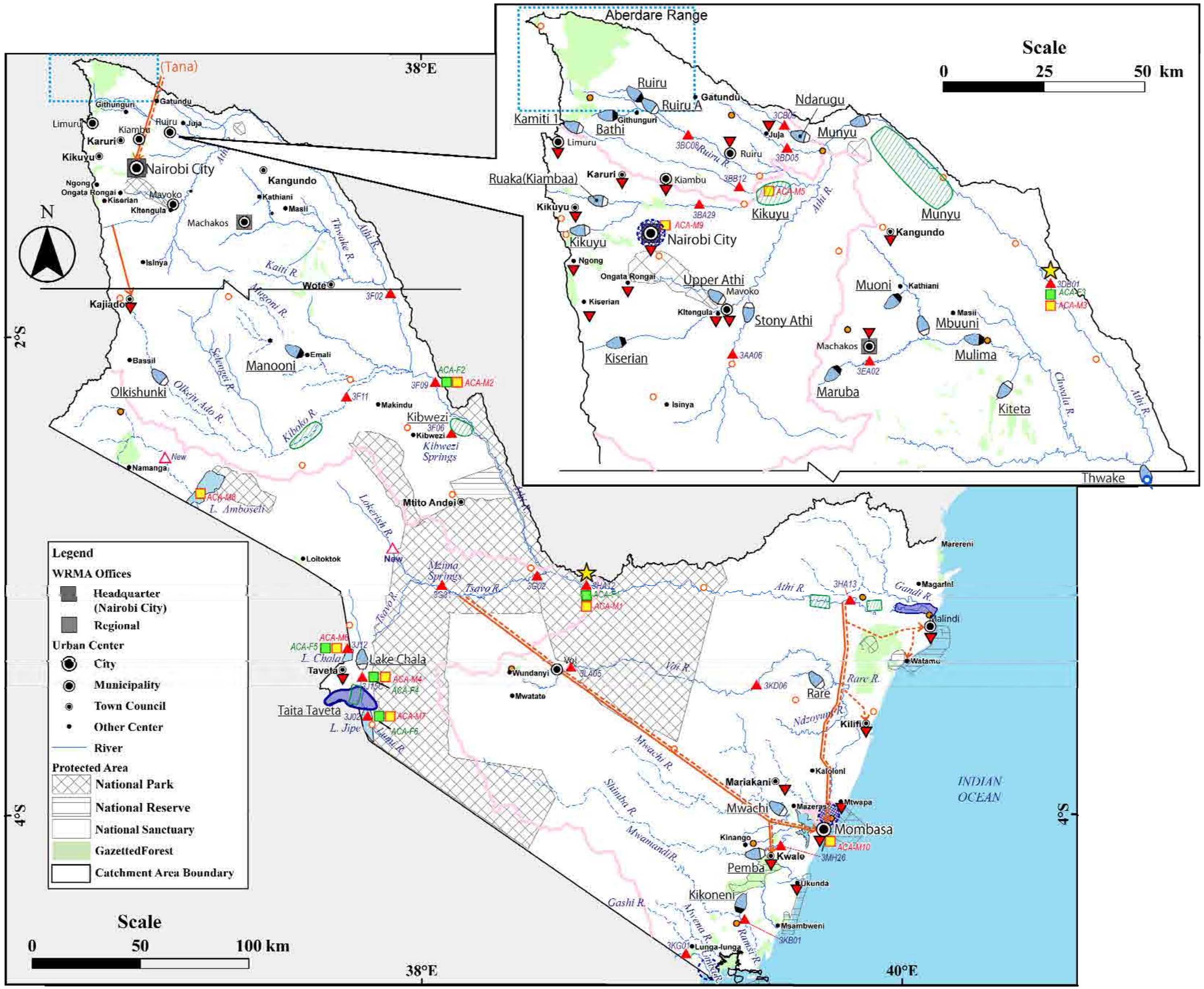
2) Evaluation of Water Resources
3) Improvement of Water Permit Issue and Management System
4) Watershed Conservation (Forestation and Small Water Sources Conservation)

Flood and Drought Disaster Management Plan
1) Flood Management
- a) 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

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 8 dams and proposed 16 dams)

Environmental Management Plan
1) Setting of Environmental Flow Rate 5 locations
2) Environmental Monitoring 10 locations

LEGEND
- Dam(Existing)
- Dam (Proposed)
- Water Transfer (Existing)
- Water Transfer (Proposed)
- Sub-regional Boundary




| THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030 | Figure 10.1.8 Proposed Management Plans for Athi Catchment Area |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | |

Source: JICA Study Team

Proposed Development Plans

Water Supply Development Plan

Urban Water Supply Development
(23 Urban Centers)

1) Rehabilitation (15 UC) 106,000 $m^3$/day
2) Expansion (14 UC) 349,000 $m^3$/day
3) New Construction (8 UC) 88,000 $m^3$/day
4) Service Population 4.90 million

Rural Water Supply (16 Counties)

1) Large Scale 211,000 $m^3$/day
2) Small Scale 145,000 $m^3$/day
3) Target Population 4.96 million

Sanitation Development Plan

Sewerage Development (18 Urban Centers)

1) Rehabilitation (6 UC) 32,000 $m^3$/day
2) Expansion (6 UC) 118,000 $m^3$/day
3) New Construction (12 UC) 248,000 $m^3$/day
4) Service Population 5.24 million

On-site Sanitation (16 Counties)

1) Installation of Proper On-site Sanitation Facilities by Individual or Communities
2) Target Population 6.13 million

Irrigation Development Plan

Large Scale Irrigation Area

1) Large Scale Irrigation 135,961 ha (4 Projects)
2) Small Scale Irrigation 15,784 ha (15 Counties)
3) Private Sector Irrigation 10,054 ha (15 Counties)

Hydropower Development Plan

P Hydropower Development

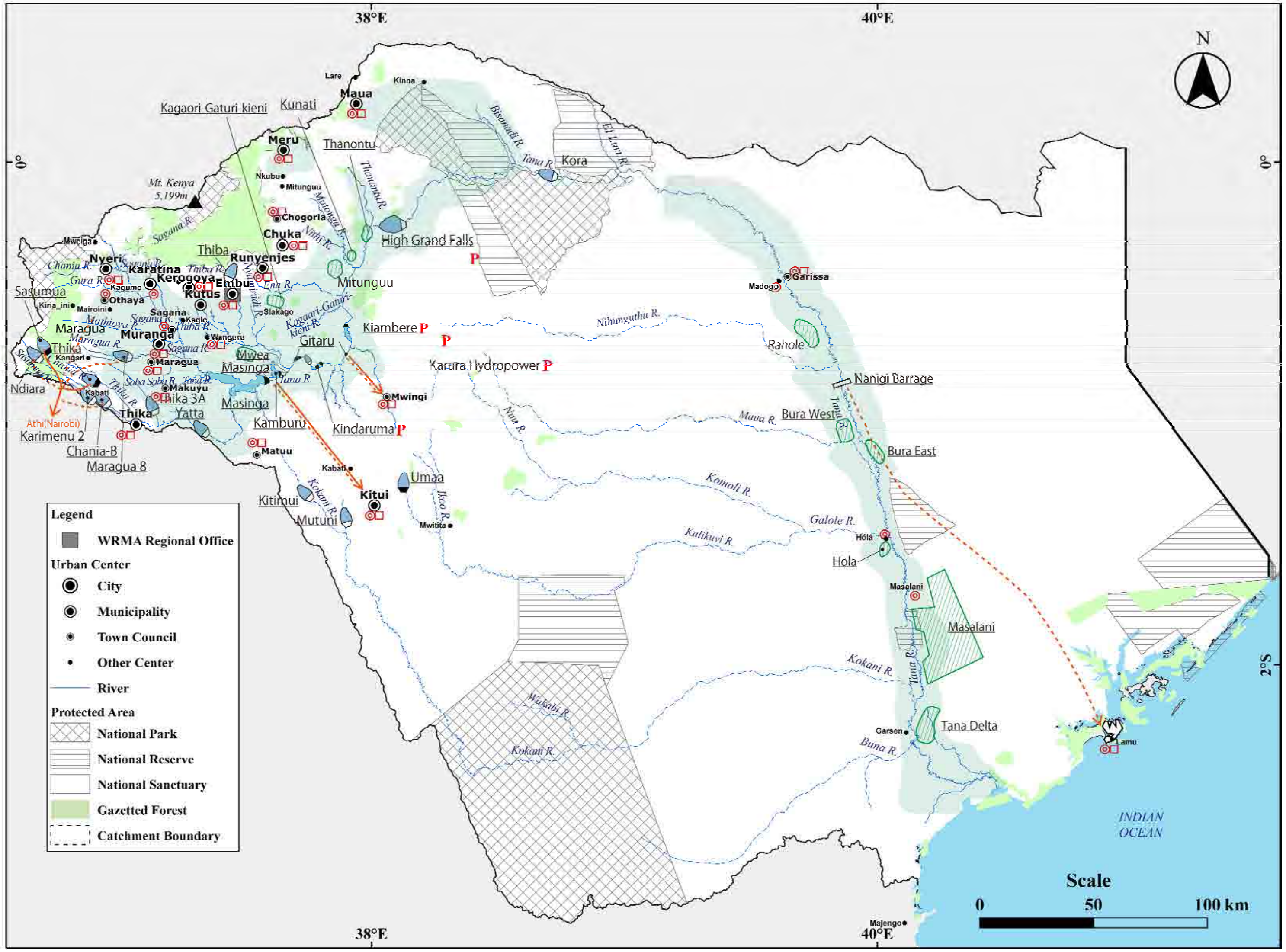
1) Kindaruma Hydropower Upgrade +32 MW
2) High Grand Falls Multipurpose Dam Project Stage 1: 500 MW Stage 2: +200 MW
3) Karura Hydropower Project 90 MW

Water Resources Development Plan

1) Storage Dams 11 nos. (5,729 MCM)
2) Small Storage Dams and Pans 3,020 nos. (151 MCM)
3) Boreholes: 1,440 nos. (144 MCM/year)
4) Inter-basin Transfer 168 MCM/year (from Tana CA to Nairobi, Ext.)
5) Intra-basin Transfer 23 MCM/year (from Masinga Dam to Kitui, Ext.)
6) Intra-basin Transfer 2 MCM/year (from Kiambere Dam to Mwingi, Ext.)
7) Intra-basin Transfer 69 MCM/year (from Tana R. to Lamu)

LEGEND

Dam(Existing)
Water Transfer (Existing)
Irrigation Potential Area




Note: See a close-up view shown in Figure 19.1.14.
Source: JICA Study Team

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

**Figure 10.1.9**
**Proposed Development Plans for Tana Catchment Area**

Proposed Management Plans

Water Resources Management Plan

1) Monitoring Networks
   - Surface Water Monitoring Station 26 locations
   - Rainfall Monitoring Station 47 locations
   - Groundwater Monitoring Station 18 locations
   - Reference Point 3 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

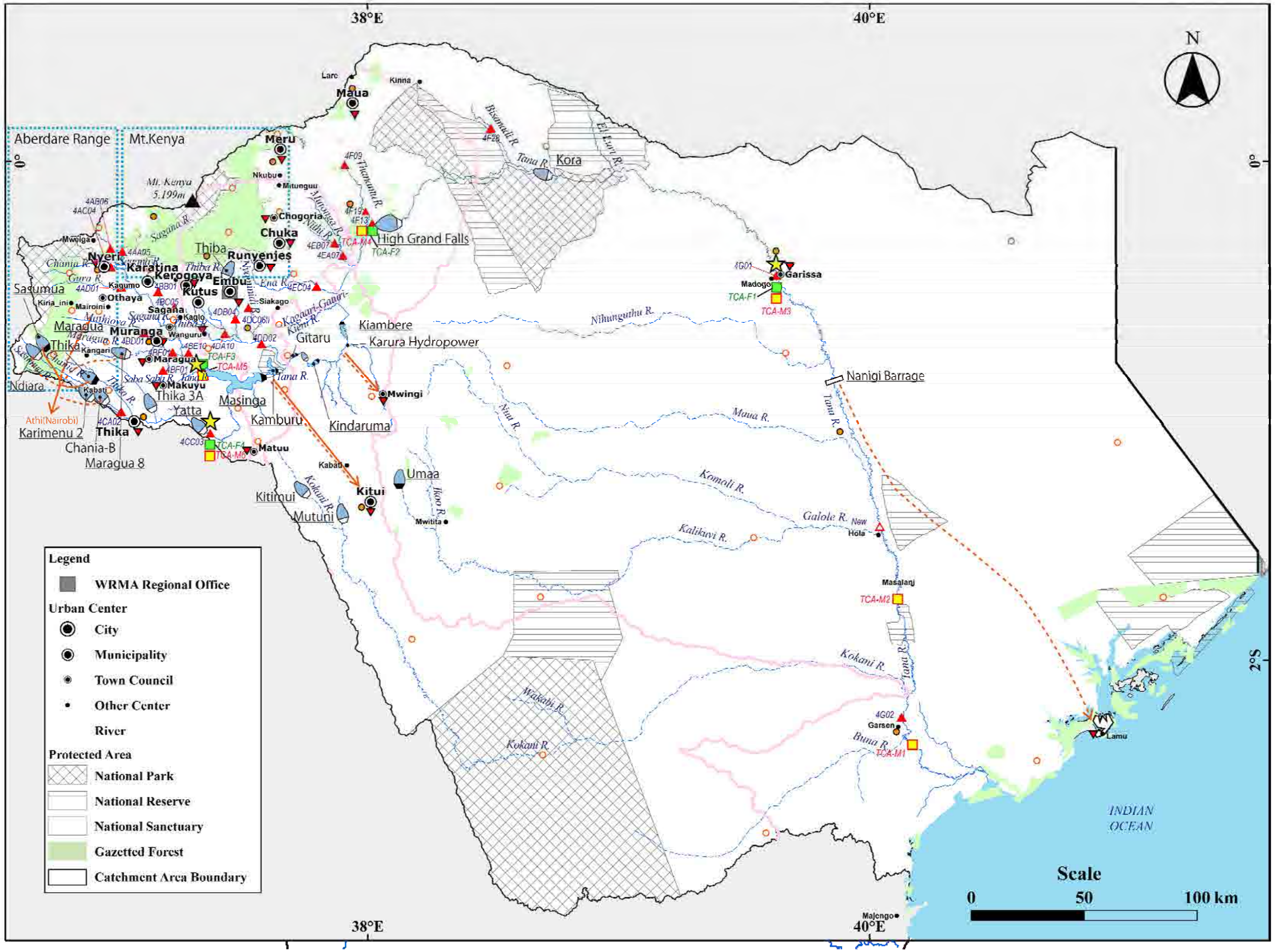
1) Flood Management
   - a) Garissa: flood control by river structure and dam, and preparation of flood hazard map and evacuation plan
   - b) Lower Tana: community-based disaster management
   - c) Kiambere Dam: Improvement of discharge warning system
2) Drought Management
   - a) Establishment of Basin Drought Conciliation Councils
   - b) Early Drought Forecasting based on long-term rainfall prediction
   - c) Water Use Restriction Rule for Reservoirs (Existing 8 dams and proposed 11 dams)

Environmental Management Plan

1) Setting of Environmental Flow Rate 4 locations
2) Environmental Monitoring 6 locations

LEGEND

- Dam(Existing)
- Dam (Proposed)
- Water Transfer (Existing)
- Water Transfer (Proposed)
- Sub-regional Boundary




Note: See a close-up view shown in Figure 19.1.14

Source: JICA Study Team

| THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030 | Figure 10.1.10 Proposed Management Plans for Tana Catchment Area |
| --- | --- |
| JAPAN INTERNATIONAL COOPERATION AGENCY | |

Proposed Development Plans

Water Supply Development Plan

Urban Water Supply Development
(12 Urban Centers)
1) Rehabilitation (6 UC) 32,000 $m^3$/day
2) Expansion (6 UC) 61,000 $m^3$/day
3) New Construction (6 UC) 31,000 $m^3$/day
4) Service Population 1.04 million

Rural Water Supply (14 Counties)
1) Large Scale 119,000 $m^3$/day
2) Small Scale 101,000 $m^3$/day
3) Target Population 3.36 million

Sanitation Development Plan

Sewerage Development (5 Urban Centers)
1) Rehabilitation (2 UC) 5,000 $m^3$/day
2) Expansion (2 UC) 27,000 $m^3$/day
3) New Construction (3 UC) 30,000 $m^3$/day
4) Service Population 0.82 million

On-site Sanitation (14 Counties)
1) Installation of Proper On-site Sanitation Facilities by Individual or Communities
2) Target Population 3.58 million

Irrigation Development Plan

Large Scale Irrigation Area
1) Large Scale Irrigation 26,202 ha (3 Projects)
2) Small Scale Irrigation 8,116 ha (10 Counties)
3) Private Sector Irrigation 7,165 ha (10 Counties)

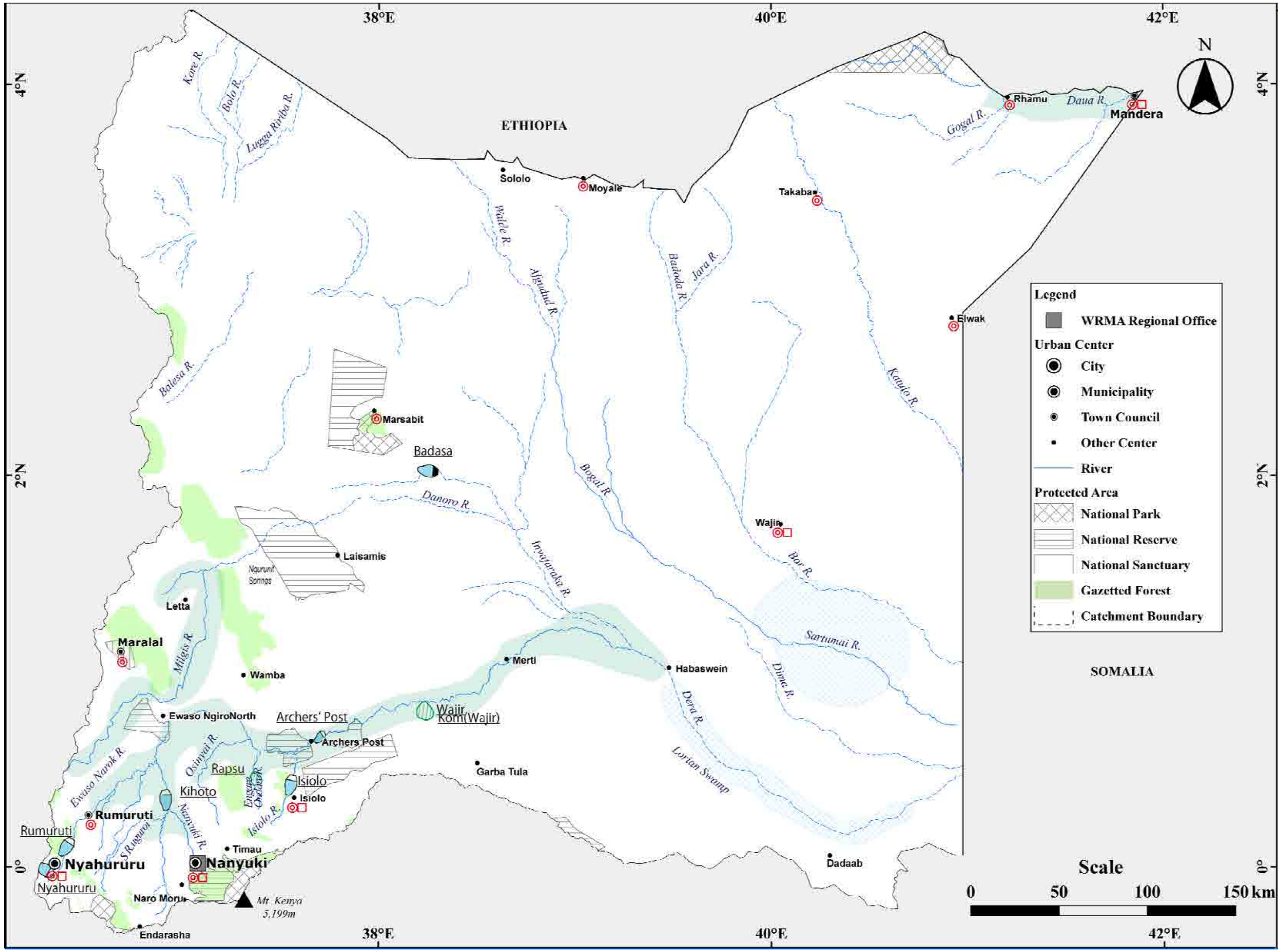
Hydropower Development Plan

(No Plan)

Water Resources Development Plan
1) Storage Dams 5 nos. (522 MCM)
2) Small Storage Dams and Pans 1,820 nos. (91 MCM)
3) Boreholes: 1,560 nos. (156 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 10.1.11
Proposed Development Plans for Ewaso Ng'iro North Catchment Area

Proposed Management Plans

Water Resources Management Plan

1) Monitoring Networks

| | | |
|---|---|---|
| | Surface Water Monitoring Station | 13 locations |
| | Rainfall Monitoring Station | 34 locations |
| | Groundwater Monitoring Station | 5 locations |
| | Reference Point | 1 location |

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

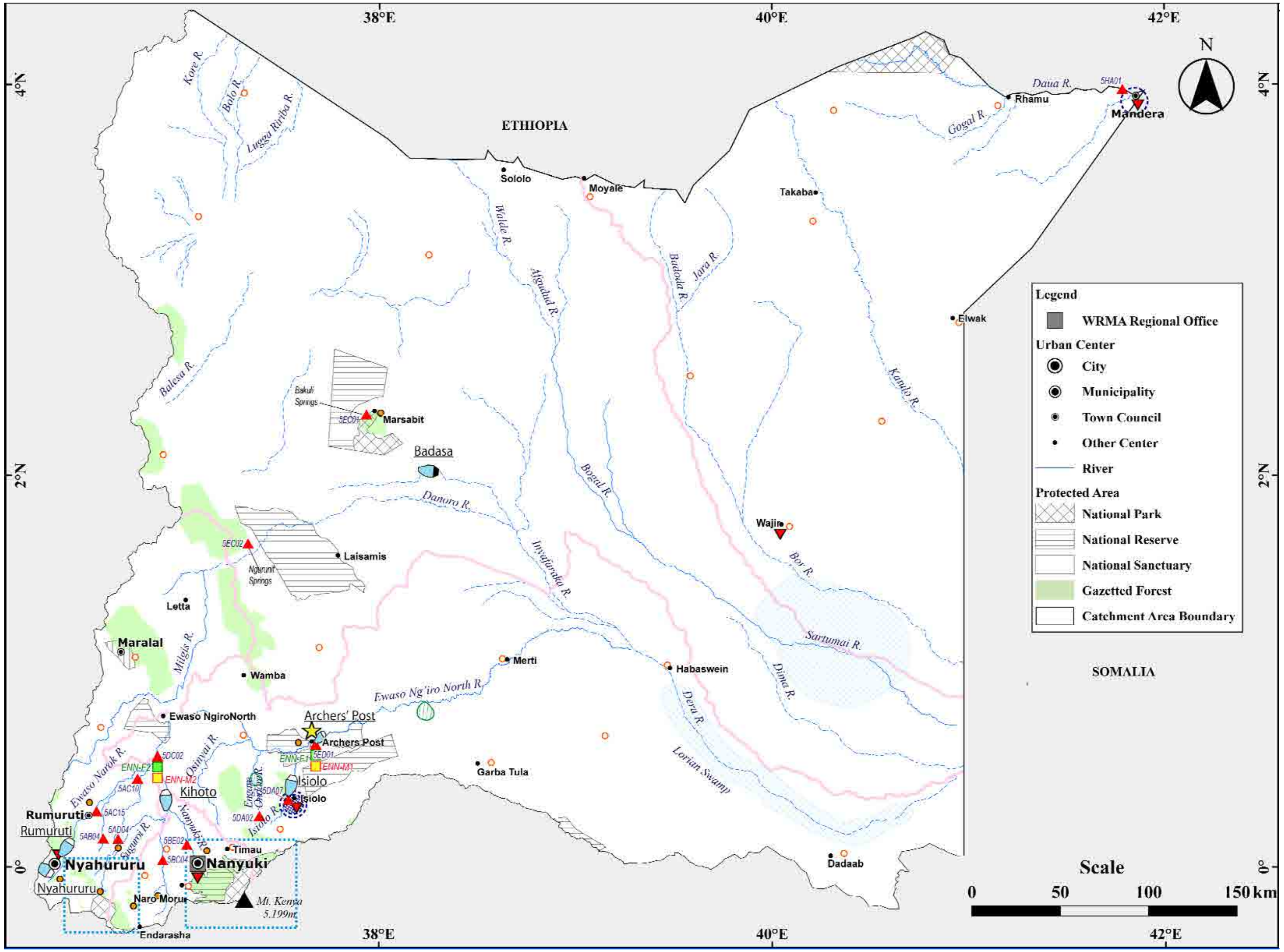
1) Flood Management
   a) Mandera: flood control by river structures, and preparation of flood hazard map and evacuation plan
   b) Isiolo: flood control by river structures and preparation of flood hazard map
   c) Isiolo: provision of urban drainage measures
2) Drought Management
   a) Establishment of Basin Drought Conciliation Councils
   b) Early Drought Forecasting based on long-term rainfall prediction
   c) Water Use Restriction Rule for Reservoirs (Existing 1 dam and proposed 5 dams)

Environmental Management Plan

1) Setting of Environmental Flow Rate — 2 locations
2) Environmental Monitoring — 2 locations

LEGEND

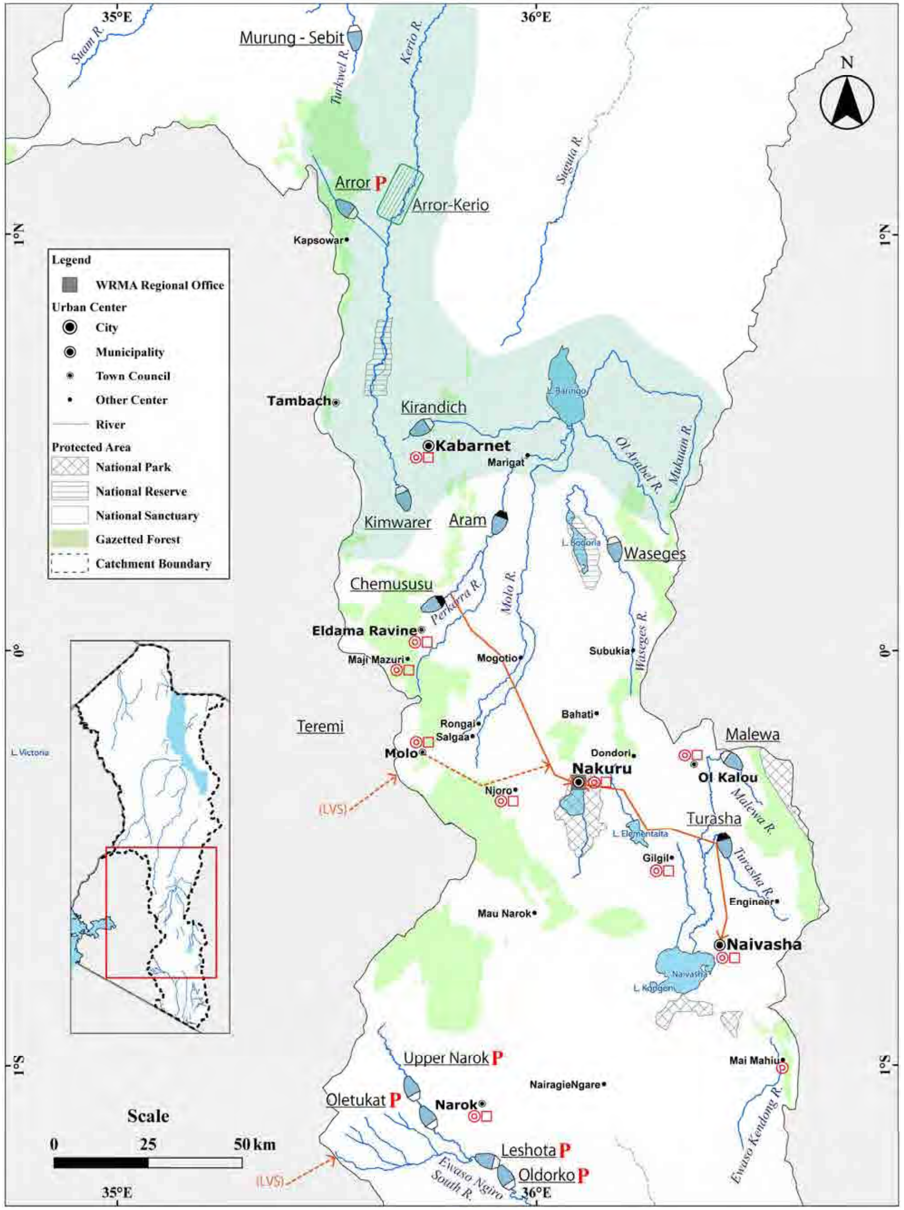
Dam(Existing)
Dam (Proposed)
Water Transfer (Existing)
Water Transfer (Proposed)
Sub-regional Boundary



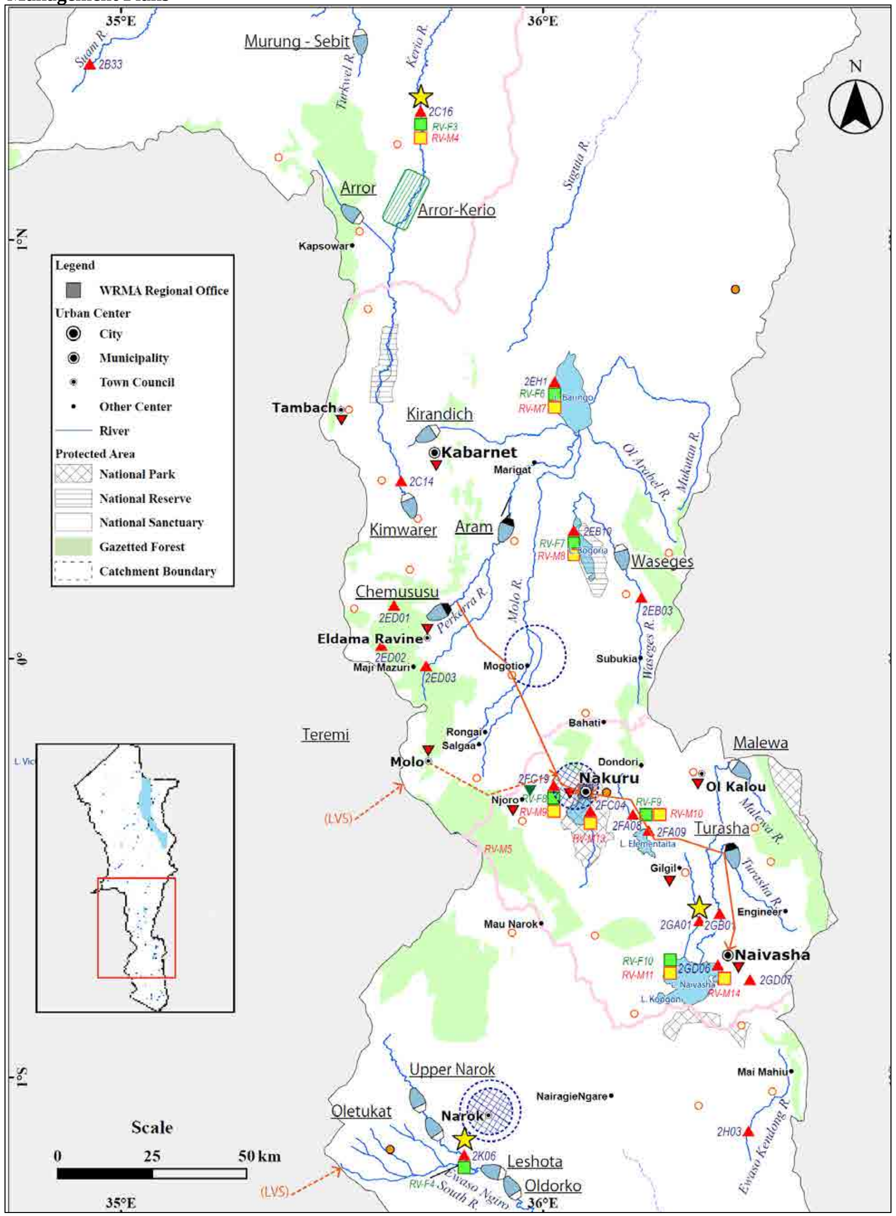

Source: JICA Study Team

| THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030 | Figure 10.1.12 Proposed Management Plans for Ewaso Ng'iro North Catchment Area |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | |

**Development Plans**



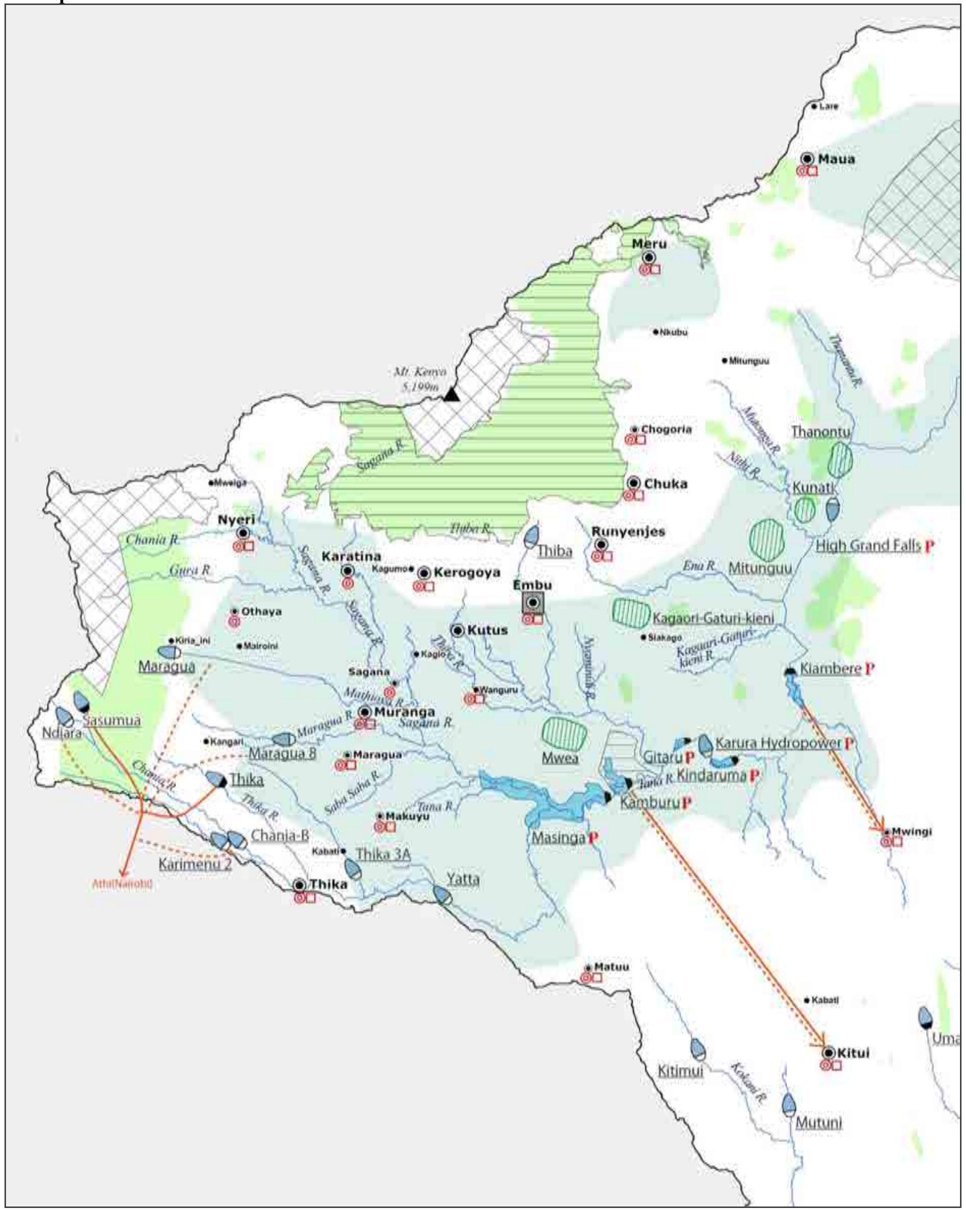

**Management Plans**



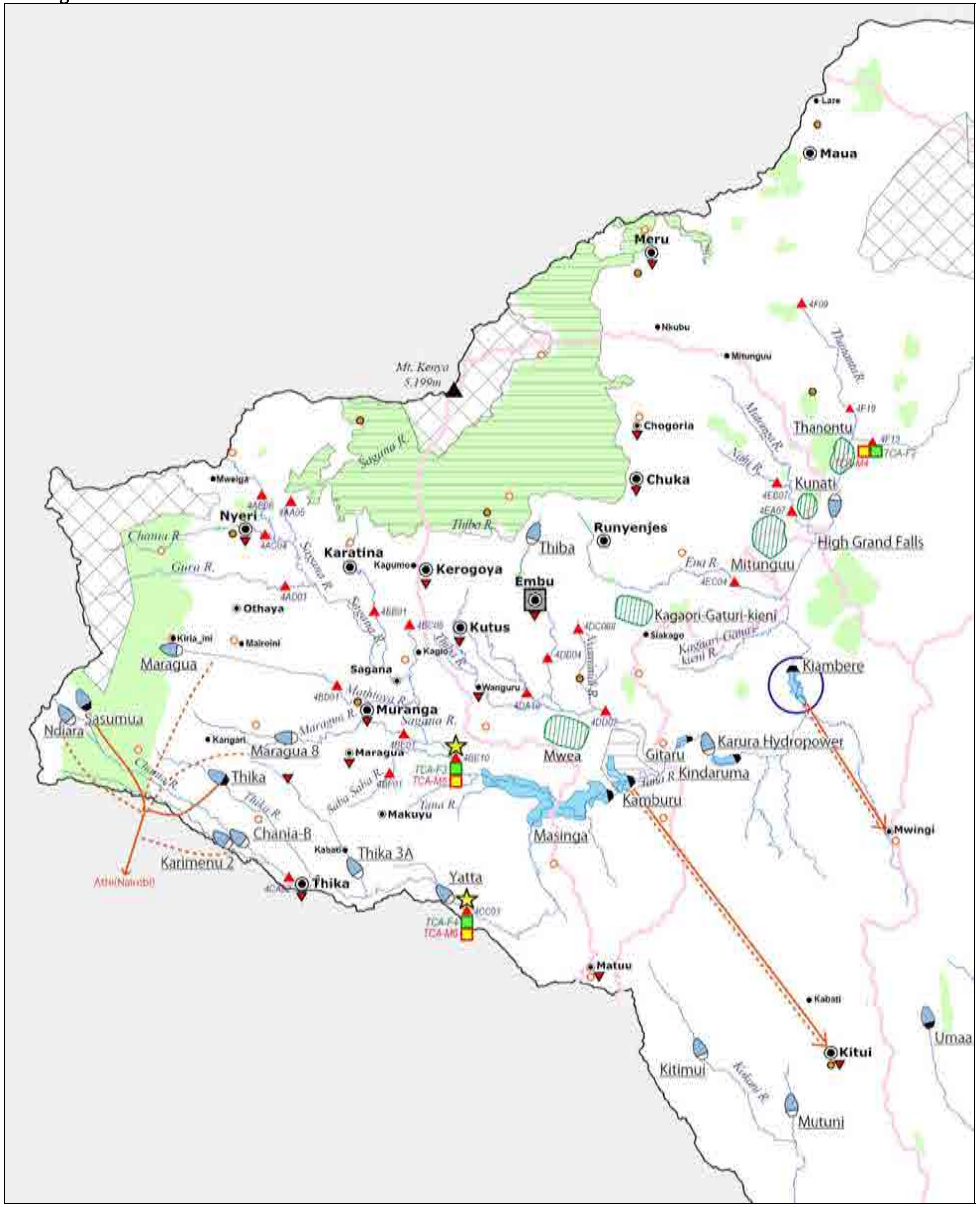

| THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030 | **Figure 10.1.13** |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | **Close-up View of Proposed Plans for Central-Southern Part of Rift Valley Catchment Area** |

Source: JICA Study Team

Development Plans




Management Plans






Source: JICA Study Team

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

**Figure 10.1.14**
**Close-up View of Proposed Plans for Western Part of Tana Catchment Area**

# *Part B*
# *Lake Victoria North Catchment Area*


**Location Map (LVNCA)**

# 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 B: LAKE VICTORIA NORTH CATCHMENT AREA

**Location Map**
**Abbreviation**

**<u>Table of Contents</u>**

## List of Tables

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## List of Abbreviations and Acronyms

| | | |
|---|---|---|
| ALRMP | : | Arid Land Resources Management Project |
| ASAL | : | Arid and Semi-arid Land |
| B/C | : | Benefit and Cost |
| BOD | : | Biochemical Oxygen Demand |
| BWRB | : | Basin Water Resources Board |
| COD | : | Chemical Oxygen Demand |
| D/D | : | Detailed Design |
| DDMC | : | District Disaster Management Committee |
| DO | : | Dissolved oxygen |
| EIRR | : | Economic Internal Rate of Return |
| FDFC | : | Flood Diagnostic and Forecasting Centre |
| FEWS | : | Flood Early Warning System |
| GOK | : | Government of Kenya |
| IFM | : | Integrated Flood Management |
| JICA | : | Japan International Cooperation Agency |
| KMD | : | Kenya Meteorological Department |
| LCPDP | : | Least Cost Power Development Plan |
| LSRWSS | : | Large Scale Rural Water Supply System |
| LVN | : | Lake Victoria North |
| LVNCA | : | Lake Victoria North Catchment Area |
| LVS | : | Lake Victoria South |
| MDNKOAL | : | Ministry of State for Development of Northern Kenya and Other Arid Lands |
| MEMR | : | Ministry of Environment and Mineral Resources |
| MORDA | : | Ministry of Regional Development Authority |
| MOSSP | : | Ministry of State for Special Programmes |
| MWI | : | Ministry of Water and Irrigation |
| NDOC | : | National Disaster Operation Centre |
| NIB | : | National Irrigation Board |
| NRW | : | Non-Revenue Water |
| NWCPC | : | National Water Conservation and Pipeline Corporation |
| NWMP | : | National Water Master Plan |
| O&M | : | Operation and Maintenance |
| PDMC | : | Provincial Disaster Management Committee |
| PS | : | Permanent Secretary |
| RVCA | : | Rift Valley Catchment Area |
| SS | : | Suspended Solids |
| SSRWSS | : | Small Scale Rural Water Supply System |
| T-N | : | Total Nitrogen |
| T-P | : | Total Phosphorus |
| WASREB | : | Water Services Regulatory Board |
| WKCDD&FMP | : | Western Kenya Community Driven Development and Flood Mitigation Project |
| WRMA | : | Water Resource Management Authority |
| WRUA | : | Water Resources Users Association |

| | | |
|---|---|---|
| WSB | : | Water Service Board |
| WSC | : | Water Service Company / Water and Sewerage Company |
| WSP | : | Water Service Provider |
| WWTP | : | Waste Water Treatment Plant |

# 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

The National Water Master Plan 2030 (NWMP 2030) covers the whole area of Kenya. The plans for water resources development and management were formulated for the six catchment areas of Water Resources Management Authority (WRMA), designated by the National Water Resources Management Strategy (2007-2009) for water resources management purposes.

This volume, Main Report Part B, presents the water master plan for the Lake Victoria North Catchment Area (LVNCA). The water master plan for LVNCA consists of the following eight component plans as mentioned in the Chapter 7 of the Main Report Part A:

<u>Development plans</u>

a) Water supply development plan
b) Sanitation development plan
c) Irrigation development plan
d) Hydropower development plan
e) Water resources development plan

<u>Management plans</u>

f) Water resources management plan
g) Flood and drought disaster management plan
h) Environmental management plan

The Main Report Part B for LVNCA includes catchment area characteristics, water resources, water demands, development and management plans, water allocation plan, cost estimates, economic evaluation, and implementation programs. The plans were formulated based on the water resources assessment, water demand projection, objectives, and overall concepts of respective subsectors presented in the Main Report Part A. The development plans aim to provide basis for future water demand projection, while the management plans aim to propose frameworks for sustainable water resources management including the aspects of flood, drought, and environment.

# CHAPTER 2 CATCHMENT CHARACTERISTICS

LVNCA is located at the western part of the country, and surrounded by Mt. Elgon in the north, and Cherengani Hills and the Mau Forest Complex in the east. LVNCA borders on Uganda in the west and faces Lake Victoria in the southwest. Total area of LVNCA is 18,374 km$^2$, corresponding to 3.2% of the country's area. Based on the Census 2009, the population of the area in 2010 was estimated at 6.97 million, or 18.1% of the total population of Kenya. Its population density is as high as 379 persons/km$^2$.

The topography of LVNCA varies from Mt. Elgon peak at 4,321 m above sea level amsl to Lake Victoria at 1,134 m amsl. The whole area of LVNCA lies in the highlands of more than 1,000 m amsl.

Major rivers are Nzoia, Yala, Malaba, Malikisi, and Sio rivers. The Nzoia River is the largest river with a drainage area of 12,853 km$^2$, or 70.0% of LVNCA, and is followed by the Yala River with a drainage area of 3,259 km$^2$. Both rivers flow into Lake Victoria. The Sio, Lwakhakha, Malakisi and Malaba rivers flow across the border with Uganda. The Sio River pours into Lake Victoria along the border with Uganda. Total drainage area of these four transboundary rivers accounts for 2,301 km$^2$, or 12.5% of LVNCA.

Lake Victoria is the second largest freshwater lake in the world and strides the borders of Kenya, Tanzania, and Uganda.

LVNCA is classified as a humid land, and not as arid and semi-arid land (non-ASAL). The mean annual rainfall ranges between 1,200 mm to 1,800 mm and the catchment area average mean annual rainfall comes to 1,420 mm. The renewable water resources which are defined by precipitation minus evapotranspiration, are estimated at 6.0 BCM/year in 2010 for LVNCA and the per capita renewable water resources is calculated at 855 m$^3$/year/capita.

Major cities and towns in LVNCA are Eldoret, Kakamega, Kitale, Bungoma, Kapenguria, Busia, Siaya, Vihiga and Kapsabet. LVNCA includes the whole area of Busia, Bungoma, and Kakamega counties; the large part of Siaya, Vihiga, Nandi, Uasin Gishu, and Trans-Nzoia counties; and small parts of Elgiyo Marakwet and West Pokot counties.

Eldoret is the largest city in LVNCA with various kinds of industries such as agricultural equipment, brewing and beverages, food processing, chemicals and pharmaceuticals, leather, textiles, timber and timber products, and light engineering. Food processing and light engineering in Kitale and paper industry in Webuye are also famous in LVNCA.

# CHAPTER 3 WATER RESOURCES, WATER DEMANDS AND WATER ALLOCATION

## 3.1 General

Future water demands will increase due to population growth and economic activities. On the other hand, available water resources are limited and affected by climate change. The water resources development and management plans in this study need to be formulated for appropriate allocation of the limited and climate-affected water resources to meet the future increase in water demands of various water users.

The available water resources consisting of surface water and groundwater were estimated for the years of 2010 (considered as present) and 2030, as detailed in Chapter 5 of the Main Report Part A and Sectoral Report (B). The estimates for 2030 include climate change impacts.

The present water uses were estimated and future water demands for the year of 2030 were projected for the subsectors of domestic, industrial, irrigation, livestock, wildlife, and inland fisheries. Since the available records on actual water uses at present were insufficient, the present water demands were estimated and will be considered as the water uses. Future water demand projections were based on the socioeconomic frameworks set in Kenya Vision 2030. The estimates and projections are detailed in Chapter 6 of the Main Report Part A and in Sectoral Reports (C) and (E).

The appropriate allocation of available water resources for 2030 was studied through the water balance studies to meet the 2030 water demands. The allocation was based on concepts and strategies for water resources development planning as well as the allocation policies derived from the current situations of the water balance between the present water resources and water demands and future trends as presented in Chapter 7 of the Main Report Part A and in Section 4.6 of this report. Through the allocation study, the water demands were modified to be supplied within the resources capacity.

The following sections briefly explain the available water resources, present water uses, future water demands, and proposed water allocation plan for LVNCA, which serve as basis for water resources development and management plans.

## 3.2 Available Water Resources

The available water resources consisting of the surface water runoff and sustainable yield of groundwater were estimated in LVNCA for the years of 2010 and 2030 as follows:

**Annual Available Water Resources (LVNCA)**

(Unit: MCM/year)

| Year | Surface Water | Groundwater | Total |
|---|---|---|---|
| 2010 | 4,626 | 116 | 4,742 |
| 2030 | 4,969 | 108 | 5,077 |
| Percentage of 2010 values | 107% | 93% | 107% |

Source: JICA Study Team (Ref. Main Report Part A, Sub-section 5.2.3)

The sustainable yield of groundwater was derived as 10% of the groundwater recharge in the catchment area excluding river courses and riparian areas with a width of 1 km, where groundwater abstraction will need to be restricted. Climate change impacts were incorporated into the above estimates for 2030. Details of the above values for annual available water resources are presented in Section 5.2 of the Main Report Part A.

The above table shows that the 2030 surface water runoff will increase to 107% of 2010 runoff, while the 2030 sustainable yield of groundwater will decrease to 93% of 2010 yield, both due to climate change impacts, resulting in an increase of 2030 available water resources to 107% of 2010 resources.

The hydrological analysis of this study explained in the Sectoral Report (B) also disclosed that the rainfall may increase in the western highland areas and may be unchanged or decrease in the coastal area in the long rainy season, but the rainfall may be almost unchanged throughout the country and slightly decrease in the coastal areas in the dry season in the future. This implies that the availability of water resources is expected to be more unevenly distributed spatially and temporally in the future.

## 3.3 Present Water Uses and Future Water Demands under Kenya Vision 2030

The annual water demands were estimated for the year 2010 and projected for 2030 in LVNCA for the domestic, industrial, irrigation, livestock, wildlife and inland fisheries subsectors. The projection for 2030 followed the national development targets of Kenya Vision 2030 and socioeconomic framework. Basic conditions of the estimates and projections and their results are described in Chapter 6 of the Main Report Part A.

The annual water demands for 2010 and 2030 are as summarised below.

**Water Demands by Subsector (LVNCA)**

(Unit: MCM/year)

| Year | Domestic | Industrial | Irrigation | Livestock | Wildlife | Fisheries | Total |
|---|---|---|---|---|---|---|---|
| 2010 | 169 | 6 | 18 | 26 | 0 | 9 | 228 |
| 2030 | 424 | 19 | 817 | 61 | 0 | 16 | 1,337 |

Source: JICA Study Team, (Ref. Main Report Part A, Section 6.10 and Setoral Report (G), Sub-section 3.3.1 (3))

The total projected water demand of 1,337 MCM/year in 2030 is approximately 5.9 times of the present water demand of 228 MCM/year due to increase in population from 6.96 million to 12.36 million and irrigation areas from 1,876 ha to 92,662 ha mentioned in Chapter 6 of the Main Report Part A. Monthly water demands in 2030 by sub-basin are shown in Table 3.3.1.

## 3.4 Proposed Water Allocation Plan

(1) Water Balance Study

The available water resources and water demands for both of 2010 and 2030 presented in the preceding sections are compared as follows:

**Available Water Resources and Water Demands (LVNCA)**

(Unit: MCM/year)

| 2010 | | | 2030 | | |
|---|---|---|---|---|---|
| Water Resources | Water Demands | Percentage | Water Resources | Water Demands | Percentage |
| 4,742 | 228 | 5% | 5,077 | 1,337 | 26% |

Source: JICA Study Team

Although the present water demands in 2010 are estimated to be 5% of the available water resources, the water demands for 2030 are expected to increase largely up to 26% of the available water resources in 2030. The ratio of 26% of water demand to water resources, which is called a water stress ratio, does not seem to indicate severe situation in the water balance for the catchment area compared with the ratio of 40% regarded to indicate severe water stress. The catchment area which does not show severe balance situation implies that there may be additional water resources available for demands more than the projected ones stated in Section 3.3.

In order to examine a more detailed situation of future water balance from the spatial and temporal perspectives, a surface water balance study for 2030 was carried out. Since the surface water demands occupy more than 80% of the total demands nationwide, it was judged that the surface water balance would give general situation of water deficits. This study divided the catchment area into 38 sub-basins and applied a study model with the existing dams and water transfers only, as discussed in Section 6.11 of the Main Report Part A. Conditions of the water balance study are described in Subsection 4.6.3 of this report and detailed in Chapter 4 of the Sectoral Report (G).

Results of the surface water balance study showed water deficits as estimated in most of the sub-basins in LVNCA as seen in Figure 6.11.2 of the Main Report Part A. The water deficits derived from the water balance study for 2010 and 2030, and a comparison with water demands are summarised below.

**Water Demands and Water Deficits (LVNCA)**

(Unit: MCM/year)

| 2010 | | | 2030 | | |
|---|---|---|---|---|---|
| Water Demands | Water Deficits | Percentage | Water Demands | Water Deficits | Percentage |
| 228 | 27 | 12% | 1,337 | 371 | 28% |

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

The water deficits for 2030 in the above table suggest requirements for planning to maximise utilisation of water recourses such as maximum development of water resources, introduction of water demand management, and limitation of water demands within the water supply capacity, as detailed in Section 6.11 of the Main Report Part A.

(2) Modified Future Water Demands

Following the suggested requirements mentioned above, the water demands for 2030 described in Section 3.3 were modified in terms of irrigation water demand considering water savings and efficient water use measures. The water balance study was carried out between the water resources and the modified water demands for 2030 with provision on various water storages and supply facilities proposed in the water resources development plan stated in Section 4.6 of this report and Sectoral Report (G).

The modified water demand projections are as summarised below.

**Modified Water Demand Projections for 2030 (LVNCA)**

(Unit: MCM/year)

| Year | Domestic | Industrial | Irrigation | Livestock | Wildlife | Fisheries | Total |
|---|---|---|---|---|---|---|---|
| 2030 | 424 | 19 | 1,359 | 61 | 0 | 16 | 1,879 |

Source: JICA Study Team

The projected demand following Kenya Vision 2030 in Section 3.3 was increased to 1,879 MCM/year by increasing the irrigation water demand corresponding to the irrigation area increase to 170,789 ha.

(3) Proposed Water Allocation Plan

Results of the balance study mentioned in the above clause (2) showed the allocated amount of surface and groundwater to satisfy the 2030 modified water demand projections as follows:

**Water Resources Allocation Plan in 2030 (LVNCA)**

(Unit: MCM/year)

| Subsector | Water Demand | Water Resources Allocation | |
|---|---|---|---|
| | | Surface Water | Groundwater |
| Domestic | 424 | 363 | 61 |
| Industrial | 19 | 10 | 9 |
| Irrigation | 1,359 | 1,332 | 27 |
| Livestock | 61 | 61 | 0 |
| Wildlife | 0 | 0 | 0 |
| Fisheries | 16 | 16 | 0 |
| Total | 1,879 | 1,782 | 97 |

Source: JICA Study Team (Ref. Setoral Report (G), Sub-section 4.4.3 (3))

The total amount of allocated surface water is 1,782 MCM/year, which is about 87% of the total water demand and about 36% of the available surface water resources. The total amount of allocated groundwater is 97MCM/year, which is about 5% of the total water demand and about 90% of the available groundwater resources. The above percentages in terms of water resources imply that the water balance situation in 2030 is expected to be almost severe or severe judging from the water stress ratio.

The allocation plan should guide the water resources management in LVNCA.

# CHAPTER 4 DEVELOPMENT AND MANAGEMENT PLANS

## 4.1 General

Based on the overall concepts and framework by subsector as described in Chapter 7 of Main Report Part A, eight component plans were prepared.

The eight component plans are water supply, sanitation, irrigation, hydropower and water resources development plans; and water resources, flood and drought disaster, and environmental management plans.

Current situations, development and management strategies, and proposed plans for the above eight component plans are explained in the next sections.

## 4.2 Water Supply Development Plan

### 4.2.1 Current Situation of Water Supply

As shown in Section 3.2 of Main Report Part A, the current population of LVNCA as of 2010 is estimated to be 6.96 million, which is composed of 1.53 million of urban population and 5.43 million of rural population. LVNCA has the highest population density among the six catchment areas. Its population is not concentrated in a specific area but distributed over the catchment area. Based on the 2009 Census data, the current situation of water connection of LVNCA was estimated as shown below.

**Current Situation of Water Connection (LVNCA)**

| Type | Piped by WSPs | Spring/Well/Borehole | Water Vendor | Stream/Lake/Pond/Others |
|---|---|---|---|---|
| Urban Population | 31% | 53% | 3% | 13% |
| Rural Population | 5% | 70% | 0% | 25% |
| Total Population | 11% | 66% | 1% | 22% |

Source: JICA Study Team, based on Census 2009 data (Ref. Sectoral Report (C), Sub-section 2.3.3)

The water provided by unregistered water vendors and water taken from streams, lakes, and ponds without proper treatment are categorised as unimproved drinking water sources. Around 23% of the population get drinking water from such unimproved drinking water sources. Also, around 66% of the population get water from springs, wells, and boreholes, which is the highest among six catchment areas. On the other hand, unprotected wells and springs are also categorised as unimproved drinking water sources, but the utilisation ratio of unprotected sources is unknown.

It is projected that the urban population will increase by 6.18 million while the rural population will decrease by 0.78 million in 2030 as shown in Section 3.2 of Main Report Part A. Hence, the total population will become 12.36 million in 2030, as shown below.

**Projected Population (LVNCA)**

(Unit: million persons)

| Year | Urban population | Rural Population | Total |
|---|---|---|---|
| 2010 | 1.53 | 5.43 | 6.96 |
| 2030 | 7.71 | 4.65 | 12.36 |

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

Currently, the piped water supply covers 31% of the urban population of LVNCA, of which target coverage ratio for 2030 is 100%. Therefore, it is required to implement large-scale urban water supply system developments to cope with the rapid growth of urban population and achieve the target coverage ratio of 100%.

As for registered water service providers (WSPs) in LVNCA, six urban WSPs, and three rural WSPs carry out water supply service. The total water supply capacity is 113,106 $m^3$/day, while the total service population is 476,892. Therefore, the average water supply amount per person is 230 L/p/day inclusive of non-revenue water (NRW). It is much higher than the national average of urban water supply of 65 L/p/day including NRW (36 l/p/day excluding NRW). WSPs in LVNCA have enough capacity for the current service population, but the NRW rate is quite high. Out of the seven urban WSPs, five WSPs have records of more than 50% of NRW. The current situations of the WSPs in LVNCA are shown in Table 4.2.1.

### 4.2.2 Development Strategy

A large percentage of the population in LVNCA are using groundwater and spring water. In addition, its surface water resources originating from Mt. Elgon and Cherngani Tugen Hills have been abandoned. The urban water supply systems (UWSS) are planned to be given priority in extracting surface water, while the rural water supply systems are planned to be given priority in extracting groundwater.

Based on the overall concept mentioned in Section 7.3 of the Main Report Part A, the UWSSs are planned for 32 urban centres (UCs) in LVNCA. The water supply capacity required for UWSS in LNVCA for 2030 is 782,000 $m^3$/day against the current water supply capacity (including those under construction) which is 135,000 $m^3$/day. This results to an additional capacity of 647,000 $m^3$/day to be developed by 2030. The additional capacity will be developed through the following projects:

a) Rehabilitation of existing UWSS

In order to achieve 20% NRW rate or less, water meters will be installed for all households and existing old pipes of UWSS for 20 UCs, which have 135,000 $m^3$/day of water supply capacity, will be replaced. In addition, the rehabilitation includes replacement and repair of mechanical and electrical equipment in water treatment plants and pumping stations.

b) Expansion of UWSS

Expansion of UWSS is planned for the 20 UCs to meet the water demand in 2030. The expansion will provide an additional 556,000 $m^3$/day.

c) Construction of new UWSS

New UWSSs are planned to be constructed for 12 UCs, which have no existing UWSS. The new construction will provide an additional 91,000 $m^3$/day.

d) Incorporation of existing plans

According to data from WSBs, there are 12 plans of water supply development projects to cover nine UCs and surrounding areas, which have 45,000 $m^3$/day of total water supply capacity in LVNCA. (Refer to Sectoral Report (C), Section 2.4) These plans are to be incorporated in NWMP 2030.

Based on the overall concept mentioned in Section 7.3 of the Main Report Part A, the rural water supply systems are planned to be developed by large-scale rural water supply system (LSRWSS) and small-scale rural water supply system (SSRWSS).

a) Development of LSRWSS

LSRWSS is proposed mainly for areas with high population density or those having difficulties extracting groundwater for personal or communal uses. LSRWSS will be developed for 1.78 million residents in 11 counties under LVNCA.

b) Development of SSRWSS

SSRWSS is proposed for 4.01 million residents in 11 counties under LVNCA, and it includes the construction and improvement of boreholes, wells, and springs for personal and communal uses, which will be implemented by individuals or communities.

### 4.2.3 Proposed Water Supply Development Plan

The proposed UWSS is presented in Table 4.2.2, while the proposed LSRWSS and SSRWSS are shown in Tables 4.2.3 and 4.2.4, respectively.

The proposed water supply development plan for LVNCA is outlined below.

**Proposed Water Supply Development Plan (LVNCA)**

| Type of Project | | Target Area | Target Capacity ($m^3$/day) | Target Population (million persons) |
|---|---|---|---|---|
| Urban Water Supply | Rehabilitation | 20 UCs | 135,000 | 6.57 |
| | Expansion | 20 UCs | 556,000 | |
| | New Construction | 12 UCs | 91,000 | |
| | Total | 32 UCs | 782,000 | |
| Rural Water Supply | LSRWSS | 11 Counties | 184,000 | 5.79 |
| | SSRWSS | 11 Counties | 220,000 | |
| | Total | 11 Counties | 404,000 | |

Source: JICA Study Team based on Tables 4.2.2 to 4.2.4.

Through the abovementioned water supply development, the water supply situation of LVNCA in 2030 will be as follows:

**Water Supply Situation in 2030 (LVNCA)**

| Items | | Urban Water Supply | Large-scale Rural Water Supply | Small-scale Rural Water Supply | Total |
|---|---|---|---|---|---|
| Service Population (million) | 2010 | 0.77 | | 4.59 | 5.36 |
| | 2030 | 6.57 | 1.78 | 4.01 | 12.36 |
| Water Supply Capacity ($m^3$/day) | 2010 | 135,000 | 10,000 | 144,000 | 289,000 |
| | 2030 | 782,000 | 184,000 | 220,000 | 1,186,000 |
| Operating Body | | Registered WSPs | Registered WSPs | Individual, Community, etc. | -- |
| Target Towns/ Areas | | 32UCs | 11 Counties | | -- |

Source: JICA Study Team (Figures for 2010 were referred to Sectoral Report (C), Section 2.3. Figures for 2030 were based on Tables 4.2.2 to 4.2.4.)

In order to ensure water sources required for the water supply systems mentioned above, it is proposed to construct five new dams and expand one existing intra-basin water transfer system in LVNCA, as the result of the water balance study. (Ref. Sectoral Report (G), Chapter 4.4)

## 4.3 Sanitation Development Plan

### 4.3.1 Current Situation of Sanitation Development

Based on Census 2009, the current situation of access to sanitation facilities in LVNCA was estimated as shown below.

**Current Situation of Access to Sanitation Facilities (LVNCA)**

| Type | Sewerage System | Septic Tank, Pit Latrine, Sesspool (On-site Treatment Facilities) | Bush, etc (No Treatment) |
|---|---|---|---|
| Urban Population | 7% | 92% | 1% |
| Rural Population | 0% | 95% | 5% |
| Total Population | 2% | 94% | 4% |

Source: JICA Study Team based on Census 2009 data (Ref. Sectoral Report (D), Sub-section 2.3.2)

Sewerage system has been developed in the limited areas in LVNCA and current sewerage coverage ratio is only 2%. There are eight small-scale wastewater treatment plants, with a total treatment capacity of about 21,000 $m^3$/day. Around 94% of the population use on-site sanitation facilities such as septic tanks. These on-site sanitation facilities include unimproved ones, and the ratio of unimproved facilities is unknown. Around 4% of the population do not have any treatment facilities, and resort to unsanitary waste disposal.

### 4.3.2 Development Strategy

Based on the overall concept described in Section 7.4 of the Main Report Part A, sewerage system development is planned for 19 UCs in LVNCA. The sewerage system development is conducted through three types of projects as follows:

a) Rehabilitation of existing sewerage system

The rehabilitation includes repair and replacement of mechanical and electrical equipment of wastewater treatment plants (WWTPs) and pumping stations, and replacement of damaged sewer pipes in seven UCs. This rehabilitation will be carried out for existing sewerage systems with the capacity of 21,000 $m^3$/day.

b) Expansion of sewerage system

In order to cover the demand in 2030, the capacities of existing sewerage systems of seven UCs will be expanded. This type of project includes the expansion and new construction of sewerage pipes, pumping stations, and WWTPs. The expansion will provide an additional capacity of 230,000 $m^3$/day.

c) Construction of New Sewerage System

There are no sewerage systems in 12 UCs. New sewerage systems will be constructed in the concerned 12 UCs that will provide an additional capacity of 209,000 $m^3$/day to meet the demand in 2030.

d) Incorporation of existing plans

According to data from WSBs, there are five plans of sewerage development projects in LVNCA, which have 17,000 $m^3$/day of total treatment capacity. (Refer to Sectoral Report (D), Section 2.4) These plans are to be incorporated in NWMP 2030.

For those outside the sewerage service area, the improved on-site treatment facilities will be provided for the remaining 6.34 million residents in 2030. Currently, 6.64 million residents (or 94% of the entire population) are using the existing on-site treatment facilities, while unimproved ones are to be improved with new housing. Development of on-site sanitation facilities is planned for 11 counties in LVNCA.

### 4.3.3 Proposed Sanitation Development Plan

The sewerage development plan is shown in Table 4.3.1, and the on-site treatment development plan is shown in Table 4.3.2. The proposed sanitation development plan for LVNCA is outlined below.

**Proposed Sanitation Development Plan (LVNCA)**

| Type of Project | | Target Area | Total Capacity ($m^3$/day) | Service Population (million persons) |
|---|---|---|---|---|
| Sewerage System (Off-site Treatment) | Rehabilitation | 7 UCs | 21,000 | 6.03 |
| | Expansion | 7 UCs | 230,000 | |
| | New Construction | 12 UCs | 209,000 | |
| | Total | 19 UCs | 460,000 | |
| On-site Treatment Facilities | | 11 Counties | -- | 6.33 |

Source: JICA Study Team based on Tables 4.3.1 and 4.3.2.

About 78% of the 7.71 million urban population in LVNCA are expected to be covered by the sewerage system. It is almost equal to 80% of the national target of sewerage coverage ratio. Through the said sanitation development plans, the sanitation situation of LVNCA in 2030 will be as follows:

**Sanitation Situation in 2030 (LVNCA)**

| Items | | Sewerage System | Septic Tank, etc (On-site Treatment Facilities) |
|---|---|---|---|
| Service Population (million) | 2010 | 0.14 | 6.54 |
| | 2030 | 6.03 | 6.33 |
| Required Treatment Capacity ($m^3$/day) | 2010 | 21,000 | -- |
| | 2030 | 460,000 | -- |
| Operating Body | | Registered WSPs | Individual, Community, etc. |
| Target Towns/ Areas | | 19 UCs | 11 Counties |

Source: JICA Study Team (Figures for 2010 above are referred to Sectoral Report (D), Section 2.3, and figures for 2030 above are based on Tables 4.3.1 and 4.3.2.)

## 4.4 Irrigation Development

### 4.4.1 Current Situation of Irrigation Development

LVNCA receives the highest annual rainfall in Kenya and has abundant water resources for irrigation. The cropping area in 2011 was 776,811 ha in total, which mostly consists of rainfed crop culture with lower productivity. The total existing irrigation area in LVNCA in 2010 is only 1,876 ha, which consist of 363 ha (19%) public irrigation schemes, 1,327 ha (71%) smallholder irrigation schemes, and 186 ha (10%) private schemes. The share of irrigation area against cropping area is 0.2% only. Existing large and small-scale irrigation systems need repair and rehabilitation of deteriorated facilities due to insufficient maintenance.

### 4.4.2 Development Strategy

Following the overall concept and framework for irrigation development mentioned in Section 7.5 of the Main Report Part A, the strategy for irrigation development in LVNCA was set as follows:

a) In order to utilise available water resources efficiently for the maximisation of irrigation development, the water-saving irrigation methods should be introduced to improve water productivity of all irrigation areas;

b) In order to strengthen the agricultural sector in LVNCA, irrigation should be expanded in rainfed agricultural areas to increase agricultural productivity and production; and

c) Owing to the sufficient river water resources available for irrigation in LVNCA, the priority to maximise irrigation area should be given to the weir irrigation to use river water, and then to dam and groundwater irrigation as far as water resources are available.

### 4.4.3 Proposed Irrigation Development Plan

As a result of the water balance study for each sub-basin in LVNCA, the maximum irrigation development areas under the application of water-saving irrigation methods were estimated as summarised below.

**Proposed Irrigation Areas in 2030 (LVNCA)**

(Unit: ha)

| Category | Existing Irrigation Area in 2010 | New Irrigation Area in 2030 | | | | | | Total Irrigation Area in 2030 |
|---|---|---|---|---|---|---|---|---|
| | | Surface Water Irrigation | | | Ground-water Irrigation (Borehole) | Water Harvesting Irrigation (Small Dam/ Water Pan) | Total New Irrigation Area | |
| | | Weir | Dam | Total | | | | |
| Large-scale | 363 | 12,600 | 65,770 | 78,370 | 0 | 0 | 78,370 | 78,733 |
| Small-scale | 1,327 | 41,638 | 0 | 41,638 | 1,784 | 3,700 | 47,122 | 48,449 |
| Private | 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 |

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

Against the provisional target of new irrigation development area of 90,786 ha (distributed to LVNCA for the national target of 1.2 million ha) mentioned in Section 7.5 of the Main Report Part A, the possible new irrigation development area comes to 168,913 ha (increase of 78,127 ha) with maximum water resources development presented in Section 4.6.

As for the large scale irrigation projects (more than 500 ha), five projects proposed by the government authorities and three projects proposed in this study listed in Table 7.5.1 in Main Report Part A were taken up for the water balance study, and six projects (78,970 ha in total) were selected to be implementation by 2030 as suitable projects to contribute to the maximisation of irrigation area in LVNCA as shown in Table 4.4.1 and their locations are shown in Figure 4.4.1. They are listed as below.

a) Lower Nzoia Irrigation Project (10,470 ha, weir and Nzoia 42A multipurpose dam);
b) Lower Sio Irrigation Project (6,600 ha, weir);
c) Yala Swamp Drainage & Irrigation Project (4,600 ha, weir);
d) Upper Nzoia Dam Irrigation Project (24,000 ha, Nzoia 34B multipurpose dam);
e) Moi's Bridge Dam Irrigation Project (19,800 ha, Moi's Bridge multipurpose dam); and
f) Kibolo Dam Irrigation Project (11,500 ha, Kibolo multipurpose dam).

The irrigation water demands necessary for the abovementioned new irrigation projects were estimated at 1,332 MCM/year for surface irrigation area and 27 MCM/year for groundwater irrigation area as shown in Table 6.5.7 in the Main Report Part A.

## 4.5 Hydropower Development Plan

### 4.5.1 Current Situation of Hydropower

(1) Existing Hydropower Station

There is no large hydropower station in the catchment area except the small hydropower station located in Sosiani located about 25 km west of Eldoret Town along the Sosiani River. The Sosiani Hydropower Station was constructed in 1955 with an installed capacity of 400 kW, which is currently owned and operated by KenGen. Locations of existing hydropower stations are shown in Figure 4.5.1.

(2) Multipurpose Dam Development Project by MORDA

There is a proposed multipurpose dam project called Nandi Forest Dam, which is located in the upstream of Yala River. The Feasibility Study of Nandi Forest Dam was completed in November 2010 by the Ministry of Regional Development Authority (MORDA). The dam is designed for hydropower, irrigation, and water supply. The hydropower component is designed to divert water from the Yala River to the Oboro River, which is located in the Lake Victoria South Catchment Area via a 14 km headrace tunnel. According to the feasibility study report by MORDA, the Nandi Forest Dam is planned to have an installed capacity of 50 MW.

(3) Other Multipurpose Dam Development Projects

There are three multipurpose dam development projects which have hydropower component. These are Hemsted Bridge Dam, Nzoia Dam 34B and Nzoia Dam 42A. All the three schemes are along the Nzoia River.

The Hemsted Bridge Dam is planned for water supply, irrigation, and hydropower development. According to information from LBDA, the hydropower component will have an installed capacity of 60 MW. However, the power generation scheme is planned as an inter-basin transfer from LVNCA to Rift Valley Catchment Area through a 53.4 km tunnel. In case such diversion scheme matches with the water balance calculation of this study, Hemsted Bridge Dam will be considered.

The Nzoia Dam 34B is planned in the upper reaches of the Nzoia River before its confluence with Kipkaren River. The dam is planned for water supply, flood control, irrigation, and hydropower development. According to the Feasibility Study Report by the National Water and Conservation and Pipeline Corporation (NWCPC) in December 2010, its hydropower component will have an installed capacity of 16 MW.

The Nzoia Dam 42A is planned in the lower reaches of Nzoia River near Ugunja Town. The dam is planned for flood control and hydropower development. According to a study report by the National Irrigation Board (NIB) in January 2011, its hydropower component will have an installed capacity of 25 MW.

### 4.5.2 Development Strategy

Following the overall planning concept and framework explained in Section 7.6 of the Main Report Part A, the following strategies will be applied for development:

a) Apply development plans based on the Least Cost Power Development Plan (LCPDP).
b) Apply hydropower components of multipurpose dam development schemes.

The above strategy will be applied to LVNCA as follows:

c) LCPDP projects: There are no plans proposed for LCPDP.
d) There are three multipurpose dam schemes which have hydropower component, namely the Nandi Forest Dam, Nzoia Dam 34B, and Nzoia Dam 42B. These three dams will be taken up as proposed plans.

### 4.5.3 Proposed Hydropower Development Plan

Based on the development strategy as mentioned in Subsection 4.5.2, the following hydropower development plans will be taken up for NWMP 2030:

(1) Nandi Forest Multipurpose Dam

As one of the proposed multipurpose dam projects by MORDA, Nandi Forest Dam is considered as a candidate project for NWMP 2030. MORDA conducted a feasibility study, which was completed in October 2010. According to the Feasibility Study Report by MORDA, the Nandi Forest Dam is planned in the middle reaches of the Yala River, which will have an installed capacity of 50 MW.

(2) Nzoia (34B) Multipurpose Dam

Nzoia (34B) Multipurpose Dam is taken up as a candidate project for NWMP 2030. Nzoia (34B) Multipurpose Dam is planned in the upstream of Nzoia River. NWCPC completed its feasibility study in March 2010. According to the feasibility study report, Nzoia Multipurpose Dam 34B will have an installed capacity of 16 MW.

(3) Nzoia (42A) Multipurpose Dam

Nzoia (42A) Multipurpose Dam is planned in the downstream of Nzoia River near Ugunja Town. According to a study report in January 2011 which was prepared by NIB, Nzoia (42A) Multipurpose Dam is scheduled to have an installed capacity of 25 MW.

The following table summarises the development projects in LVNCA.

**Proposed Hydropower Development Projects (LVNCA)**

| No. | Name of Scheme | Installed Capacity (MW) | Purpose | Source of Information |
|---|---|---|---|---|
| 1 | Nandi Forest Multipurpose Dam | 50 | Water Supply, Irrigation, and Hydropower | Feasibility Study Report, November 2010, MORDA |
| 2 | Nzoia 34B Multipurpose Dam | 16 | Water Supply, Irrigation, Flood Control, and Hydropower | Preliminary Design Report, December 2010, NWCPC |
| 3 | Nzoia 42A Multipurpose Dam | 25 | Flood Control and Hydropower | Preliminary Investigation Report (Draft Final), January 2011, NIB |
| | Total | 91 | | |

Source: MORDA, NWCPC, NIB

Locations of hydropower development projects are as shown in Figure 4.5.2.

## 4.6 Water Resources Development Plan

### 4.6.1 Current Situation of Water Resources Development

LVNCA has a total catchment area of 18,374 km$^2$, and an annual average rainfall of 1,420 mm which is the largest among those for the six WRMA catchment areas. The main rivers in LVNCA are Nzoia and Yala rivers. The available water resources estimated in LVNCA for 2010 (present) are 4,626 MCM/year for surface water and 116 MCM/year for groundwater.

The present water demands in LVNCA were estimated to be 228 MCM/year based on the population of 6.96 million and irrigation area of 1,876 ha as presented in Chapter 3. The existing water resources structures and facilities, except for direct intake facilities from rivers that satisfy the present water demands are listed below. The locations of dams and water transfers are shown in Figure 4.6.1.

**Existing Water Resources Structures and Facilities (LVNCA)**

| Existing Structures/ Facilities | Name of Structures/ Facilities | Purposes | Notes |
|---|---|---|---|
| Dam | Moiben Dam | Domestic water supply to Eldoret | Storage volume of 18 MCM |
| Dam | Twin Rivers Dam | Domestic water supply to Eldoret | - |
| Dam | Ellegirini Dam | Domestic water supply to Eldoret | Storage volume of 2 MCM |
| Dam | Kipkarren Dam | Domestic water supply to Eldoret | Storage volume of 3 MCM |
| Dam | Lessos Dam | Domestic water supply | Storage volume of 1 MCM |
| Intra-basin Water Transfer | From Moiben Dam | Domestic water supply to Eldoret / Iten | 5 MCM/year in total |
| Inter-basin Water Transfer | From Moiben Dam | Domestic water supply to Tambach | |
| Small Dam/Water Pan | Total No.= 270 | Domestic and livestock water supply | Total storage volume of 8.1 MCM, average volume per facility of 30,000 $m^3$ |
| Borehole | Total No.= 1,776 | Domestic water supply mainly | Total abstraction volume of 41 MCM/year |

Source: JICA Study Team based on NWMP (1992) and data from MWI, WRMA, NWCPC, and LVNWSB

The total storage volume of existing water resource structures and facilities in LVNCA is approximately 32 MCM summing the volumes of dams and small dams/ water pans listed in the above table. Out of the 26 existing dams nationwide as described in Chapter 2 of the Sectoral Report (G), five dams are found in LVNCA, which are for domestic water supply purpose. There is no dam being constructed at present. The dam with completed detailed design is the Nandi Forest Dam, which is intended by MORDA for hydropower, and domestic and irrigation water supply. The dams being planned and design in LVNCA are Siyoi Dam by NWCPC for domestic water supply, Nzoia Dam at 34B site by NWCPC for domestic and irrigation water supply, flood control, and hydropower, and Nzoia Dam at 42A site by MOSSP/MWI for domestic and irrigation water supply, flood control, and hydropower.

The total storage volume of the small dams/water pans is 8.1 MCM, which is 25% of the total storage volume in LVNCA. There are 1,776 boreholes in LVNCA, which comprise approximately 14% of the national total of 12,444 boreholes (MWI). These boreholes supply around 24% of the domestic water demands in LVNCA.

The values of present water supply reliability in LVNCA were estimated by the water balance study to be 1/7 at the reference points of Webuye (1DA02) in Nzoia River and Bondo (1FG01) in Yala River under the condition of existing water resource structures/ facilities mentioned above. The water supply reliability of 1/7 means that the present water demands are satisfied with the available water resources with existing water resources structures under drought condition with probability of once in 7 years.

### 4.6.2 Development Strategy

The water demands projected for the year 2030 as well as the estimated present water demands in LVNCA are explained in Chapter 3 and summarised as follows:

**Present and Future Water Demands (LVNCA)**

(Unit: MCM/year)

| Subsector | Present Water Demand (2010) | Future Water Demand (2030) |
|---|---|---|
| Domestic | 169 | 424 |
| Industrial | 6 | 19 |
| Irrigation | 18 | 1,359 |
| Livestock | 26 | 61 |
| Wildlife | 0 | 0 |
| Fisheries | 9 | 16 |
| Total | 228 | 1,879 |

Source: JICA Study Team (Ref. Main Report Part A, Chapter 6 and Table 6.10.1)

The water demand projections for 2030 show a great increase by about 8.2 times compared with the present demands due to considerable expected increase in population to 12.36 million and irrigation areas to 170,789 ha as mentioned in Chapter 6 of the Main Report Part A.

Judging from the estimated 2030 water deficits discussed in Section 3.4 (1), it is certain that the existing water resources structures and facilities will not be able to satisfy the great increase in water demand for 2030, therefore, new structures/facilities are required to be developed. As the estimated available 2030 surface water of 4,969 MCM/year is larger than groundwater of 108 MCM/year in the catchment area, the development will focus on surface waters.

Strategies for the water resources development in LVNCA were set as enumerated below, following the overall planning concept and framework as stated in Chapter 7 of the Main Report Part A, and based on the current situation of the catchment area and future water demand projections.

a) Since surface water is abundant within the catchment area, the development plan focuses on the maximum abstraction of surface water.

b) The existing intra-basin water transfer facilities from Moiben Dam to Eldoret and Iten will be included in the development plan to satisfy future domestic water demands in the area. The inter-basin water transfer plan from Nandi Forest Dam in LVNCA to LVSCA, of which the detailed design is completed by MORDA, is also included in the development plan for hydropower generation, irrigation and domestic water supply to Kisumu in LVSCA. The volume of water transferred from Nandi Forest Dam to LVSCA is included in the water demands mentioned in Sub-section 4.6.2 of the Main Report Part C for LVSCA.

c) Dam development is essential and will be promoted over the catchment area to satisfy the increased future large water demands such as domestic, industrial and irrigation water demands in the entire catchment area. Candidate dam development projects for maximising surface water abstraction include in principle i) dams proposed by the NWMP (1992), and ii) dams being design and planned by the government including the Kenya Vision 2030 flagship projects.

d) Small dams and/or water pans will be developed in small rivers over the catchment area for small and scattered demands including rural domestic, livestock, small scale irrigation, wildlife and inland fisheries water supply purposes at locations where suitable damsites are not expected for large dams but the surface water is available.

e) The groundwater is to be exploited for domestic, industrial and irrigation uses where the surface water is not available or insufficient.

### 4.6.3 Proposed Water Resources Development Plan

(1) Water Balance Study

The water balance study was carried out for the year 2030 between the available water resources and water demand projections in order to assess the magnitudes of water shortage and to quantify the water resources volumes to be stored or transferred. Estimated figures of the available 2030 water resources consisting of the surface water and groundwater cover the period of 20 years from 2021 to 2040, and the water demand projections are for the year 2030. The available 2030 water resources are shown by sub-basin in Table 4.6.1 in terms of monthly mean surface water and annual mean groundwater. The 2030 water demands are shown by water use sub-sectors and by sub-basin in Table 4.6.2.

The water balance study followed the policies of the water allocation as stated in Section 7.2 of the Main Report Part A. The summary of which are tabulated 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 surface water balance study for 2030 was conducted on the monthly basis by dividing the catchment area into sub-basins as shown in Figure 4.6.2 and by applying the surface water resources and demands to a computation model developed for LVNCA as shown in Figure 4.6.3. Prior to the surface water balance study, the amount of the water demands to be supplied by groundwater was subtracted from the total water demand as explained in Section 4.3 of the Sectoral Report (G). Water demands for livestock, wildlife, and inland fisheries to be supplied by surface water were excluded from the surface water demand applied for the balance study. It is because these demands are small in amount representing about 2% of the surface water resources nationwide, and distributing widely apart from rivers. The livestock, wildlife and fishery demands are to be supplied by surface water with small dams/water pans.

Conditions of the surface water balance study are explained in Section 4.3 of the Sectoral Report (G) and are summarised as follows: i) the model consists of 38 sub-basins, water demand points, existing water resource infrastructure, and candidates for future development such as dams and water transfer facilities; ii) monthly mean values of the naturalised water resources and demands are applied; iii) the amount of the reserve is determined as 95% value of the naturalised present daily flow duration curve in Figure 4.6.4 with the probability of once in 10 years as shown in Table 4.6.3; and iv) return flow rates of 25%, 5%, and 100% for urban domestic water supply, paddy irrigation, and hydropower generation are applied.

Although most dam candidates studied by the government or proposed by the NWMP (1992) were incorporated in the water balance study, some of the dams were compared and selected as follows:

a) Moi's Bridge Dam and Hemsted Bridge Dam: Moi's Bridge Dam site (catchment area of 858 $km^2$) is located along a tributary of the Nzoia River, while Hemsted Bridge Dam site (catchment area of 3,825 $km^2$) is situated along the main channel of Nzoia River. The former site is in the upstream of the latter site. Moi's Bridge Dam was selected to be studied in the water balance since it has a larger storage efficiency and its upstream location has a wider coverage of demands which are supplied with water through gravity flow.

b) Nandi Forest Dam and Kimondi Dam: Nandi Forest Dam site (catchment area of 1,339 $km^2$) is located along the main channel of Yala River, while Kimondi Dam site (catchment area of 692 $km^2$) is situated along a tributary of Yala River. Nandi Forest Dam was selected to be studied in the water balance, since its detailed design has been completed.

Lists of the dams studied by the government or proposed by NWMP (1992) are given in Table 4.6.4. Lists of the water transfer candidates are shown in Table 4.6.5.

(2) Proposed Water Resources Development Plan

Based on the results of the water balance study for 2030 as described in the preceding clause (1), the required new water resources structures/facilities in LVNCA are as follows:

1) Dams

Proposed storage volumes of the dams for domestic, industrial and irrigation uses as tabulated below were derived from the water balance study as the volumes from which water would be supplied to the deficits caused by the respective water demands.

**Proposed Dams (LVNCA)**

(Unit: MCM)

| Name of Dams | Storage Volume for Domestic/ Industrial | Storage Volume for Irrigation | Storage Volume for Hydropower | Flood Control Space | Total Storage Volume | Remarks |
|---|---|---|---|---|---|---|
| Siyoi Dam | 4.1 | 0.0 | 0.0 | 0.0 | 4.1 * | Flagship Project, D/D ongoing (NWCPC) |
| Moi's Bridge Dam | 22.0 | 192.0 | 0.0 | 0.0 | 214.0 | |
| Nzoia Dam at 34B Site | 0.0 | 203.7 | 0.0 | 0.0 | 203.7 * | Flagship Project, D/D ongoing (NWCPC) |
| Kibolo Dam | 17.0 | 23.0 | 0.0 | 0.0 | 40.0 | |
| Teremi Dam | 3.0 | 0.0 | 0.0 | 0.0 | 3.0 | |
| Nzoia Dam at 42A Site | 0.0 | 139.0 | 0.0 | 256.0 | 395.0 * | Flagship Project, D/D ongoing (MOSSP/ MWI) |
| Nandi Forest Dam | 89.0 | (131.0) | 131.0 | 0.0 | 220.0 * | D/D completed (MORDA) |
| Total | 135.1 | 557.7 | 131.0 | 256.0 | 1,079.8 | |

Note: * Total storage volumes planned or designed by the government.
D/D=Detailed design
Source: JICA Study Team, based on information from relevant government agencies

The development plan is formulated for domestic and industrial water supply to ensure the supply for 10-year probable drought and irrigation water supply for 5-year probable drought as stated in Section 7.1 of the Main Report Part A. The storage volumes determined are the volume of the second largest estimated in the water balance study for 20 years for domestic and industrial use, and that of the fourth largest for irrigation use.

The respective total storage volumes of Siyoi, Nzoia (34B), Nzoia (42A) and Nandi Forest dams followed the detailed designs which are on-going or completed as shown in the above table.

The storage volume of hydropower use for Nandi Forest Dam was estimated by subtracting the volume of estimated domestic/industrial use from the total storage volume proposed by MORDA. Water for irrigation use in LVSCA will be supplied from Nandi Forest Dam after water transfer to LVSCA for hydropower generation.

The flood control space of Nzoia Dam (42A) was estimated by subtracting the volume of estimated irrigation use from the effective storage volume proposed by MOSSP/MWI, as a space in which floods can be stored.

Table 4.6.6 presents details of the proposed dams, and Figure 4.6.1 shows the location of the proposed dams.

2) Water Transfers

The proposed amount of intra-basin water transfer from Moiben Dam to Eldoret/Iten as mentioned below was derived from the water balance study as the amount to meet domestic water demands in Eldoret and Iten. The amount of inter-basin water transfer from Nandi Forest Dam to LVSCA followed designs of MORDA.

**Proposed Water Transfers (LVNCA)**

(Unit: MCM/year)

| Structures | Amount for Domestic | Amount for Hydropower/ Irrigation | Total Water Transfer Amount | Remarks |
|---|---|---|---|---|
| Intra-basin Water Transfer from Moiben Dam to Eldoret/Iten (Expansion) | 5 | 0 | 5 | |
| Inter-basin Water Transfer from Nandi Forest Dam to LVSCA | 16 | 173 | 189 | D/D completed (MORDA) |

Source: JICA Study Team, based on information from relevant government agencies

Table 4.6.6 presents details of the proposed water transfers, and Figure 4.6.1 shows the location of the proposed water transfers.

3) Small Dams and Water Pans

The proposed storage volumes of small dams/water pans for domestic use were estimated based on water deficits calculated after the supply of available water from dams and boreholes. The storage volumes for irrigation use were estimated considering the conditions of the irrigation subsector.

The proposed storage volumes of small dams/water pans for livestock, wildlife and fisheries are volumes of their water demands for 2030.

**Proposed Small Dams/ Water Pans (LVNCA)**

(Unit: MCM)

| Structures | Volume for Domestic | Volume for Irrigation | Volume for Livestock | Volume for Wildlife/ Fisheries | Total Storage Volume | Remarks |
|---|---|---|---|---|---|---|
| Small Dam/ Water Pan | 74 | 30 | 61 | 16 | 181 | Total No. of small dams/ water pans = 3,620 |

Note: Excluding the 8 MCM storage volume of the existing small dams and water pans.
Source: JICA Study Team

The total number of the small dams / water pans of 3,620 was estimated by applying the volume per dam/ pan of 50,000 $m^3$ as the minimum capacity following the volume applied in NWMP (1992) and assumed based on the existing volumes.

4) Boreholes

The proposed groundwater abstraction volumes of boreholes for domestic and industrial uses were estimated by applying assumed percentages to the total water demands. The percentages of 5%, 50%, 100% and 50% were assumed for urban domestic, large rural domestic, small rural domestic and industrial water supply respectively as explained in Sub-section 4.3.1 (1) of the Sectoral Report (G). In the case that some water deficits were calculated in the surface water balance study and only groundwater was available, the deficits were added to the groundwater abstraction volumes estimated above.

The proposed groundwater abstraction volume of boreholes for irrigation use was estimated considering the conditions of the irrigation subsector mentioned in Section 7.5 of the Main Report Part A. The estimated volumes are as follows:

**Proposed Boreholes (LVNCA)**

(Unit: MCM/year)

| Facilities | Volume for Domestic/ Industrial | Volume for Irrigation | Total Abstraction Volume | Remarks |
|---|---|---|---|---|
| Borehole | 29 | 27 | 56 | Total No. of boreholes = 560 |

Note: Excluding the 41 MCM/year abstraction of existing boreholes.
Source: JICA Study Team

The total number of the boreholes of 560 was estimated by applying the capacity per borehole of 100,000 $m^3$/year assumed based on the existing data.

(3) Evaluation of Proposed Water Resources Development Plan

Results of the water balance between water demand and supply for 2030 in LVNCA are summarised in Table 4.6.7 showing 2030 water demands, water supply from river water and new water resources structures such as dams, water transfers, small dams/water pans and groundwater (boreholes), and water balance between demand and supply. This table proves that 2030 water demands will be satisfied by the river water and new water resources structures under the target water supply reliabilities of 1/10 for domestic and industrial uses and 1/5 for irrigation use.

The water supply reliability for 2030 at the reference points proposed for water resources management in LVNCA is summarised below as well as that for 2010:

**Water Supply Reliability at Reference Point (LVNCA)**

| Reference Point | Present (2010) Water Supply Reliability | Future (2030) Water Supply Reliability |
|---|---|---|
| Nzoia River (1DA02), Webuye | 1/7 | 1/5 |
| Yala River (1FG01), Bondo | 1/7 | 1/10 |

Source: JICA Study Team (Ref. Sectral Report (G), Sub-section 4.4.3 (3) and Table 4.4.4)

The future water supply reliability at the reference point of Webuye in Nzoia River is estimated at 1/5, since water demand downstream of the reference point is irrigation use only. The future water supply reliability at the reference point of Bondo in Yala River is estimated at 1/10, since water demand downstream of the reference point is domestic use only. The future reliability will decrease at Webuye compared with the present one due to large increase of the water demands, although the estimated future reliability conforms to the target value mentioned in Section 7.1 of the Main Report Part A. Appropriate water resources development and management will be required to maintain the target reliability.

The naturalised surface water resources, reserves, water demands, yields of the water resources development structures, and water supply reliabilities estimated at the reference points are tabulated in Table 4.6.8.

Figure 4.6.5 shows estimated river flow for 2010 and 2030 at the reference points in LVNCA under 2010 and 2030 surface water resources, demands and structures conditions.

## 4.7 Water Resources Management Plan

### 4.7.1 Current Situation of Water Resources Management

LVNCA has an annual basin mean rainfall of 1,420 mm, which is the highest among the six catchment areas of WRMA, and its available water resource is abundant. The catchment area includes major cities such as Eldoret, Kitale, and Kakamega, and is the most-populated area in Kenya with a population density of 379 persons/km$^2$. High water demands are expected in the future that will be lead by domestic and industrial water supply as well as irrigation water uses.

Major rivers in LVNCA that flow into Lake Victoria are Nzoia and Yala. The three international rivers namely, Sio, Malaba and Malakisi, flow across the national border into Uganda. WRMA has its Lake Victoria North Regional Office in Kakamega. Under the regional office, there are three subregional offices of Kitale that covers the northern part, Siaya that covers the southwestern part, and Eldoret that covers the southeastern part of the catchment. The Kakamega Regional Office covers the rest of catchment area, namely, Sio-Malaba-Malakisi River basins and middle stretch of Nzoia River. Figure 4.7.1 shows the Management Unit Boundary and Subregional Office Management Boundary.

The following table shows the current monitoring targets of WRMA, numbers of operational stations and their achievement ratio for surface water, groundwater, water quality, and rainfall. Surface water monitoring stations are well maintained while groundwater and rainfall stations are fairly maintained.

**Current Monitoring Situations of Water Resource (LVNCA)**

(Unit: nos)

| Item | Surface Water Level | Groundwater Level | Surface Water Quality | Groundwater Quality | Rainfall |
|---|---|---|---|---|---|
| Target | 28 | 13 | 24 | 11 | 65 |
| Operational | 21 | 9 | 24 | 10 | 52 |
| Achievement (%) | 75 | 69 | 100 | 90 | 80 |

Source: WRMA Performance Report 1 (July 2010)

The current situations of water permit issuance and management by WRMA are as shown below. The rate of valid permits against issued permits is relatively high.

**Current Situations of Water Permits Issuance (LVNCA)**

(Unit: nos)

| Item | Application | Authorised | Issued Permits | Valid Permits | Ratio of Validity (%) |
|---|---|---|---|---|---|
| Surface Water | 919 | 432 | 269 | 180 | 67 |
| Groundwater | 878 | 540 | 140 | 110 | 79 |
| Total | 1,797 | 972 | 409 | 290 | 71 |

Source: WRMA Performance Report 1 (July 2010)

It is important to conduct watershed conservation for Mt. Elgon, Cherangani Hills, and Mau Forest Complex, which are major water sources of Nzoia and Yala rivers within LVNCA. Deforestation and forest degradation are rampant in these forests.

According to the results of satellite image analysis in this study[1], the forest area in LVNCA in 2010 was about 107,000 ha, which corresponded to 5.8% of forest cover in the catchment area. The deforested areas during the last two decades were about 46,000 ha, which meant the decrease of about 30% of the forest areas in 20 years since 1990.

According to interviews with stakeholders of watershed conservation including WRMA and KFS in LVNCA, there were deteriorations on small water sources such as 23 springs and 14 wetlands. However, there were no significant problems reported because of less dependency on such small water sources in LVNCA.

WRMA pointed out that the deforestation and forest degradation caused soil erosion affecting its inflow into rivers, which was one of the causes of flood. There were other causes of soil erosion and inflow into rivers such as sheet erosion from cultivated areas. As detailed information on soil erosion areas such as location, magnitude, water use, water quality, vegetation and method of management are unknown, further study is required.

### 4.7.2 Management Strategy

Based on the overall planning concept and framework mentioned in Section 7.8 the of Main Report Part A, water resources management strategy for LVNCA was set for major components of i) monitoring, ii) evaluation, iii) water permit issuance and control, and iv) watershed conservation as follows:

[1] Sectoral Report (B) Chapter 9 Land Use Analysis

### (1) Monitoring

Monitoring strategies are described for five monitoring items, which are i) surface water level, ii) surface water quality, iii) groundwater level, iv) groundwater quality, and v) rainfall. At surface water monitoring and groundwater monitoring stations, water quantity and quality are monitored, while at rainfall monitoring stations, rainfall amount is monitored.

#### 1) Surface Water Level

Nzoia and Yala rivers were selected as representative rivers for capturing runoff characteristics of the basin. The Nozia River has several tributaries in the upper, middle, and lower reaches (refer to Figure 4.7.1), while the Yala River has three tributaries in the upper and middle reaches. Surface water level monitoring stations are reviewed to capture major points in the Nzoia and Yala rivers and their tributaries. The Nzoia River covers 70% of LVNCA while the Yala River covers only 18%. The rest of 12% of the basin is covered by international rivers of Sio, Malaba and Malakisi. Surface water level of the Sio, Malaba and Malakisi rivers are also monitored at points where these rivers are flowing out from Kenya to Uganda so that discharge to the neighbouring country can be captured and controlled. In addition, a reference point is to be set as a point that contributes to water resources development and management activities. At reference points, normal discharge value is to be set as a managerial indicator for low flow management.

The surface water level of Lake Victoria should be monitored as major lakes, however, as there is a monitoring point in Kisumu (1HB04) which is under the Lake Victoria South Catchment Area (LVSCA), no measurement is made in LVNCA. Also, there is no major spring water to be monitored in LVNCA.

#### 2) Surface Water Quality

Surface water quality monitoring points were also selected from the representative rivers of Nzoia and Yala. For these two rivers, selected monitoring points should be located at the downstream of pollution sources, such as major cities and irrigation schemes. Such points should be monitored monthly.

In addition, other surface water level monitoring points are selected for water quality monitoring on a quarterly basis. Such monitoring data is required as reference water quality for the evaluation of water permit application in the relevant basin.

#### 3) Groundwater Level

Groundwater monitoring points were set at locations where significant groundwater use is expected in the future. Such points are in urban centres which have both water supply and sanitation plans. In the selected monitoring points, groundwater levels are monitored monthly with dedicated boreholes. It is important to monitor and confirm that the groundwater levels are recoverable in an annual cycle for sustainable use.

4) Groundwater Quality

Groundwater quality is monitored at the same points of groundwater level monitoring.

5) Rainfall

The rainfall station density should be considered by climatic regions for arid, semi-arid or humid areas. As most of LVNCA belongs to humid areas, a criterion of one station in 500 to 1,000 $km^2$ was applied for selection of rainfall monitoring stations.

(2) Evaluation

1) Water Resources Quantity Evaluation

The water resources quantity evaluation is conducted annually based on i) monitoring data for surface water, groundwater, and rainfall; and ii) records of water permit issuance. Abstraction survey data will be used as necessary to grasp actual water use status. For surface water resources evaluation, the Nzoia and Yala rivers should be focused as they are the representative rivers in LVNCA.

2) Water Resources Quality Evaluation

The water resources quality evaluation is also conducted annually based on monitoring data for surface water and groundwater quality.

(3) Water Permit Issuance and Control

Prior to future impeding water demand in the basin, water permits should be duly controlled and issued based on the actual status of water use. For this, the latest version of issued permits should be controlled. In addition, water allocation guidelines should be revised considering the future demand and water resources development plans. To conduct these activities, the enforcement of officers for water rights should be considered by reflecting the current situation of staffing.

(4) Watershed Conservation

Of the three major items of: a) recovery of forest areas; b) conservation of small water sources; and c) control of soil erosion, item b) is not an issue in LVNCA. Therefore, items a) and c) are to be considered by LVNCA.

1) Recovery of Forest Areas

Forest recovery will be implemented through reforestation focusing on Mt. Elgon, Cherangani Hills, and Mau Forest Complex, which belong to the Five Water Towers of Kenya.

2) Control of Soil Erosion

Preventive measures for soil erosion caused by deforestation in the catchment area will be considered.

### 4.7.3 Proposed Water Resources Management Plan

Based on the management strategy described in Subsection 4.7.2, the water resources management plan for LVNCA is proposed as follows:

(1) Monitoring

Monitoring plans are described for five monitoring items, which are i) surface water level, ii) surface water quality, iii) groundwater level, iv) groundwater quality, and v) rainfall. Locations of proposed monitoring stations are as shown in Figure 4.7.2.

1) Surface Water Level

Surface water level is observed twice a day by an honorarium gauge reader. 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. There were 15 monitoring points selected as representative points for the Nzoia River and six points for the Yala River. Each of the international rivers of Sio, Malaba and Malakisi, has one point each selected for monitoring to confirm that appropriate amount of water is flowing into the neighbouring country, Uganda. In total, 24 monitoring points were selected for daily basis monitoring. For the Nzoia and Yala rivers, reference points were selected as follows:

a) 1DA02 is located in the middle reach of the Nzoia River near Webuye Town. Monitoring started in 1947.

b) 1FG01 is located in the middle to lower reach of the Yala River near Bondo Town. Monitoring started in 1947.

Both of the above reference points are set to check the flow regime of the river after satisfying upstream water demand and confirming available discharge to satisfy the downstream demand. For that purpose, based on the management strategy described in Subsection 4.7.2, normal discharge values are set at the above two reference points as shown below. These normal discharge values are used for low water management.

**Normal Discharge at Reference Point (LVNCA)**

(Unit: $m^3$/sec)

| Reference Point | Normal Discharge (Reserve + Water Demand for the Downstream of Reference Point) | |
|---|---|---|
| | 2010 | 2030 |
| Nzoia River (1DA02) | 16.1 (=15.9+0.2) | 19.5 (=15.9+3.6) |
| Yala River (1FG01) | 6.8 (=6.7+0.1) | 6.9 (=6.7+0.2) |

Source: JICA Study Team (Ref. Sectral Report (G), Sub-section 4.4.3 (3) and Table 4.4.4)

The above normal discharges are to be reviewed and revised as necessary in the "Water Resources Quantity Evaluation" based on monitoring, which is to be mentioned in the following clause. Such review and revision works are to be made based on issued water permits (water demand) and reserve of that year. In case the observed discharge at a reference point is lower than the normal discharge, it is probable that there would be over-abstraction of water in the upstream or decreased reserve caused by an extreme drought.

In such a case it is necessary to identify the reason and take measures such as increase of the level of oversight for water abstraction or drought conciliation.

2) Surface Water Quality

Stations with monthly basis monitoring

Based on the management strategy, water quality of the five points is monitored on a monthly basis as discussed below. This monitoring is for watching and detecting possible pollutant sources that may affect to water usage in the relevant river.

a) 1BD02 (upstream area of the Nzoia River near Hemsted Bridge): To monitor the impacts on river water quality caused by effluent from major towns of Kitale and Kapenguria and from irrigation schemes.
b) 1CE01 (at the confluence of tributaries located in the left bank of the Nzoia River near Lumakanda Town): To monitor the impacts on river water quality caused by effluent from urban areas and factories from the largest town Eldoret and effluent from irrigation schemes.
c) 1DA02 (in the middle reaches of the Nzoia River near Webuye Town): To monitor the impacts on river water quality caused by effluent from major towns in the upper reach and from irrigation schemes.
d) 1EE01 (in the downstream reaches of the Nzoia River near Ukwala): To monitor the impacts on river water quality caused by effluent from Kakamega and Mumias towns in the middle to lower reaches of the Nzoia River and effluent from irrigation schemes.
e) 1FG01 (in the middle reaches of the Yala River near Yala Town): To monitor the impacts on river water quality caused by effluent from Nandi Hills, Kapsabet, Vihiga, etc., which are located in the upstream reaches and effluent from irrigation schemes.

Stations with quarterly basis monitoring

Apart from the above five monitoring stations, water quality will also be monitored on a quarterly basis (January, April, July and October of each year) by 19 other surface water monitoring stations. Such data are used as reference when WRMA issues water permits. The 19 monitoring stations are:

1AA01, 1AD02, 1AH01, 1BB01, 1BE06, 1BH01, 1CA02, 1CB05, 1DB01, 1DD01, 1EB02, 1ED01, 1EF01, 1EG02, 1FD02, 1FE02, 1FF03, 1FG01, and 1FG03.

3) Groundwater Level

Based on the management strategy, 19 points were selected for groundwater level monitoring through dedicated boreholes for monthly basis monitoring. These points are located near urban centres where there are water supply and sanitation plans with expected high growth of groundwater demand in the future. The 19 points are in the towns of:

Kapenguria, Kitale, Moi’s Bridge, Matunda, Kimilili, Malaba, Malakisi, Bungoma, Webuye, Iten, Busia, Mumias, Eldoret, Kakamega, Kapsabet, Siaya, Bondo, Luanda, and Vihiga.

4) Groundwater Quality

Groundwater quality is monitored at the same locations where groundwater level monitoring stations are located. Groundwater quality monitoring is conducted quarterly.

5) Rainfall

Most of the areas in LVNCA belong to humid areas in the climatic region. As to the overall concept, the distribution of rainfall monitoring stations was reviewed with criteria of one location in 500 to 1,000 $km^2$. As a result of the review, 42 rainfall monitoring stations were selected for daily basis monitoring.

(2) Evaluation

1) Water Resources Quantity Evaluation

Based on the management strategy, water resources quantity evaluation is conducted annually based on i) monitoring data for surface water, groundwater, and rainfall, and ii) water permit issuance data. For this, a water resources evaluation team is formed consisted of: i) one chief hydrologist from LVN Regional Office in Kakamega, and ii) one assistant hydrologist each from Kitale, Eldoret and Siaya subregional offices. Water resources evaluation works are to be conducted for the whole LVNCA on both surface and groundwater based on the monitored data.

2) Water Resources Quality Evaluation

Based on the management strategy, water resources quality evaluation is also conducted annually based on monitoring data for surface water and groundwater quality. For this, a chief water quality expert is assigned in the water quality test laboratory in Kakamega.

(3) Water Permit Issuance and Control

Based on the management strategy, the following activities are proposed:

a) Control of the latest version of issued water permits
- Periodical update of water permit database
- Establishment and enhancement of notification system for expired permits

b) Revision of guidelines for water allocation
- Formulation of water allocation plans considering future water demand

c) Increase of the number of water right officers as shown below for smooth implementation of water permit issuance and control.

**Number of Required Water Right Officers (LVNCA)**

| Offices | Number of Water Right Officers | | |
|---|---|---|---|
| | Current | Required | Future |
| LVN RO | 1 | No change | 1 |
| Kitale SRO | 2 | No change | 2 |
| Eldoret SRO | 1 | +1 | 2 |
| Siaya SRO | 1 | +1 | 2 |
| Total | 5 | +2 | 7 |

Note : RO=Regional Office, SRO=Subregional Office
Source: JICA Study Team, based on interview with WRMA Regional Office

(4) Watershed Conservation

Based on the management strategy, the following activities are proposed for watershed conservation:

1) Recovery of Forest Areas

As for forest recovery for watershed conservation, about 230,000 ha of forestation is proposed in LVNCA to achieve the target of Kenya Vision 2030. Current situations of the forest areas in LVNCA and potential areas for forestation are shown in Figure 4.7.3.

The following steps were applied in preparing Figure 4.7.3:

a) Identified present forest areas and deforested areas (in this master plan, the satellite image analysis was used), and overlay the gazette forest areas;
b) Identified the important forest areas including deforested areas as water source forests;
c) Delineated the potential forestation areas on those located in step b), and formulated the area with consideration of significant forest area; and
d) Connected the isolated small gazetted forest areas by corridor and delineated the potential forestation area with the combination of these two areas.

Of the target forest, the gazetted forest is supposed to be recovered by Kenya Forest Service (KFS).

2) Control of Soil Erosion

As for control of soil erosion, it is proposed to carry out a survey on damaged areas where soil erosion occurred in the catchment area. The survey should investigate location, scale of current situation, and required countermeasures.

## 4.8 Flood and Drought Disaster Management Plan

### 4.8.1 Current Situation of Flood Disaster Management

(1) Flood Situation

LVNCA and LVSCA have been very vulnerable to flood disasters in Kenya. In November 2006, in Budalangi, the collapse of dikes led to flooding which caused displacement of more than 10,000 people. In October to November 2008, heavy rains affected the western region and affected the bank of the Nzoia River that caused massive flooding in the area.

(2) Flood Disaster Management

Due to this historical background, the Western Kenya Community Driven Development and Flood Mitigation Project (WKCDD&FMP), which is funded by the Government of Kenya and World Bank, has been implemented since 2007 as described in Section 2.4 (1) of the Sectoral Report (J). The project is implemented based on a concept of integrated flood management consisting of various components including construction of multipurpose dams, construction and rehabilitation of dikes, river improvement works, and establishment of flood early warning systems. Therefore, it is expected that flood damages will be mitigated by the structural and non-structural measures of the project in the future once completed.

However, although the project is still on-going, there have already been some issues on operation and maintenance (O&M) such as theft or malfunction of monitoring equipment. In addition, although flood early warning system has been developed through cooperation among the WRMA LVN Regional Office, KMD, and DOC as described in Section 2.3.1 (4) 4) of Sectoral Report (J), a post-project operation plan including an office to be transferred for the system has not been determined.

Dikes have so far been constructed with a length of 16.6 km on the left bank and 16.2 km on the right bank along the Nzoia River, and 9 km on the right bank along the Yala River. They have contributed to flood control against normal floods, however it was recorded that those dikes were damaged due to the massive flood in 2008. At the time, it was also said that inadequate flood fighting activities have resulted in the extension of inundated areas. In recent years, river improvement works of 1.7 km and revetment works of 0.7 km were implemented along the Nzoia River. NWCPC’s activities in terms of river improvement works are in progress mainly in Nzoia River as of November 2012. The improvement works in Nzoia River include heightening and realignment of existing dikes and river training.

The current flood forecasting system before completion of WKCDD&FMP has 27 river gauge stations under the management of WRMA. Out of the 27 stations, the Ruambwa Station in the Nzoia River has been provided with a two-step warning water level, namely Alert and Alarm as shown in the table in Section 2.3.1 (4) 3) of Sectoral Report (J). Once river water level reaches the warning levels, the WRMA LVN Regional Office will disseminate the information and warn the public through the relevant organisations.

### 4.8.2 Current Situation of Drought Disaster Management

(1) Drought Situation

Although there have been no drought damages reported in LVNCA, water balance situation in the future is expected to have problems because irrigation and domestic water demands will largely increase, according to the water balance study for NWMP 2030.

(2) Drought Disaster Management

There are five existing dams for the domestic water supply purposes, namely Moiben, Twin Rivers, Ellegirini, Kipkarren, and Lessos dams. However, drought disaster management including water use restriction of the reservoirs has not been especially implemented.

### 4.8.3 Flood Disaster Management Strategy

As explained in the concept and framework e) mentioned in Section 7.9 of Main Report Part A, the proposed examination area in LVNCA is only the Yala Swamp. The area covers 200 $km^2$ between the lower reaches of Nzoia and Yala Rivers. It is expected that the critical areas in Yala Swamp including Budalangi Constituency will be protected by structural measures to be constructed through the on-going WKCDD&FMP as previously described. Also, community-based disaster management system is being established through the project as a measure to mitigate damages caused by extraordinary floods exceeding the design level of the structural measures.

Therefore, the basic strategy for Yala Swamp is to incorporate the structural measures planned by WKCDD&FMP into NWMP 2030. Meanwhile, the strategy in terms of non-structural measures is to focus on operation and maintenance issues for the existing and on-going flood management measures. The following are the basic policies to formulate the flood disaster management plan in LVNCA:

a) Implementation of flood control measures, which are planned in WKCDD&FMP,
b) Operation of flood early warning system (FEWS) in the Nzoia River basin by the WRMA LVN Regional Office in collaboration with KMD, and
c) Preparation of flood fighting plans for both the existing and planned dikes along the lower reaches of the Nzoia and Yala Rivers.

The abovementioned FEWS should be initiated by WRMA LVN, which is the responsible organisation for water resources management at catchment level, after the project is completed. In this situation, KMD and NDOC will be positioned as the cooperating organisations for flood management. In addition, it is required to mitigate damages from extraordinary floods by preparing a flood fighting plan based on the past experience of dike failure.

### 4.8.4 Drought Disaster Management Strategy

Based on the overall concepts mentioned in Section 7.9 of the Main Report Part A, drought management strategy for LVNCA will cover i) the preparation of rules on water use of existing and proposed reservoirs, ii) establishment of basin drought conciliation councils, and iii) establishment of drought early warning system.

### 4.8.5 Proposed Flood Disaster Management Plan

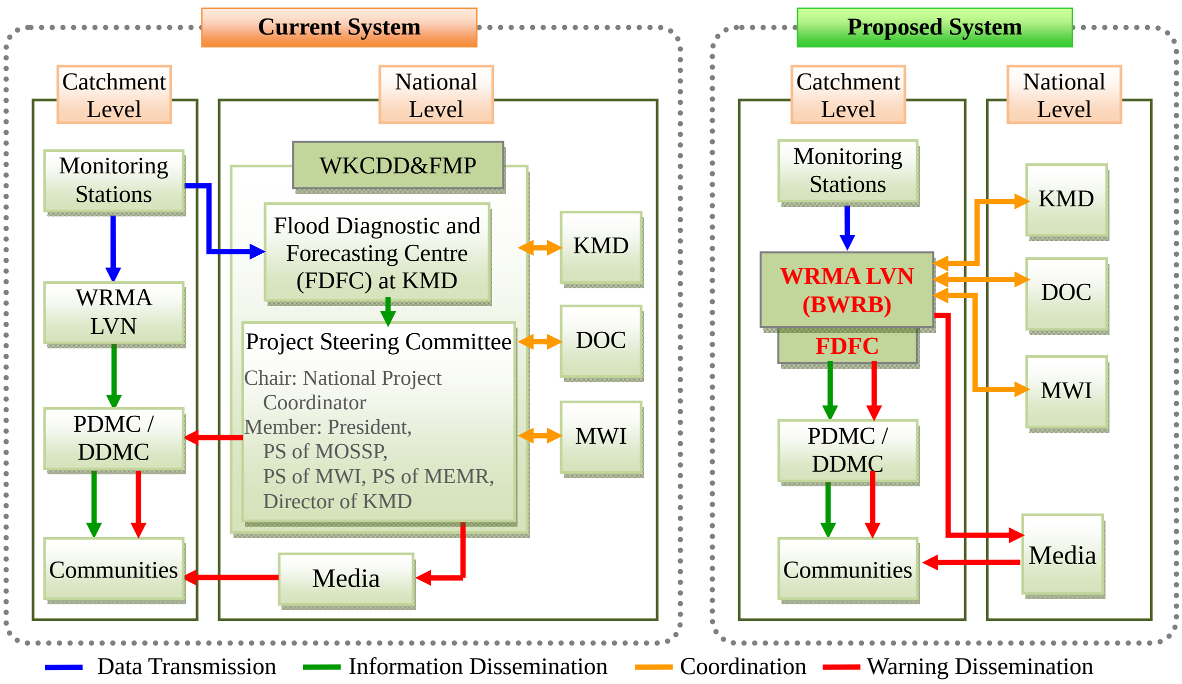
In line with the above management strategies, the proposed flood disaster management plan for LVNCA is illustrated in Figure 4.8.1, and discussed as follows:

(1) Implementation of Flood Control Measures Planned in WKCDD&FMP

The plan of WKCDD&FMP includes various flood control measures such construction of new multi-purpose dams, construction of new and rehabilitation of dikes and river improvement works. It is proposed to incorporate the existing plan into NWMP 2030. The plans were formulated in accordance with the concept of integrated flood management (IFM) and are considered reasonable and proper for the Nzoia River basin.

(2) Operation of FEWS in the Nzoia River Basin

It is proposed to improve the operational system for flood early warning that is currently being established in the Nzoia River basin through WKCDD&FMP. Both the current and proposed systems are compared in the figure below. The red characters in the figure denote points for improvement. Although flood forecasting analysis is made primarily by the KMD headquarters during the project implementation period, it should be done in the future by WRMA regional offices on their own initiative in cooperation with KMD. Warning information shall also be provided by WRMA regional offices. Incidentally, the target area of WKCDD&FMP makes up most of LVNCA.




Note: BWRB = Basin Water Resources Board, FDFC = Flood Diagnostic Forecasting Centre
Source: JICA Study Team based on interviews with WRMA LVN Regional Office, National Disaster Operation Centre

**Comparison of Current and Proposed Operational Systems for FEWS**

(3) Preparation of Flood Fighting Plan for the Nzoia and Yala Rivers

Flood fighting plan for the existing dikes along the lower reaches of Nzoia and Yala Rivers shall be prepared by the WRMA LVN Regional Office. The target section for the flood fighting plan is 18.4 km on the left bank and 16.2 km on the right bank of the Nzoia River, and 9 km on the right bank of the Yala River.

The flood fighting plan of NWMP 2030 aims mainly at avoiding an expansion of inundation area caused by dike breaching and/or overtopping. The contents of the flood fighting plan should focus on institutionalisation of flood fighting corps, activities for normal times, and flood fighting engineering method.

### 4.8.6 Proposed Drought Disaster Management Plan

(1) Preparation of Water Use Restriction Rule for Reservoirs

1) Target Dam

It is proposed to prepare water use restrictions for the respective reservoirs. The names of target dams are shown in the table below. It is noted in below list that there are five existing and seven proposed dams in LVNCA.

**Target Dams for Water Use Restriction Rules (LVNCA)**

| River System | No. | Dam Name | Status | |
|---|---|---|---|---|
| | | | Existing | Proposed |
| Nzoia | 1 | Moiben | O | |
| | 2 | Siyoi | | O |
| | 3 | Moi's Bridge | | O |
| | 4 | Nzoia (34B) | | O |
| | 5 | Ellegirini | O | |
| | 6 | Twin Rivers | O | |
| | 7 | Kibolo | | O |
| | 8 | Kipkarren | O | |
| | 9 | Teremi | | O |
| | 10 | Nzoia (42A) | | O |
| Yala | 11 | Lessos | O | |
| | 12 | Nandi Forest | | O |
| Total | | | 5 | 7 |

Source: JICA Study Team (Ref. Sectoral Report (G), 2.3.1 (1) and Table 4.4.1)

2) Setting of Reference Reservoir Water Level

To clearly understand the timing of necessary actions for water use restriction, three-step reference water level for reservoirs, namely Normal, Alert and Alarm, shall be set for the respective reservoirs. The water level should be originally determined by the percentage of reservoir water storage depending on season and month, water demand for each purpose, past experiences, etc., of each dam. The definitions of each reference water level are as follows:

- Normal: Water level where Basin Drought Conciliation Council is summoned to discuss actions to be taken when the reservoir water level is expected to become lower than this
- Alert: Water level where water use restrictions should commence
- Alarm: Water level where the reservoir water level shall not be lowered further by controlling the outflow discharge from the reservoir

3) Determination of Reduction Rate

A method to determine the 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, subsequent water level shall be forecasted by considering future weather forecasts. Then, necessary reduction rate in water intake for all basins will be determined;

b) Based on clause a), reduction rate shall be determined for the respective intended purposes such as domestic water supply, industry, and agriculture, considering the possibility to save water volume for each purpose. At this time, it is essential to consider priority order that has been conventionally stipulated in Kenya; and

c) While referring to the actual data on reduction rates during the past drought, the final reduction rate shall be determined.

Figure 4.8.2 provides an example record of reservoir water use restriction implemented in Sameura Dam on the Yoshino River in Japan during the severe drought time in 2005.

(2) Establishment of Basin Drought Conciliation Council

It is proposed to establish a Basin Drought Conciliation Council on the basis of a river basin unit representing a river system and drainage system.

The previous table shows all the dams, which are incorporated into the water resources development plan of NWMP 2030, and their river systems. One council shall be established for each river system. The number of councils to be established in LVNCA will be two for Nzoia and Yala river systems, as illustrated in Figure 4.8.1.

The council shall be composed of WRMA regional offices, relevant counties, representatives for water users (WRUAs), etc. The council shall be established to legally avoid water conflict at drought time.

(3) Drought Early Forecast

Water use restriction should be considered at the early stages, taking into account the weather conditions, water storage in the reservoirs, social impacts in the worst case scenarios, etc. At present, KMD issues long-term rainfall forecast of 4-day, 7-day, 1-month, and 3-month (seasonal), which are officially released on the website of KMD or published in newspaper. This information shall be utilised to commence timely water use restriction.

As described in Section 5.1 of Sectoral Report (J), drought early warning system in terms of livelihood zone has been established through ALRMP II using KMD's forecasts for the purpose of preparing communities against drought damage or raising awareness to save water. In a similar way, specialised drought early forecast for water use restriction will be established.

## 4.9 Environmental Management Plan

### 4.9.1 Current Situation of Environmental Management

The southern part of LVNCA faces the northeastern side of Lake Victoria, which is the largest freshwater lake in Africa. Major rivers in the catchment area are the Nzoia and Yala rivers. The rivers do not have environmental flow rate.

LVNCA covers one national park, one national reserve, Mt. Elgon, the Cherangani Hills, and the Mau Forest Complex. The catchment has a few protected areas, however, the area has rich freshwater and forest vegetation. Yala Swamp is located in the Yala River mouth and covers an area of 17,500 ha. The swamp is not designated as national protected area. However, Yala Swamp ecosystem, third largest in the country after Lorian Swamp and Tana River Delta, provides major ecological and hydrological functions and is a major source of livelihood for its surrounding communities. In addition, the swamp is designated as an important bird area (IBA) due to its papyrus vegetation.

Lake Victoria faces many environmental challenges such as degradation of lake ecosystem due to alien invasive species, water pollution and eutrophication by human sewage, and water level drawdown due to rainfall decrease. To cope with these challenges, the Lake Victoria Environmental Management Project has been conducted by Kenya, Uganda, and Tanzania since 1990. The project researched the sustainable use of natural water resources and maintenance of the lake ecosystem. Programs such as the environmental education program are under implementation in each country. The freshwater fishery in Lake Victoria is the largest in Kenya and accounts for 78.7% of the total freshwater fisheries production. Water resources development projects, such as the Yala Swamp Irrigation Project, might accelerate the eutrophication of Lake Victoria and affect fish species upstream in rivers. Thus, it is necessary to monitor the situation through environmental monitoring.

Mt. Elgon, Cherangani Hills, and the Mau Forest Complex are the most important water conservation forests in Kenya. The forests have been destroyed by illegal logging and encroachment due to population growth. Mt. Elgon, which is bisected by the border of Kenya and Uganda, is a water source of the Nzoia River and is designated as a national park. Deforestation has affected the water resource conservation.

LVNCA is the most densely populated area. It is necessary to consider socio-environmental issues at the time of implementation of development projects.

**Summary of Natural Environmental Resources (LVNCA)**

| Protected Area | | Total Area | Number of Wildlife Species | Location |
|---|---|---|---|---|
| National Park (N.P.) | | | | |
| 1 | Mt. Elgon N.P. | 169 km$^2$ | 197 | Trans-Nzoia District, Rift Valley Province |
| National Reserve (N.R.) | | | | |
| 2 | Kakamega Forest N.R. | 44.7 km$^2$ | 209 | Western Province |
| 3 | Chepkitale N.R | 178.2 km$^2$ | No information | Central Mt. Elgon |
| Five Water Towers | | | | |
| 4 | Mt. Elgon | 73,706 ha | No information | On the border between Kenya and Uganda |
| 5 | Cherangani Hills | 120,000 ha | No information | Western ridge of the Great Rift Valley |
| 6 | Mau Forest Complex | 400,000 ha | No information | Central RVCA |

Source: JICA Study Team based on ProtectedPlanet.net (http://www.protectedplanet.net/about) and Wildlife Bill, 2011

### 4.9.2 Management Strategy

Based on the overall concept and framework mentioned in Section 7.10 of the Main Report Part A, it is proposed to set the environmental flow rate and to carry out environmental monitoring for major rivers and lakes in LVNCA.

The water resources development projects in NWMP 2030 are mostly proposed on the Nzoia and Yala rivers, which are the main rivers in LVNCA. Therefore, the setting of the environmental flow rate and environmental monitoring are proposed for these two rivers. In addition, environmental monitoring is also proposed for Lake Victoria which is now facing water environment degradation.

### 4.9.3 Proposed Environmental Management Plan

Based on the above management strategy and selection criteria for environmental flow rate and environmental monitoring points mentioned in the overall concept and framework, the environmental flow rate setting and environmental monitoring of environmental management plan for LVNCA proposed at the points are as shown in the following table. Locations of the proposed points are shown in Figure 4.9.1.

**Proposed Environmental Flow Rate Setting Points (LVNCA)**

| Target | Environmental Flow Setting Point | | Proposed Major Development Projects | Vegetation | Reserve* ($m^3/s$) | Monitoring Point of WRM |
|---|---|---|---|---|---|---|
| Nzoia River | LVN-F1 | Lower reaches of the Nzoia River | Nzoia (42A) and Teremi dams | Rain forest | 34.1 | 1EE01 |
| | LVN-F2 | Reference point (Webuye Town) | Nzoia (34B) and Kibolo dams | Rain forest | 15.9 | 1DA02 |
| | LVN-F3 | Moi's Bridge Town | Siyoi and Moi's Bridge dams | Rain forest | 2.5 | 1BB01 |
| Yala River | LVN-F4 | Reference point (Yala Town) | Nandi Forest Dam | Evergreen bushland with wooded grassland | 6.7 | 1FG01 |
| | LVN-F5 | Downstream of Nandi Forest Dam | Nandi Forest Dam | Rain forest | 5.1 | 1FE02 |

Note: * Reserve includes the water for ecological needs and basic human needs as mentioned in WRMA Guidelines for Water Allocation.

Source: JICA Study Team (Ref. Sectoral Report (H), Section 3.2(1))

In addition, the environmental survey for setting the environmental flow rate (current river flow rate, water quality, and river ecosystem) shall be conducted in the Nzoia and Yala river basins.

**Proposed Environmental Monitoring Points (LVNCA)**

| Target | Monitoring Point | | Reserve* ($m^3/s$) | Monitoring Point of WRM | Selection Criteria |
|---|---|---|---|---|---|
| Nzoia River | LVN-M1 | Lower reaches of the Nzoia River | 34.1 | 1EE01 | d) Upstream points from the protected area |
| | LVN-M2 | Reference point (Webuye Town) | 15.9 | 1DA02 | a) Representative point to monitor the river ecosystem |
| Yala River | LVN-M3 | Yala Swamp | - | 1FG03 | b) Points where rare or characteristic ecosystem exists (Yala Swamp)<br>d) Upstream points from the protected area |
| Lake Victoria | LVN-M4 | Near river mouth of the Nzoia River | None | - | e) Major lakes in the catchment area, and<br>f) International rivers and lakes. |
| | LVN-M5 | Near river mouth of the Yala River | None | - | |

Note: * Reserve includes the water for ecological needs and basic human needs as mentioned in WRMA Guidelines for Water Allocation.

Source: JICA Study Team (Ref. Sectoral Report (H), Section 3.2(1))

# CHAPTER 5 COST ESTIMATES

## 5.1 Basic Conditions and Methodologies for Cost Estimates

### 5.1.1 Conditions and Methodologies of Cost Estimates for Development Plans

Costs for the projects proposed in the development plans formulated for LVNCA in this study were estimated to identify the overall general costs, to evaluate general economic viability, and to discuss about the general idea or scheme of financing for the implementation of the proposed projects. Development plans include water supply, sanitation, irrigation, hydropower and other water resources development plans.

The project costs (construction costs) together with annual O&M costs and replacement costs were estimated for the proposed projects in the respective development plans using the following methods:

(1) Water Supply Development Projects

a) As for the expansion and new construction of water supply systems, the cost estimates were considered on three categories: i) dams and large-scale bulk water transfer systems; ii) water intake, boreholes, and water transmission lines with pumping stations; and iii) water distribution systems with water treatment plants and pumping stations, separately. Except for dams and large-scale bulk water transfer systems, the project costs were estimated by applying a unit cost of US$2,250/$m^3$. If dams or large-scale water transfer systems are required for water supply system, the costs were estimated separately as described in paragraph e) below. As for the rehabilitation of water supply systems, the project costs were estimated by applying a unit cost of US$675/$m^3$ for water supply capacity of existing water supply system.

b) The above unit costs were derived and adjusted from the data in the existing reports prepared by WSBs and the Aftercare Study Report. The used data include direct and indirect construction costs (administration and engineering services). Land acquisition costs were not estimated because of the marginal amount for water supply projects.

c) The annual O&M costs were estimated for the water supply projects by applying a unit cost of US$0.3/$m^3$ for water production. The unit cost was estimated based on the data in the existing reports prepared by WASREB and WSBs. The replacement costs for electromechanical works were estimated as 30% of the project costs. The replacement was assumed to be conducted every 15 years.

(2) Sanitation Development Projects

a) As for the expansion and new development of sewerage systems, the project costs were estimated by applying a unit cost of US$2,000/$m^3$ for wastewater treatment capacity required. As for the rehabilitation, the project costs were estimated by applying a unit cost of US$600/$m^3$ for treatment capacity of existing sewerage system. The unit costs were derived and adjusted from the data in the existing reports prepared by WSBs and the Aftercare Study Report. The used data include direct and indirect construction costs (administration and engineering services). Land acquisition costs were not estimated because of the marginal amount for the sewerage projects.

b) The annual O&M costs were estimated for the sewerage projects by applying a unit cost of US$0.2/$m^3$ for treatment capacity. The unit cost was estimated based on the data in the existing reports prepared by WASREB and WSBs. The replacement costs for electromechanical works were estimated as 30% of the project costs. The replacement was assumed to be conducted every 15 years.

c) Other sanitation projects

(3) Irrigation Development Projects

a) For the large- and small-scale irrigation projects, the costs for civil works estimated by government authorities were employed with adjustments, when necessary. The construction costs include the physical contingency at 15% of the direct construction costs. Land acquisition costs were assumed to be KSh100,000/ha based on the actual data for other projects, when data were not available.

b) For the new large- and small-scale irrigation projects having no detailed cost data, the project costs were estimated by applying unit costs per ha and indirect construction costs calculated as above. The unit construction costs were assumed at KSh900,000/ha for large-scale dam irrigation, KSh600,000/ha for small-scale dam irrigation, KSh400,000/ha for weir irrigation, and KSh900,000/ha for groundwater irrigation projects by applying the actual costs of similar projects.

c) For private irrigation projects, the unit project cost was assumed at KSh1.5 million/ha referring to the actual investment cost data for drip irrigation system invested by private sectors. This unit cost includes all indirect costs such as engineering services, technical training, and contingencies.

d) The annual O&M costs were estimated as 0.3% of the direct construction costs for water source facilities (dam, weir, and borehole), and 1% for irrigation canal systems. Replacement costs such as mechanical works were assumed as 20% of the direct construction costs, which will be conducted every 20 years.

(4) Hydropower Development Projects

a) For the hydropower projects, project costs were estimated based on the available cost estimates by the government authorities with adjustments. The cost data were regarded to include direct and indirect construction costs. Land acquisition costs were not estimated because of their marginal amounts.

b) Annual O&M costs were estimated as 0.5% of the project costs including replacement costs.

(5) Water Resources Development Projects

a) For dams, project costs were estimated by using a dam project cost curve showing the relationship between the costs and dam embankment volumes in cases where no cost data were available for dam projects. The cost curve was prepared based on the existing costs and dam volume information. In the case that cost data were provided for the planned dams by the Government of Kenya, the data were used and adjusted as project costs.

b) For water transfer facilities, project costs were estimated based on the existing cost data prepared by the Government of Kenya with adjustments depending on pipe size.

c) The abovementioned existing cost data include the direct and indirect construction costs (administration and engineering services). Land acquisition costs for dam and water transfer projects were estimated separately by applying a unit cost of KSh100,000/ha, which was assumed based on actual data.

d) The annual O&M costs for dam and water transfer projects were estimated as 0.5% of the project costs. The percentage was assumed based on the values in the NWMP (1992) and figures usually used in planning similar projects. The replacement costs were not considered for dams and water transfer facilities.

e) The project costs for small dams for rural water supply purposes were estimated based on actual construction data. The costs of boreholes were estimated in the subsectors of water supply and irrigation.

Other basic conditions applied for cost estimates are as follows:

a) Cost estimates were based on the market price on November 1, 2012.

b) The exchange rate used for the cost estimates was US$1.0 = KSh85.24 dated November 1, 2012.

The project costs estimated in this study are only preliminary to grasp the financial status. Therefore, these cost estimates should not be used for specific purposes of financial arrangements of the said projects.

### 5.1.2 Conditions and Methodologies of Cost Estimates for Management Plans

Costs for the proposed management plans for LVNCA were estimated for the respective water resources management, flood and drought disaster management, and environmental management plans to know the costs and to discuss about the general idea of financing the implementation of the plans.

The costs were estimated with two major items namely development cost and recurrent cost as usually applied in the management sectors of the Government. The development cost was estimated as the cost of construction or installation of facilities, equipment, and systems for management activities including required studies and surveys. The recurrent cost was estimated as the cost of periodical monitoring and measurement works for management activities, which were required annually, including operation and maintenance costs. Both the development and recurrent costs were estimated based on the prepared implementation programmes.

The development and recurrent costs were estimated for the proposed management plans through the following methods:

a) For water resources management plan, both development and recurrent costs were estimated by applying the unit costs for management activities based on interviews with WRMA staff in charge of related management activities.

b) For flood and drought disaster management plans, development costs were estimated referring to the existing master plan studies such as the Nyando Flood Management Master Plan (2009) and NWMP (1992) with adjustments. The annual recurrent costs were assumed to be 0.5% of the development costs.

c) For environmental management plan, both development and recurrent costs were estimated by applying the unit costs for management activities in terms of required manpower, meetings, surveys, and monitoring.

For water resources management plan, it was assumed that 40% of existing river and rainfall gauging stations require rehabilitation.

As for the cost estimates for flood and drought disaster management plans, the following were noted:

a) The project costs of dams with flood control allocation were excluded and were estimated separately in the water resources development plan,
b) The project costs for river improvement works were excluded because there were little basic data necessary for planning and cost estimates for the works, and
c) The project costs for drought management plan were excluded because these were considered to be within WRMA's regular tasks.

Other basic conditions applied for the cost estimates were as follows:

a) The cost estimates were based on the market price on November 1, 2012.
b) The exchange rate used for the cost estimates was US$1.0 = KSh85.24, dated November 1, 2012.

The development and recurrent costs estimated in this study are only preliminary to grasp the financial status. Therefore, these costs should not be used for specific purposes of financial arrangements for the said plans.

## 5.2 Cost Estimate for Proposed Plans

### 5.2.1 Cost Estimate for Proposed Development Plans

(1) General Scopes of Proposed Plans for Cost Estimate

The general scopes for cost estimate of the proposed development plans include the following:

1) Water Supply Development Plan

The rehabilitation project includes replacement of old pipes, installation and replacement of water meters, and repair and replacement of mechanical and electrical equipment. Source works include construction of water intake facilities and boreholes with pumps. Water transmission system covers pipelines and pumping stations.

2) Sanitation Development Plan

The rehabilitation project includes replacement of old sewers and repair and replacement of mechanical and electrical equipment. For the cost estimates, waste stabilisation pond was assumed to be adopted for all wastewater treatment works.

3) Irrigation Development Plan

There are three categories of the irrigation projects, namely large-scale, small-scale, and private irrigation. Water sources for irrigation projects include weirs, dams, groundwater, and rainwater harvesting facilities such as small dams and water pans.

4) Hydropower Development Plan

Of the 14 hydropower projects proposed for Kenya, three projects are proposed in LVNCA. These three projects are proposed as hydropower components of multipurpose dam projects.

5) Water Resources Development Plan

The cost of dam includes that for the dam and related structures such as spillways, river outlets, and river diversions.

(2) Estimated Costs

The project and annual O&M costs for the projects proposed in the development plans for LVNCA were estimated based on the conditions and methodologies stated in the preceding section. Results of the estimates are shown in Tables 5.2.1 to 5.2.6 and are summarised below.

**Estimated Costs for Proposed Projects in Development Plans (LVNCA)**

(Unit: KSh million)

<table>
<tr><th>Development Plan</th><th>Proposed Project</th><th>Type</th><th>Project Cost</th><th>Annual O&M Cost</th></tr>
<tr><td rowspan="7">Water Supply*</td><td rowspan="3">Urban Water Supply (32 UCs)</td><td>Rehabilitation</td><td>7,578</td><td>-</td></tr>
<tr><td>New construction</td><td>136,580</td><td>6,101</td></tr>
<tr><td>Sub-total</td><td>144,158</td><td>6,101</td></tr>
<tr><td rowspan="3">Rural Water Supply (11 Counties)</td><td>Rehabilitation</td><td>528</td><td>-</td></tr>
<tr><td>New construction</td><td>32,553</td><td>1,584</td></tr>
<tr><td>Sub-total</td><td>33,082</td><td>1,584</td></tr>
<tr><td colspan="2">Sub-total</td><td>177,240</td><td>7,685</td></tr>
<tr><td rowspan="3">Sanitation*</td><td rowspan="2">Sewerage System (19 UCs)</td><td>Rehabilitation</td><td>1,074</td><td>-</td></tr>
<tr><td>New construction</td><td>74,781</td><td>4,094</td></tr>
<tr><td colspan="2">Sub-total</td><td>75,855</td><td>4,094</td></tr>
<tr><td rowspan="4">Irrigation**</td><td>Large-scale Irrigation (78,370 ha)</td><td>New construction</td><td>82,194</td><td>247</td></tr>
<tr><td>Small-scale Irrigation (47,122 ha)</td><td>New construction</td><td>30,451</td><td>152</td></tr>
<tr><td>Private Irrigation (43,421 ha)</td><td>New construction</td><td>84,178</td><td>842</td></tr>
<tr><td colspan="2">Sub-total</td><td>196,823</td><td>1,241</td></tr>
<tr><td>Hydropower</td><td>3 Projects</td><td>New construction</td><td>26,442</td><td>132</td></tr>
<tr><td colspan="3">Total</td><td>476,360</td><td>13,152</td></tr>
</table>

Note: UC = Urban Centre
* O&M cost of existing water supply and sewerage facilities to be rehabilitated was not estimated due to lack of data required for cost estimate.
** Rehabilitation cost of existing irrigation facilities was not estimated due to lack of data required for cost estimate though there are needs of rehabilitation of them.
Source: JICA Study Team (Ref. Tables 5.2.1 – 5.2.5)

The costs for the proposed water resources development were estimated to be KSh51,144 million for project cost, and KSh256 million for O&M cost, which include the costs of seven dams and two water transfer systems. The costs had been allocated to the costs for water supply, irrigation, and hydropower subsectors.

### 5.2.2 Cost Estimate for Proposed Management Plans

(1) General Scopes of Proposed Plans for Cost Estimate

The general scopes for cost estimate of the proposed management plans include the following:

1) Water Resources Management Plan

The development costs for the water resources management plan were estimated for the activities of i) monitoring of river stage, groundwater level, and rainfall; ii) evaluation such as upgrading the hydrometeorological database and establishment of additional water quality test laboratory; iii) permitting such as upgrading the permits database; and iv) watershed conservation such as forestation.

The recurrent costs for the water resources management plan were estimated for the activities of i) monitoring of surface and groundwater, rainfall and water quality, and ii) operation of the catchment forum.

2) Flood and Drought Disaster Management Plan

The development costs for the flood disaster management plan were estimated for the construction of structures and preparation of hazard maps and evacuation plans.

The recurrent costs for the flood disaster management plan were estimated for the operation and maintenance of structures, updating of documents and maps, and replacement of equipment.

3) Environmental Management Plan

The development costs for the environmental management plan were estimated for i) the environmental survey for setting the environmental flow rate, and ii) setting of the environmental flow rate.

The recurrent costs for the environmental management plan were estimated for the environmental monitoring.

(2) Estimated Costs

The development and recurrent costs for the proposed management plans of LVNCA were estimated based on the conditions and methodologies stated in the preceding section. Results of the estimates are shown in Tables 5.2.7 to 5.2.9 and summarised below.

**Estimated Costs for Proposed Management Plans (LVNCA)**

(Unit: KSh million)

| Management Plan | Proposed Plans | Development Costs | Annual Recurrent Costs * |
|---|---|---|---|
| Water Resources Management | Monitoring | 117 | 126 |
| | Evaluation | 30 | - |
| | Permitting | 18 | - |
| | Watershed Conservation (234,000 ha) | 18,486 | - |
| | Operation of Catchment Forum | - | 1 |
| | Sub-total | 18,651 | 127 |
| Flood and Drought Disaster Management | FFWS (1 location) | 30 | 0.2 |
| | Flood Fighting (1 location) | 30 | 0.2 |
| | Sub-total | 60 | 0.4 |
| Environmental Management | Setting of Environmental Flow Rate including Survey (5 locations) | 35 | - |
| | Environmental Monitoring (5 locations) | - | 0.8 |
| | Sub-total | 35 | 0.8 |
| Total | | 18,746 | 128.2 |

Note: * Recurrent cost includes O&M cost..
FFWS = Flood Forecasting and Warning System
Source: JICA Study Team (Ref. Tables 5.2.7 – 5.2.9)

# CHAPTER 6 ECONOMIC EVALUATION

## 6.1 Basic Conditions and Methodology for Economic Evaluation

The overall economic evaluation was performed for four sectors: 1) urban water supply (for 32 UCs, excluding rehabilitation works), 2) sewerage (for 19 UCs, excluding rehabilitation works), 3) large-scale irrigation (with 75,670 ha), and 4) hydropower (with three dams) in LVNCA at a master plan level. The following assumptions were made for economic analysis:

a) Price Level

Investment costs and O&M costs are estimated at the November 1, 2012 price level. Exchange rate applied is US$1.0 = KSh85.24 = ¥79.98.

b) Social Discount Rate

The social discount rate reflects the opportunity cost of capital to the national economy. In this study, 10% of the prevailing opportunity cost of capital in the water sector of Kenya is applied.

c) Economic Life of Facilities

The economic life of project facilities is set at 50 years for irrigation and hydropower projects, and 30 years for water supply and sanitation projects which are generally applied for economic evaluation. Further, economic life of dam is set at 50 years while that for water transfer facility is set at 30 years which are generally applied.

d) Cost Allocation for Multipurpose Dams

The costs of multipurpose dams are allocated to the three subsectors of urban water supply, irrigation, and hydropower according to the degree of contribution of the dams to each subsector.

e) Economic Cost

The financial cost of the project is converted to the economic cost for economic evaluation. The prices of internationally tradable goods and services are valued on the basis of the international border prices, which can often be found in the World Bank's "Commodity Prices and Price Forecast". The prices of non-traded goods and services were converted from their financial values to economic values by applying a standard conversion factor of 0.90 based on the facts that the ratio of taxation against the GDP in Kenya is about 11%, as well as on the fact that the conversion factors widely applied in the water sector of Kenya are mostly around 0.90.

f) Economic Benefit

The details of economic benefit calculations for the four subsectors are described in the sectoral reports. The economic benefit was estimated by setting the items of economic benefits.

Based on the abovementioned basic conditions for economic evaluation, economic benefits were estimated as follows:

**Estimated Economic Benefits (LVNCA)**

| Subsector | Items of Economic Benefits | Benefit at Net Present Value |
|---|---|---|
| Water Supply | - Cost saving for water users<br>- Increase of water supply amount | KSh 194.2 billion (30 years) |
| Sewerage | - Cost saving for users<br>- Affordability to pay<br>- Improvement of public health | KSh 94.3 billion (30 years) |
| Irrigation | - Crop production increase | KSh 101.0 billion (50 years) |
| Hydropower | - Capacity increase<br>- Energy increase | KSh 22.6 billion (50 years) |

Source: JICA Study Team

## 6.2 Economic Evaluation for Proposed Plan

The table below shows the estimated economic and financial costs, and the results of economic evaluation in LVNCA.

**Summary of Economic Evaluation Results (LVNCA)**

(Unit: KSh billion)

| Subsector | Scope | Estimated Financial Cost | Estimated Economic Cost | Net Present Value | | B/C | EIRR |
|---|---|---|---|---|---|---|---|
| | | | | Cost | Benefit | | |
| Water Supply | 32 UCs | 134.7 | 126.9 | 148.8 | 194.2 | 1.31 | 14.0% |
| Sewerage | 19 UCs | 74.8 | 70.3 | 86.1 | 94.3 | 1.09 | 11.3% |
| Irrigation | 75,670 ha | 64.6 | 593.8 | 51.5 | 101.0 | 1.96 | 17.2% |
| Hydropower | 3 projects | 26.4 | 25.0 | 20.6 | 22.6 | 1.10 | 10.9% |

Source: JICA Study Team

The total economic costs for water resources development is estimated at KSh282.0 billion, of which the water supply subsector is the largest (KSh 126.9 billion), followed by irrigation projects (KSh 70.3 billion). In terms of economic viability, all subsectors were found to be economically feasible with more than 10% of EIRR. On the other hand, the hydropower subsector had a slightly low efficiency from the economic point of view. The results of economic analysis for the four subsectors are summarised as follows:

a) Water supply projects in LVNCA do not require high cost of structures for water source development, such as large-scale dams or water transmission system, which resulted in high economic viability in this subsector;

b) All sewerage projects were estimated to be slightly over 10% in the evaluation. The sewerage projects should be promoted from the perspective of environmental conservation, human health, and water recycling;

c) The plain land in LVNCA is suitable for irrigation development, which results in the high economic viability of the irrigation subsector; and

d) EIRR in the hydropower subsector was higher than the threshold of economic viability, but the high construction cost of the Nandi Forest Hydropower Project lowered the overall economic viability in this catchment, which should be reviewed carefully before the implementation.

# CHAPTER 7 IMPLEMENTATION PROGRAMMES

## 7.1 General

Implementation programmes were prepared for the projects proposed in the water supply, sanitation, irrigation, hydropower, and water resources development plans; and for the management plans proposed for water resources management, flood and drought disaster management, and environmental management. The prepared implementation programmes will be a roadmap for the smooth implementation of the projects and plans by the target year of 2030.

The implementation programmes for the projects are composed of the projects assessed to be viable technically, economically, and environmentally.

## 7.2 Criteria for Prioritisation for Implementation

### 7.2.1 Criteria for Prioritisation of Development Plans

In order to prepare the implementation programmes, the proposed projects and plans were prioritised for implementation in accordance with the following criteria in terms of project status and sub-sector:

(1) Prioritisation by Project Status

The priority ranking was set for the proposed projects in accordance with the following criteria by project status:

Priority ranking 1: Projects with finance,
Priority ranking 2: Projects with detailed designs completed,
Priority ranking 3: Projects with feasibility studies completed, and
Priority ranking 4: Projects other than the above.

It is noted that the national flagship projects and projects proposed by the government organisations in charge were included in the ranking above.

(2) Prioritisation by Subsector

For projects having the same ranking in project status derived from the abovementioned ranking study, the following criteria were applied for further prioritisation of the respective subsectors:

1) Water supply:
- a) Rehabilitation of the existing facilities will be made prior to their expansion.
- b) Projects with large service population such as urban water supply and large-scale rural water supply projects have higher priority.
- c) Small-scale rural water supply projects will be implemented progressively by individuals and communities.

2) Sanitation:
- a) Rehabilitation of the existing facilities will be made prior to their expansion.

b) Sewerage projects in the urban area with more severe impacts on the environment have higher priority.

c) On-site sanitation facilities will be installed progressively by individuals and communities.

3) Irrigation: a) Rehabilitation of existing facilities will be made prior to their expansion.

b) Projects with higher economic viability including large- and small-scale projects proposed by the government organisations have higher priority.

c) Other small-scale and private projects will be implemented progressively under counties and by private companies, respectively.

4) Hydropower: a) Hydropower project will be implemented following the water resources development for water supply and irrigation.

5) Water resources: a) Water resources development such as dams, water transfers, small dams, water pans, and boreholes will be implemented in accordance with the requirements for water supply and irrigation development.

### 7.2.2 Criteria for Prioritisation of Management Plans

Criteria for prioritisation of the proposed management plans for implementation were set as presented below for the water resources management, flood and drought disaster management, and environmental management.

(1) Criteria for Water Resources Management Plan

Considering the magnitude of contribution to stable and sustainable management works, the following activities were prioritised among development activities in water resources management:

a) Replacement of iron posts for river water gauges to concrete post,
b) Installation of dedicated boreholes for groundwater monitoring,
c) Installation and rehabilitation of river and rainfall gauging stations, and
d) Establishment of additional water quality test laboratories.

Among the recurrent activities, items that can start immediately were prioritised.

(2) Criteria for Flood and Drought Disaster Management Plan

1) Flood Disaster Management Plan

a) Non-structural measures are scheduled mostly in the short term because they serve as immediate measures to mitigate flood damage before the completion of structural measures.

b) The construction schedule of multipurpose dams is certainly in accordance with the water resources development subsector.

c) Urban drainage measures where studies have been completed are scheduled in the short term.

2) Drought Disaster Management Plan

a) Drought disaster management plans such as preparation of water use restriction for reservoirs and establishment of basin drought conciliation council should be implemented as early as possible wherever applicable.

(3) Environmental Management Plan

Prior to the implementation of development projects, environmental flow rate should be set as early as possible, because it will be rather difficult to revise the flow rate after the start of certain development projects. For this, environmental survey should start immediately to set the environmental flow rate. Therefore, the following priorities were set:

a) Environmental survey to set the environmental flow rate, which should be conducted during the short term.
b) Locations of setting environmental flow rate should be prioritised by referring to the implementation programme of development plans such as dams.

After setting the environmental flow rate, environmental monitoring should be conducted to confirm the adequacy of the flow rate. Therefore, environmental monitoring for examining the established environmental flow rate should be conducted during the medium term.

At important points where there is currently no measurement by WRMA, environmental monitoring should start immediately. Such activities should be started in the short term.

## 7.3 Implementation Schedule of Proposed Plans

The implementation schedules of proposed plans were prepared under the following conditions as well as the criteria for prioritisation as described in the preceding sections:

a) All proposed projects and plans should be realised by the target year of 2030.
b) The programmes must follow the existing implementation schedules having been prepared by the Government of Kenya.
d) The programmes should be prepared in close harmony with the requirements of other water subsectors.
e) The programmes must be prepared, of which annual disbursement costs are to be as even as possible.

The proposed implementation schedules are shown in Figures 7.3.1 to 7.3.5 for the development plans and Figures 7.3.6 to 7.3.8 for the management plans. Prior to implementation of the development projects, environmental impact assessment (EIA) should be implemented including the issues of compensation.

# *Tables*

## Table 3.3.1 Monthly Water Demand by Sub-Basin in 2030 (LVNCA)

($m^3/s$)

| Sub-basin | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Des | Annual (MCM/year) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1AA | 1.3 | 1.2 | 0.8 | 0.2 | 0.1 | 0.1 | 0.5 | 0.1 | 0.6 | 0.6 | 0.6 | 0.9 | 18 |
| 1AB | 0.6 | 0.5 | 0.4 | 0.3 | 0.3 | 0.3 | 0.4 | 0.3 | 0.4 | 0.4 | 0.4 | 0.5 | 12 |
| 1AC | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | 4 |
| 1AD | 2.3 | 2.0 | 1.5 | 0.5 | 0.2 | 0.2 | 1.0 | 0.2 | 1.1 | 1.1 | 1.0 | 1.6 | 34 |
| 1AE | 2.0 | 1.7 | 1.2 | 0.3 | 0.1 | 0.1 | 0.8 | 0.1 | 0.9 | 0.9 | 0.8 | 1.3 | 26 |
| 1AF | 2.4 | 2.1 | 1.5 | 0.4 | 0.2 | 0.2 | 1.0 | 0.2 | 1.1 | 1.1 | 1.0 | 1.6 | 33 |
| 1AG | 2.0 | 1.7 | 1.2 | 0.3 | 0.2 | 0.2 | 0.8 | 0.2 | 0.9 | 0.9 | 0.9 | 1.3 | 28 |
| 1AH | 6.8 | 6.1 | 4.4 | 1.4 | 0.7 | 0.7 | 3.0 | 0.7 | 3.3 | 3.4 | 3.1 | 4.7 | 101 |
| 1BA | 0.8 | 0.8 | 0.6 | 0.7 | 0.2 | 0.3 | 0.1 | 0.1 | 0.3 | 0.4 | 0.7 | 0.7 | 15 |
| 1BB | 1.2 | 1.2 | 0.9 | 1.0 | 0.4 | 0.5 | 0.2 | 0.2 | 0.5 | 0.6 | 1.0 | 1.1 | 23 |
| 1BC | 1.0 | 1.1 | 0.9 | 0.7 | 0.4 | 0.6 | 0.4 | 0.4 | 0.5 | 0.6 | 0.8 | 1.0 | 22 |
| 1BD | 1.2 | 1.1 | 0.9 | 1.0 | 0.4 | 0.6 | 0.3 | 0.3 | 0.5 | 0.7 | 1.0 | 1.0 | 24 |
| 1BE | 1.8 | 1.7 | 1.4 | 1.5 | 0.7 | 0.9 | 0.5 | 0.5 | 0.9 | 1.1 | 1.5 | 1.6 | 37 |
| 1BG | 2.5 | 2.5 | 2.2 | 2.3 | 1.5 | 1.7 | 1.3 | 1.3 | 1.7 | 1.9 | 2.2 | 2.4 | 61 |
| 1BH | 1.7 | 1.7 | 1.5 | 1.6 | 1.1 | 1.2 | 1.0 | 1.0 | 1.2 | 1.3 | 1.6 | 1.6 | 43 |
| 1CA | 0.9 | 0.9 | 0.7 | 0.7 | 0.5 | 0.5 | 0.2 | 0.2 | 0.4 | 0.7 | 0.7 | 0.8 | 19 |
| 1CB | 2.4 | 2.4 | 2.3 | 2.2 | 2.1 | 2.0 | 1.8 | 1.8 | 1.9 | 2.3 | 2.3 | 2.4 | 68 |
| 1CC | 0.7 | 0.8 | 0.7 | 0.3 | 0.4 | 0.2 | 0.2 | 0.2 | 0.4 | 0.6 | 0.6 | 0.7 | 15 |
| 1CD | 0.7 | 0.7 | 0.6 | 0.5 | 0.4 | 0.3 | 0.1 | 0.1 | 0.3 | 0.5 | 0.6 | 0.6 | 14 |
| 1CE | 0.5 | 0.5 | 0.4 | 0.4 | 0.3 | 0.3 | 0.2 | 0.2 | 0.2 | 0.4 | 0.4 | 0.5 | 11 |
| 1DA | 1.4 | 1.4 | 1.2 | 1.1 | 0.9 | 0.8 | 0.5 | 0.5 | 0.7 | 1.2 | 1.2 | 1.3 | 32 |
| 1DB | 1.2 | 1.2 | 1.0 | 1.0 | 0.5 | 0.6 | 0.3 | 0.3 | 0.6 | 0.7 | 1.0 | 1.1 | 25 |
| 1DC | 0.7 | 0.6 | 0.5 | 0.2 | 0.2 | 0.2 | 0.4 | 0.2 | 0.4 | 0.4 | 0.4 | 0.5 | 12 |
| 1DD | 1.2 | 1.1 | 1.0 | 0.7 | 0.7 | 0.7 | 0.9 | 0.7 | 0.9 | 0.9 | 0.9 | 1.0 | 27 |
| 1EA | 0.9 | 0.9 | 0.7 | 0.5 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.5 | 0.6 | 0.7 | 15 |
| 1EB | 1.6 | 1.7 | 1.5 | 1.3 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.2 | 1.4 | 1.5 | 40 |
| 1EC | 0.5 | 0.6 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 10 |
| 1ED | 1.0 | 1.0 | 0.9 | 0.8 | 0.8 | 0.8 | 0.9 | 0.8 | 0.9 | 0.9 | 0.9 | 1.0 | 28 |
| 1EE | 2.5 | 2.3 | 1.6 | 0.4 | 0.1 | 0.1 | 1.1 | 0.1 | 1.2 | 1.2 | 1.1 | 1.7 | 35 |
| 1EF | 3.9 | 4.2 | 2.6 | 3.1 | 1.4 | 4.2 | 3.3 | 0.3 | 2.0 | 3.5 | 3.2 | 3.4 | 92 |
| 1EG | 3.4 | 3.6 | 2.3 | 2.7 | 1.3 | 3.6 | 2.9 | 0.4 | 1.8 | 3.1 | 2.8 | 2.9 | 81 |
| 1FA | 0.3 | 0.3 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | 0.2 | 0.3 | 0.3 | 0.3 | 7 |
| 1FB | 0.4 | 0.5 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | 0.3 | 0.4 | 8 |
| 1FC | 1.0 | 1.0 | 0.9 | 0.8 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.8 | 0.9 | 0.9 | 26 |
| 1FD | 0.6 | 0.6 | 0.5 | 0.4 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.4 | 0.5 | 0.5 | 12 |
| 1FE | 1.3 | 1.4 | 1.1 | 0.8 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.8 | 1.0 | 1.1 | 24 |
| 1FF | 2.0 | 2.0 | 1.8 | 1.8 | 1.8 | 2.1 | 1.8 | 1.5 | 1.7 | 2.0 | 1.9 | 1.9 | 59 |
| 1FG | 8.3 | 8.9 | 5.5 | 6.7 | 3.1 | 8.8 | 7.2 | 0.8 | 4.3 | 7.5 | 6.9 | 7.2 | 197 |
| Total | 65.1 | 64.0 | 48.4 | 39.4 | 24.1 | 35.4 | 36.0 | 16.5 | 34.7 | 45.5 | 46.8 | 54.2 | 1,337 |

Source: JICA Study Team

**Table 4.2.1 Water Service Providers (WSPs) (LVNCA)**

| WSPs | Service Towns/Areas | Service Population in 2010 | Capacity ($m^3$/day) | NRW |
|---|---|---|---|---|
| [Urban] | | | | |
| Eldoret WSC | Eldoret | 220,198 | 36,400 | 25% |
| Nzoia WSC | Kitale, Kapolet, Kimilili, Kamtiong', Webuye, Bungoma, Matisi, Malakhisi, Malaba, Kocholia | 129,798 | 27,200 | 61% |
| Western WSC | Kakamega, Mumias, Busia, Nambale | | 25,080 | 56% |
| Amatsi WSC | Maseno, Mbale, Kaimosi, Vihiga | 25,767 | 6,350 | 46% |
| Kapsabet Nandi WSC | Kapsabet | 1,584 | 3,800 | 63% |
| Sibo WSC | Yala, Sega, Ugunja, Ukwala, Siaya, Mauna, Bondo, Asembo bay, South Sakwa-Bondo | 52,590 | 10,704 | 64% |
| Kapenguria WSC | Kapenguria | 18,281 | 2,043 | 56% |
| Item Tambach Water Project | Iten, Tambach | 6,492 | 1,110 | 42% |
| [Rural] | | | | |
| Uasin Gishu District | Sosiani, Sigowet, Mosombor | 17,116 | 1,299 | 38% |
| Lugari District | Lugari | 5,512 | 164 | N.A. |
| Trans Zoia District | Kitale | 5,046 | 66 | 25% |
| | | | | |
| Total | | 482,384 | 114,216 | |

Source: Performance Report of Kenya’s Water Services, No. 4, 2011, and data from WSBs

## Table 4.2.2 Proposed Water Supply Development Plan for UWSS (LVNCA)

| Urban Centre | | Service Population in 2030 | Water Demand in2030 ($m^3$/day) | Current Capacity in 2010 ($m^3$/day) | Under Construction ($m^3$/day) | Proposed Projects | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Rehabilitation Works ($m^3$/day) | Expansion Works ($m^3$/day) | New Construction ($m^3$/day) |
| 1 | Eldoret | 1,105,499 | 131,554 | 36,400 | 11,800 | 48,200 | 83,354 | 0 |
| 2 | Vihiga | 597,496 | 71,102 | 60 | 0 | 60 | 71,042 | 0 |
| 3 | Kitale | 534,528 | 63,609 | 10,000 | 0 | 10,000 | 53,609 | 0 |
| 4 | Mumias | 503,318 | 59,895 | 1,680 | 15,000 | 16,680 | 43,215 | 0 |
| 5 | Kimilili | 477,847 | 56,864 | 3,200 | 1,800 | 5,000 | 51,864 | 0 |
| 6 | Kakamega | 461,945 | 54,971 | 16,000 | 0 | 16,000 | 38,971 | 0 |
| 7 | Kapsabet | 436,952 | 51,997 | 3,800 | 0 | 3,800 | 48,197 | 0 |
| 8 | Bungoma | 281,225 | 33,466 | 7,000 | 0 | 7,000 | 26,466 | 0 |
| 9 | Busia | 261,664 | 31,138 | 7,400 | 0 | 7,400 | 23,738 | 0 |
| 10 | Luanda | 248,400 | 29,560 | 0 | 0 | 0 | 0 | 29,560 |
| 11 | Iten/Tambach | 212,992 | 25,346 | 1,100 | 0 | 1,100 | 24,246 | 0 |
| 12 | Webuye | 208,119 | 24,766 | 7,000 | 0 | 7,000 | 17,766 | 0 |
| 13 | Kapenguria | 171,382 | 20,394 | 1,680 | 0 | 1,680 | 18,714 | 0 |
| 14 | Bondo | 168,472 | 20,048 | 1,125 | 0 | 1,125 | 18,923 | 0 |
| 15 | Siaya | 61,452 | 7,313 | 2,100 | 0 | 2,100 | 5,213 | 0 |
| 16 | Yala | 32,277 | 3,841 | 2,400 | 0 | 2,400 | 1,441 | 0 |
| 17 | Ugunja | 36,455 | 4,338 | 385 | 0 | 385 | 3,953 | 0 |
| 18 | Ukwala | 26,110 | 3,107 | 360 | 0 | 360 | 2,747 | 0 |
| 19 | Malaba | 108,112 | 12,865 | 2,200 | 0 | 2,200 | 10,665 | 0 |
| 20 | Malakisi | 85,993 | 10,233 | 0 | 0 | 0 | 0 | 10,233 |
| 21 | Chwele | 72,115 | 8,582 | 0 | 1,200 | 1,200 | 7,382 | 0 |
| 22 | Butere | 64,332 | 7,656 | 0 | 0 | 0 | 0 | 7,656 |
| 23 | Kiminini | 60,330 | 7,179 | 0 | 0 | 0 | 0 | 7,179 |
| 24 | Usenge | 58,861 | 7,004 | 0 | 0 | 0 | 0 | 7,004 |
| 25 | Moi's Bridge | 58,266 | 6,934 | 0 | 0 | 0 | 0 | 6,934 |
| 26 | Nandi Hills | 50,942 | 6,062 | 0 | 0 | 0 | 0 | 6,062 |
| 27 | Lumakanda | 44,681 | 5,317 | 0 | 1,200 | 1,200 | 4,117 | 0 |
| 28 | Matunda | 37,643 | 4,480 | 0 | 0 | 0 | 0 | 4,480 |
| 29 | Port Victoria | 33,027 | 3,930 | 0 | 0 | 0 | 0 | 3,930 |
| 30 | Nambale | 24,872 | 2,960 | 0 | 0 | 0 | 0 | 2,960 |
| 31 | Burnt Forest | 24,792 | 2,950 | 0 | 0 | 0 | 0 | 2,950 |
| 32 | Malava | 20,488 | 2,438 | 0 | 0 | 0 | 0 | 2,438 |
| | Total | 6,570,585 | 781,900 | 103,890 | 31,000 | 134,890 | 555,624 | 91,386 |
| | | | | | | | 647,010 | |

Note: The service population of piped water supply (UWSS+LSRWSS) in 2010 was estimated at 0.77 million. The service population for each urban centre in 2010 is not clear. All urban population of urban centre in 2030 was counted as service population.

Source: JICA Study Team, based on data from WSBs and Census 2009

### Table 4.2.3 Proposed Water Supply Development Plan for LSRWSS (LVNCA)

| Item | Service Population in 2030 | Water Demand in 2030 ($m^3$/day) | Current Capacity in 2010 ($m^3$/day) | Proposed Projects | |
|---|---|---|---|---|---|
| | | | | Rehabilitation Works ($m^3$/day) | New Construction ($m^3$/day) |
| Urban Pop. | 1.13 | 135,000 | 15,000 | 15,000 | 169,000 |
| Rural Pop. | 0.65 | 49,000 | | | |
| Total | 1.78 | 184,000 | | | |

Note: The service population of piped water supply (UWSS+LSRWSS) in 2010 is estimated at 0.77 million.

Source: JICA Study Team, based on data from WSBs and Census 2009

### Table 4.2.4 Proposed Water Supply Development Plan for SSRWSS (LVNCA)

| Counties | Service Population in 2010 | Service Population in 2030 | Difference (2010-2030) | Required Water Supply Amount in 2030 ($m^3$/day) |
|---|---|---|---|---|
| 11 | 3,888,000 | 4,007,252 | 119,252 | 220,399 |

Source: JICA Study Team, based on data from Census 2009

### Table 4.3.1 Proposed Sewerage Development Plan (LVNCA)

| Major Urban Area | | Service Population in 2030 | Required Capacity in 2030 ($m^3$/day) | Current Capacity in 2010 ($m^3$/day) | Under Construction ($m^3$/day) | Proposed Projects | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Rehabilitation Works ($m^3$/day) | Expansion Works ($m^3$/day) | New Construction ($m^3$/day) |
| 1 | Eldoret | 1,105,499 | 84,239 | 4,800 | 0 | 4,800 | 79,439 | 0 |
| 2 | Vihiga | 597,496 | 45,529 | 0 | 0 | 0 | 0 | 45,529 |
| 3 | Kitale | 534,528 | 40,731 | 800 | 0 | 800 | 39,931 | 0 |
| 4 | Mumias | 503,318 | 38,353 | 0 | 0 | 0 | 0 | 38,353 |
| 5 | Kimilili | 477,847 | 36,412 | 0 | 0 | 0 | 0 | 36,412 |
| 6 | Kakamega | 461,945 | 35,200 | 2,700 | 0 | 2,700 | 32,500 | 0 |
| 7 | Kapsabet | 436,952 | 33,296 | 2,500 | 0 | 2,500 | 30,796 | 0 |
| 8 | Bungoma | 281,225 | 21,429 | 4,500 | 0 | 4,500 | 16,929 | 0 |
| 9 | Busia | 261,664 | 19,939 | 3,000 | 0 | 3,000 | 16,939 | 0 |
| 10 | Luanda | 248,400 | 18,928 | 0 | 0 | 0 | 0 | 18,928 |
| 11 | Iten/Tambach | 212,992 | 16,230 | 0 | 0 | 0 | 0 | 16,230 |
| 12 | Webuye | 208,119 | 15,859 | 2,700 | 0 | 2,700 | 13,159 | 0 |
| 13 | Kapenguria | 171,382 | 13,059 | 0 | 0 | 0 | 0 | 13,059 |
| 14 | Bondo | 168,472 | 12,838 | 0 | 0 | 0 | 0 | 12,838 |
| 15 | Malaba | 108,112 | 8,238 | 0 | 0 | 0 | 0 | 8,238 |
| 16 | Malakisi | 85,993 | 6,553 | 0 | 0 | 0 | 0 | 6,553 |
| 17 | Siaya | 72,115 | 5,495 | 0 | 0 | 0 | 0 | 5,495 |
| 18 | Moi's Bridge | 58,266 | 4,440 | 0 | 0 | 0 | 0 | 4,440 |
| 19 | Matunda | 37,643 | 2,868 | 0 | 0 | 0 | 0 | 2,868 |
| | Total | 6,031,965 | 459,636 | 21,000 | 0 | 21,000 | 229,693 | 208,943 |

Note: Data of the service population for each urban centre in 2010 is not available. All urban population of urban centre in 2030 is counted as service population.

Source: JICA Study Team, based on data from WSBs and Census 2009

**Table 4.3.2 Users and Required Units of On-Site Sewerage Facilities (LVNCA)**

| Counties | Users in 2010 | Users in 2030 | Difference (2010-2030) | Required Units of On-site Facilities* |
|---|---|---|---|---|
| 11 | 6,540,000 | 6,330,000 | -210,000 | 1,266,000 |

Note: * 5 users/facilities

Source: JICA Study Team, based on data from Census 2009

## Table 4.4.1 Large Scale Irrigation Projects Selected for Implementation by 2030 (LVNCA)

| No | Name of Project | County | Sub-basin Code | Irrigation Area (ha) | Project Type*[1] | Water Source Facilities*[2] | | Present Status*[3] | Estimated Cost*[4] (KSh mil.) | Executing Agency |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Type | Name of Dam | | | |
| 1. | Kibolo Irrigation | Kakanmega | 1CE | 11,500 | New | Dam | Kibolo | Proposed | 6,435 | LBDA |
| 2. | Lower Nzoia Irrigation | Busia & Siaya | 1EF | 10,470 | New | Multi-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 Irrgation | 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 |

Note: *1: Reh = Rehabilitation, Ext = Extension; *2: Multi = Multipurpose, E = Existing; *3: F/S = Feasibility study, D/D = Detailed design,
*4: Estimated Cost = Construction cost for irrigation sytem (excluding cost allocation of multipurpose dam)

Source: JICA Study Team, based on information from government authorities.

## Table 4.6.1 Available Surface Water and Groundwater Resources for 2030 by Sub-basin (LVNCA)

| | Surface Water ($m^3/s$) | | | | | | | | | | | | | Groundwater |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sub-basin | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Average | (MCM/year) |
| 1AA | 0.7 | 0.5 | 0.7 | 2.4 | 3.7 | 1.9 | 1.3 | 1.6 | 2.0 | 2.2 | 2.3 | 1.2 | 1.7 | 1.9 |
| 1AB | 1.6 | 1.2 | 1.5 | 4.6 | 6.7 | 4.1 | 3.2 | 3.9 | 4.2 | 4.5 | 4.5 | 2.4 | 3.5 | 0.3 |
| 1AC | 0.1 | 0.0 | 0.1 | 0.8 | 1.4 | 0.8 | 0.5 | 0.6 | 0.8 | 0.8 | 0.9 | 0.4 | 0.6 | 1.4 |
| 1AD | 0.9 | 0.6 | 0.8 | 2.9 | 4.8 | 2.5 | 1.5 | 1.5 | 2.1 | 2.6 | 3.0 | 1.7 | 2.1 | 2.8 |
| 1AE | 0.4 | 0.3 | 0.4 | 1.2 | 2.0 | 1.0 | 0.6 | 0.5 | 0.7 | 1.0 | 1.3 | 0.8 | 0.9 | 3.2 |
| 1AF | 1.2 | 0.9 | 1.1 | 3.2 | 4.9 | 2.8 | 1.8 | 1.8 | 2.4 | 2.8 | 3.2 | 2.0 | 2.3 | 4.7 |
| 1AG | 0.8 | 0.5 | 0.6 | 2.4 | 3.9 | 2.1 | 1.3 | 1.2 | 1.7 | 2.0 | 2.5 | 1.5 | 1.7 | 4.9 |
| 1AH | 0.6 | 0.3 | 0.5 | 2.5 | 4.0 | 1.6 | 0.8 | 0.8 | 1.3 | 1.9 | 2.5 | 1.4 | 1.5 | 7.7 |
| 1BA | 1.1 | 0.6 | 0.6 | 2.7 | 4.1 | 2.6 | 3.0 | 3.5 | 1.9 | 2.3 | 2.7 | 1.5 | 2.2 | 3.9 |
| 1BB | 3.6 | 2.7 | 2.6 | 8.6 | 13.6 | 8.8 | 10.3 | 11.8 | 7.3 | 8.4 | 8.9 | 4.8 | 7.6 | 6.2 |
| 1BC | 1.9 | 1.4 | 1.3 | 3.3 | 6.6 | 5.4 | 5.8 | 6.8 | 5.6 | 5.6 | 5.0 | 2.7 | 4.3 | 6.4 |
| 1BD | 2.6 | 2.2 | 2.2 | 3.4 | 5.3 | 4.3 | 4.2 | 5.5 | 4.9 | 4.4 | 4.3 | 3.1 | 3.9 | 1.6 |
| 1BE | 3.0 | 2.0 | 1.8 | 5.2 | 11.4 | 9.3 | 9.0 | 11.6 | 10.4 | 9.9 | 9.1 | 4.8 | 7.3 | 5.6 |
| 1BG | 3.7 | 3.0 | 3.1 | 7.5 | 12.2 | 9.3 | 8.6 | 11.4 | 10.6 | 10.2 | 9.1 | 4.9 | 7.8 | 4.0 |
| 1BH | 2.5 | 2.0 | 2.2 | 5.7 | 8.9 | 6.6 | 5.8 | 7.4 | 7.3 | 7.0 | 6.5 | 3.5 | 5.4 | 0.6 |
| 1CA | 2.5 | 2.2 | 2.1 | 3.5 | 4.9 | 3.8 | 4.1 | 5.0 | 3.8 | 3.5 | 3.7 | 2.9 | 3.5 | 2.9 |
| 1CB | 2.4 | 1.9 | 1.8 | 4.1 | 5.5 | 4.2 | 4.8 | 5.8 | 4.3 | 3.9 | 4.0 | 2.9 | 3.8 | 3.6 |
| 1CC | 4.1 | 3.6 | 3.6 | 6.5 | 7.8 | 6.3 | 7.3 | 8.1 | 6.4 | 6.1 | 6.0 | 4.7 | 5.9 | 2.5 |
| 1CD | 7.3 | 6.1 | 6.1 | 12.3 | 16.5 | 12.9 | 14.3 | 17.4 | 13.6 | 12.3 | 12.1 | 8.6 | 11.6 | 0.6 |
| 1CE | 1.8 | 1.6 | 1.7 | 3.1 | 4.2 | 3.6 | 3.5 | 4.5 | 4.0 | 3.7 | 3.3 | 2.2 | 3.1 | 0.3 |
| 1DA | 3.4 | 3.0 | 3.5 | 7.2 | 9.5 | 7.3 | 6.5 | 8.4 | 8.4 | 7.8 | 7.3 | 4.6 | 6.4 | 0.7 |
| 1DB | 5.5 | 4.8 | 5.3 | 10.8 | 14.8 | 10.8 | 9.4 | 11.0 | 11.2 | 11.3 | 10.9 | 6.8 | 9.4 | 0.9 |
| 1DC | 2.5 | 2.1 | 2.2 | 4.3 | 6.4 | 4.8 | 3.8 | 4.2 | 4.8 | 4.6 | 4.8 | 3.3 | 4.0 | 0.5 |
| 1DD | 2.7 | 2.3 | 2.5 | 4.7 | 6.9 | 4.9 | 3.7 | 3.8 | 4.5 | 4.6 | 5.1 | 3.7 | 4.1 | 0.5 |
| 1EA | 5.6 | 5.1 | 5.7 | 10.4 | 12.2 | 10.0 | 9.3 | 11.0 | 10.4 | 9.8 | 9.4 | 6.8 | 8.8 | 0.6 |
| 1EB | 4.6 | 4.2 | 4.6 | 7.7 | 9.0 | 7.1 | 6.3 | 7.1 | 7.2 | 7.1 | 7.0 | 5.4 | 6.4 | 0.5 |
| 1EC | 2.7 | 2.5 | 2.7 | 4.4 | 5.4 | 4.3 | 3.9 | 4.6 | 4.9 | 4.8 | 4.6 | 3.4 | 4.0 | 0.3 |
| 1ED | 1.1 | 1.0 | 1.0 | 1.9 | 2.6 | 1.8 | 1.4 | 1.5 | 1.7 | 1.8 | 1.9 | 1.4 | 1.6 | 0.1 |
| 1EE | 1.2 | 0.7 | 0.8 | 2.6 | 5.7 | 3.1 | 1.3 | 1.3 | 2.1 | 2.6 | 3.6 | 2.5 | 2.3 | 0.4 |
| 1EF | 0.7 | 0.1 | 0.3 | 2.5 | 6.4 | 2.4 | 0.2 | 0.3 | 1.2 | 2.0 | 3.6 | 2.5 | 1.9 | 6.3 |
| 1EG | 2.2 | 1.3 | 1.6 | 5.0 | 8.0 | 4.7 | 2.7 | 2.7 | 3.4 | 4.2 | 5.1 | 4.0 | 3.7 | 3.4 |
| 1FA | 0.7 | 0.5 | 0.5 | 1.8 | 2.3 | 1.7 | 2.0 | 2.4 | 1.8 | 1.6 | 1.6 | 1.0 | 1.5 | 2.5 |
| 1FB | 3.0 | 2.6 | 3.0 | 6.6 | 8.1 | 6.6 | 6.9 | 7.8 | 6.7 | 6.2 | 6.1 | 4.1 | 5.6 | 1.5 |
| 1FC | 1.8 | 1.6 | 1.8 | 3.5 | 4.5 | 3.7 | 3.6 | 4.1 | 3.8 | 3.4 | 3.4 | 2.5 | 3.1 | 1.9 |
| 1FD | 2.9 | 2.5 | 2.8 | 6.4 | 8.0 | 6.3 | 6.4 | 7.1 | 6.2 | 5.8 | 6.0 | 4.1 | 5.4 | 2.6 |
| 1FE | 4.6 | 3.7 | 4.5 | 11.0 | 13.7 | 10.1 | 8.3 | 9.3 | 9.4 | 9.2 | 9.3 | 7.0 | 8.3 | 3.2 |
| 1FF | 0.7 | 0.2 | 0.6 | 2.8 | 3.6 | 2.2 | 1.2 | 1.2 | 1.4 | 1.6 | 1.9 | 1.5 | 1.6 | 3.7 |
| 1FG | 1.7 | 0.2 | 1.1 | 6.7 | 10.7 | 3.2 | 0.3 | 0.7 | 1.6 | 3.3 | 5.9 | 4.8 | 3.3 | 13.5 |

Source: JICA Study Team

**Table 4.6.2 Water Demands for 2030 by Sub-sector and Sub-basin (LVNCA)**

($m^3/s$)

| Sub-basin | Domestic | | Industrial | | Irrigation | | Livestock | | Wildlife | | Fisheries | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2010 | 2030 | 2010 | 2030 | 2010 | 2030 | 2010 | 2030 | 2010 | 2030 | 2010 | 2030 |
| 1AA | 0.06 | 0.05 | 0.00 | 0.00 | 0.00 | 0.09 | 0.01 | 0.02 | 0.00 | 0.00 | 0.00 | 0.01 |
| 1AB | 0.05 | 0.22 | 0.00 | 0.01 | 0.00 | 0.07 | 0.01 | 0.02 | 0.00 | 0.00 | 0.01 | 0.01 |
| 1AC | 0.04 | 0.05 | 0.00 | 0.00 | 0.00 | 0.04 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 |
| 1AD | 0.11 | 0.20 | 0.00 | 0.01 | 0.01 | 0.09 | 0.01 | 0.03 | 0.00 | 0.00 | 0.01 | 0.01 |
| 1AE | 0.08 | 0.04 | 0.00 | 0.00 | 0.01 | 0.09 | 0.01 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1AF | 0.18 | 0.11 | 0.00 | 0.00 | 0.01 | 0.15 | 0.02 | 0.05 | 0.00 | 0.00 | 0.01 | 0.01 |
| 1AG | 0.16 | 0.10 | 0.00 | 0.00 | 0.01 | 0.15 | 0.02 | 0.04 | 0.00 | 0.00 | 0.01 | 0.02 |
| 1AH | 0.18 | 0.65 | 0.00 | 0.03 | 0.02 | 0.17 | 0.02 | 0.05 | 0.00 | 0.00 | 0.01 | 0.02 |
| 1BA | 0.08 | 0.07 | 0.01 | 0.00 | 0.04 | 0.12 | 0.02 | 0.05 | 0.00 | 0.00 | 0.00 | 0.01 |
| 1BB | 0.16 | 0.13 | 0.01 | 0.01 | 0.03 | 0.56 | 0.03 | 0.07 | 0.00 | 0.00 | 0.01 | 0.02 |
| 1BC | 0.08 | 0.35 | 0.00 | 0.01 | 0.02 | 0.37 | 0.02 | 0.06 | 0.00 | 0.00 | 0.00 | 0.01 |
| 1BD | 0.20 | 0.21 | 0.02 | 0.01 | 0.01 | 0.40 | 0.03 | 0.07 | 0.00 | 0.00 | 0.01 | 0.01 |
| 1BE | 0.25 | 0.41 | 0.01 | 0.01 | 0.01 | 5.48 | 0.03 | 0.08 | 0.00 | 0.00 | 0.00 | 0.01 |
| 1BG | 0.33 | 1.19 | 0.01 | 0.05 | 0.01 | 6.49 | 0.04 | 0.09 | 0.00 | 0.00 | 0.01 | 0.01 |
| 1BH | 0.15 | 0.86 | 0.00 | 0.04 | 0.00 | 0.19 | 0.02 | 0.05 | 0.00 | 0.00 | 0.01 | 0.01 |
| 1CA | 0.20 | 0.13 | 0.02 | 0.01 | 0.01 | 0.26 | 0.03 | 0.06 | 0.00 | 0.00 | 0.01 | 0.01 |
| 1CB | 0.15 | 1.62 | 0.01 | 0.08 | 0.02 | 0.20 | 0.02 | 0.06 | 0.00 | 0.00 | 0.01 | 0.02 |
| 1CC | 0.15 | 0.09 | 0.01 | 0.00 | 0.01 | 0.25 | 0.02 | 0.06 | 0.00 | 0.00 | 0.01 | 0.02 |
| 1CD | 0.08 | 0.08 | 0.00 | 0.00 | 0.02 | 0.38 | 0.02 | 0.05 | 0.00 | 0.00 | 0.00 | 0.01 |
| 1CE | 0.07 | 0.12 | 0.00 | 0.00 | 0.00 | 3.52 | 0.01 | 0.03 | 0.00 | 0.00 | 0.00 | 0.01 |
| 1DA | 0.20 | 0.44 | 0.01 | 0.02 | 0.01 | 2.59 | 0.03 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1DB | 0.20 | 0.22 | 0.00 | 0.00 | 0.00 | 0.73 | 0.03 | 0.07 | 0.00 | 0.00 | 0.01 | 0.02 |
| 1DC | 0.16 | 0.14 | 0.01 | 0.00 | 0.00 | 0.23 | 0.02 | 0.05 | 0.00 | 0.00 | 0.00 | 0.01 |
| 1DD | 0.18 | 0.59 | 0.00 | 0.03 | 0.00 | 0.25 | 0.02 | 0.05 | 0.00 | 0.00 | 0.01 | 0.02 |
| 1EA | 0.12 | 0.13 | 0.00 | 0.01 | 0.00 | 0.43 | 0.02 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1EB | 0.21 | 0.80 | 0.01 | 0.10 | 0.00 | 0.74 | 0.02 | 0.06 | 0.00 | 0.00 | 0.01 | 0.03 |
| 1EC | 0.12 | 0.08 | 0.01 | 0.00 | 0.00 | 0.26 | 0.01 | 0.03 | 0.00 | 0.00 | 0.01 | 0.01 |
| 1ED | 0.07 | 0.75 | 0.00 | 0.04 | 0.00 | 0.02 | 0.01 | 0.02 | 0.00 | 0.00 | 0.00 | 0.01 |
| 1EE | 0.11 | 0.08 | 0.00 | 0.00 | 0.01 | 1.77 | 0.02 | 0.04 | 0.00 | 0.00 | 0.00 | 0.01 |
| 1EF | 0.10 | 0.21 | 0.00 | 0.00 | 0.04 | 1.68 | 0.02 | 0.04 | 0.00 | 0.00 | 0.01 | 0.02 |
| 1EG | 0.16 | 0.33 | 0.00 | 0.01 | 0.04 | 1.22 | 0.03 | 0.07 | 0.00 | 0.00 | 0.01 | 0.02 |
| 1FA | 0.07 | 0.07 | 0.00 | 0.00 | 0.00 | 0.13 | 0.01 | 0.02 | 0.00 | 0.00 | 0.01 | 0.01 |
| 1FB | 0.08 | 0.05 | 0.00 | 0.00 | 0.01 | 0.19 | 0.02 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1FC | 0.08 | 0.64 | 0.00 | 0.03 | 0.01 | 0.10 | 0.01 | 0.03 | 0.00 | 0.00 | 0.00 | 0.01 |
| 1FD | 0.09 | 0.13 | 0.00 | 0.00 | 0.01 | 0.20 | 0.02 | 0.04 | 0.00 | 0.00 | 0.00 | 0.01 |
| 1FE | 0.26 | 0.22 | 0.00 | 0.00 | 0.01 | 0.73 | 0.04 | 0.11 | 0.00 | 0.00 | 0.02 | 0.03 |
| 1FF | 0.20 | 1.29 | 0.01 | 0.06 | 0.00 | 0.01 | 0.03 | 0.07 | 0.00 | 0.00 | 0.01 | 0.03 |
| 1FG | 0.20 | 0.61 | 0.00 | 0.02 | 0.10 | 7.28 | 0.04 | 0.10 | 0.00 | 0.00 | 0.01 | 0.03 |

Source: JICA Study Team

**Table 4.6.3 Reserve Quantity by Sub-basin for Water Balance Study (LVNCA)**

| Sub-basin | Catchment Area ($km^2$) | Accumulated Catchment Area ($km^2$) | River Name | Reserve *1 ($m^3/s$) | Node *2 |
|---|---|---|---|---|---|
| 1BA | 637 | | Nzoia River | 0.2 | 6 |
| 1BB | 755 | 1,391 | | 1.6 | 10 |
| 1BC | 771 | | | 0.7 | 16 |
| 1BE | 1,153 | 3,315 | | 2.8 | 25 |
| 1BD | 687 | 4,002 | | 4.2 | 33 |
| 1BH | 581 | | | 1.0 | 41 |
| 1BG | 914 | 5,496 | | 7.0 | 44 |
| 1CA | 718 | | | 1.5 | 46 |
| 1CB | 657 | | | 1.2 | 61 |
| 1CC | 664 | | | 2.8 | 68 |
| 1CD | 517 | 1,181 | | 4.1 | 72 |
| 1CE | 258 | 2,814 | | 8.0 | 77 |
| 1DA | 528 | 8,838 | | 17.3 | 87 |
| 1DB | 728 | | | 3.3 | 93 |
| 1DC | 351 | 9,918 | | 22.1 | 98 |
| 1DD | 368 | 10,286 | | 23.8 | 102 |
| 1EA | 441 | | | 4.0 | 108 |
| 1EB | 382 | 823 | | 7.5 | 113 |
| 1EC | 237 | | | 2.1 | 115 |
| 1ED | 131 | 1,191 | | 10.4 | 124 |
| 1EE | 395 | 11,872 | | 34.1 | 133 |
| 1EG | 554 | 554 | | 0.8 | 135 |
| 1EF | 426 | 12,853 | | 33.5 | 140 |
| | | | | | |
| 1FA | 238 | | Yala River | 0.2 | 167 |
| 1FB | 370 | 608 | | 1.8 | 171 |
| 1FC | 272 | 879 | | 3.0 | 179 |
| 1FD | 476 | | | 1.5 | 189 |
| 1FE | 661 | 2,017 | | 6.8 | 198 |
| 1FF | 273 | | | 0.0 | 204 |
| 1FG | 970 | 3,259 | | 4.3 | 210 |
| | | | | | |
| 1AA | 203 | | | 0.3 | 142 |
| | | | | | |
| 1AB | 285 | | | 0.7 | 144 |
| 1AC | 112 | | | 0.0 | 146 |
| 1AD | 254 | 652 | | 1.0 | 152 |
| | | | | | |
| 1AE | 184 | | | 0.2 | 154 |
| | | | | | |
| 1AF | 403 | | | 0.6 | 156 |
| 1AG | 347 | | | 0.2 | 159 |
| 1AH | 512 | 1,262 | | 1.0 | 165 |
| | | | | | |
| 1HC | 600 | | | 0.0 | 212 |

Note: *1 = Reserve was set at 95% value of the naturalized present daily flow duration curve with a probability of once in 10 years.
*2 = Node numbers in Figure 4.6.3.
Source: JICA Study Team

# Table 4.6.4 Dam Candidates (LVNCA)

(1) Priority Dams proposed in NWMP (1992)

| | | NWMP (1992) | | | | Current Status | | | |
|---|---|---|---|---|---|---|---|---|---|
| Catchment Area | | Proposed Dams | Sub-basin | Stage | Purpose | Related Agency/ Owner | Status/ Construction Year | Source of Information | Remarks |
| 1. | LVN | 1. Moiben (Chebara) | 1BA | D/D | W | LVNWSB/ Eldoret Municipality | Completed (1997) | NWCPC | Operated by ELDOWAS. |
| | | 2. Mukulusi | 1EA | M/P | W | LVNWSB | No further study is done. | NWCPC | |

(2) Future Development Potential Dams at the time of NWMP (1992)

| | | NWMP (1992) | | | | Current Status | | | |
|---|---|---|---|---|---|---|---|---|---|
| Catchment Area | | Future Development Potential Dams | | Sub-basin | Purpose | Related Agency/ Owner | Status/ Construction Year | Source of Information | Remarks |
| 1. | LVN | 01 | Moi's Bridge | 1BE | P, I, W | - | No further study is done. | WRMA | |
| | | 02 | Hemsted Brg. | 1BD | W, I, P | MOSSP/ MWI | Proposed in Pre-F/S (2010) as a future potential site. | MWI | There are two (2) alternative damsites at 33A and 33B. |
| | | 03 | Kibolo | 1CE | W | | | | No information is found. |
| | | 04 | Webuye Falls | 1DA | P | MORDA | No further study is done. | MORDA | MORDA 18 Projects |
| | | 05 | Teremi | 1DB | P | MORDA | No further study is done. | MORDA | MORDA 18 Projects |
| | | 06 | Kimondi | 1FC | W, I | | | | No information is found. |
| | | 07 | Nandi Forest | 1FD | I, P, W | LBDA/ MORDA | F/S done (2010), D/D completed (2011) | MORDA | MORDA 18 Projects |
| | | 08 | Mushangumbo | 1FE | P | | | | No information is found. |

(3) Dam Schemes Studied by Government

| | | Identified Dams | | | | Current Status | | | |
|---|---|---|---|---|---|---|---|---|---|
| Catchment Area | | Dams not in NWMP (1992) | | Sub-basin | Purpose | Related Agency/ Owner | Status/ Construction Year | Source of Information | Remarks |
| 1. | LVN | 1 | Siyoi | 1BC | W | NWCPC | F/S, D/D ongoing (to be completed in 2013) | NWCPC | 2008-12 Flagship Projects under Vision 2030 |
| | | 2 | Nzoia (at site No. 34B) | 1BG | W, F, I, P | NWCPC | F/S, D/D, T/D ongoing (to be completed in 2013) | NWCPC | (2008-12 Flagship Projects under Vision 2030)* |
| | | 3 | Nzoia (at site No. 42A) | 1EE | F, P | MOSSP/ MWI | F/S, D/D ongoing (to be completed in 2013) | MWI | (2008-12 Flagship Projects under Vision 2030)*, Under WKCDD&FMP |

Note:
Purpose: W=water supply, I=irrigation, P=hydropower, F=flood control
Project Stage: M/P=master plan, Pre-F/S=prefeasibility study, F/S=feasibility study, D/D=detailed design, T/D=tender documents, U/C=under construction

Source: JICA Study Team based on NWMP (1992) and information from the government agencies mentioned in the above tables.

## Table 4.6.5 Water Transfer Candidates (LVNCA)

(1) Priority Water Transfer Schemes proposed in NWMP (1992)

a) Intra-basin Bulk Water Transfer Schemes

| Catchment Area | | No. | NWMP (1992) Intra- basin Water Transfer | | | | | Current Status | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Sub-basin | Water Source | | Sub-basin | Notes | Related Agency / Owner | Status/ Construction Year | Source of Information | Remarks |
| 1. | LVN | R1 | 1AG | Sio River | without dam | 1AH | | - | No further study is done. | LVNWSB | |
| | | R2 | 1BA | Moiben Dam | | 1CB | | Eldoret Municipality | Operational | NWCPC, LVNWSB | |
| | | R3 | 1EA | Mukulusi Dam | | 1EB | | LVNWSB | No further study is done. | NWCPC, LVSWSB | |

b) Inter-basin Bulk Water Transfer Schemes

| Catchment Area | | No. | NWMP (1992) Inter- basin Water Transfer | | | | | Current Status | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Sub-basin | Water Source | | Sub-basin | Notes | Related Agency / Owner | Status/ Construction Year | Source of Information | Remarks |
| 1. | LVN | E1 | 1BA | Moiben Dam | | 2CB | | Eldoret Municipality | Operational | NWCPC, LVNWSB | Expansion for water treatment is ongoing. |
| | | E2 | 1FF | Edzawa Dam | small dam | 1HB | | MWI/ NWCPC | No further study is done. | LVNWSB | |

(2) Water Transfer Schemes Studied by Government

a) Intra-basin Bulk Water Transfer Schemes

None

b) Inter-basin Bulk Water Transfer Schemes

| Catchment Area | | No. | Sub-basin | Water Source | | Sub-basin | Related Agency / Owner | Status/ Construction Year | Source of Information | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | LVN | | 1BC | Siyoi Dam* | | 1BC | NWCPC | F/S, D/D ongoing | NWCPC | |
| | | | 1BG | Nzoia Dam (at No.34B site)* | | 1BG | NWCPC | F/S, D/D ongoing | NWCPC | |
| | | | 1FD | Nandi Forest Dam | | 1HA1 | LBDA/ MORDA | D/D completed | MORDA | |
| | | | | | | 1HA2 | LBDA/ MORDA | D/D completed | MORDA | |

Note:

Project Stage: M/P=master plan, Pre-F/S=prefeasibility study, F/S=feasibility study, D/D=detailed design, T/D=tender documents, U/C=under construction

* = Listed by NWCPC as “Inter-basin Transfer Schemes.”

Source: JICA Study Team based on NWMP (1992) and information from the government agencies mentioned in the above tables.

## Table 4.6.6 Proposed Dams and Water Transfer (LVNCA)

(1) Proposed Dams

| No. | Name of Dam | Sub-basin | Relevant County | Purpose 1) | Effective Storage Volume (MCM) | Storage Volume Allocation (MCM) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Domestic and Industrial | Irrigation | Hydro-power | Flood Control |
| 1 | Siyoi | 1BC | Trans-Nzoia, West Pokot | W (Kapenguria) | 2) *4.1* | *4.1* | *0.0* | | |
| 2 | Moi's Bridge | 1BE | Trans-Nzoia | W (Moi's Bridge, Matunda), I (19,800 ha) | 214.0 | 22.0 | 192.0 | | |
| 3 | Nzoia (34B) | 1BG | Bungoma, Kakamega | I (24,000 ha), P (16 MW), F | *203.7* | 4) 0.0 | 203.7 | | |
| 4 | Kibolo | 1CE | Uasin Gishu | W (Lumakanda), I (11,500 ha) | 40.0 | 17.0 | 23.0 | | |
| 5 | Teremi | 1DB | Bungoma | W (Kimilili, Bungoma, Chwele) | 3.0 | 3.0 | 0.0 | | |
| 6 | Nzoia (42A) | 1EE | Siaya | I (10,470 ha), P (25 MW), F | *395.0* | 4) 0.0 | 139.0 | | 256.0 |
| 7 | Nandi Forest | 1FD | Nandi | W (Yala, Kisumu in LVSCA), I (7,272 ha in LVSCA), P (50 MW) | 3) *220.0* | 4) 89.0 | 5) (131.0) | 131.0 | |
| | Total | | | | 1,079.8 | 135.1 | 557.7 | 131.0 | 256.0 |

Note:
1) W=Domestic and industrial water supply, I=Irrigation, P=Hydropower, F=Flood control
2) Figures in Italic Font are those proposed by the Kenyan Government.
3) An adjustment is made to the effective storage volume by deducting dead storage volume from the reservoir storage volume indicated in the existing reports.
4) Allocated storage volumes are estimated by the JICA Study Team, since these are not available in the existing design reports.
5) Storage volumes in parentheses mean that the volumes are to be used first for hydropower generation and then used for irrigation and/ or domestic water purpose.
Source: JICA Study Team

(2) Proposed Water Transfer

| Wter Transfer Scheme | | Relevant County | Purpose | Capacity, Dimensions |
|---|---|---|---|---|
| 1 | Moiben Dam to Eldoret/ Iten (Expansion) | Elgiyo Marakwet, Uasin Gishu | W | Capacity of 5 MCM/year, Pipeline of 600 mm dia, 60 km long |
| 2 | Nandi Forest Dam to LVSCA | Nandi, Kisumu | W, I, P | Capacity of 189 MCM/year |

Source: JICA Study Team based on NWMP (1992) and data from NWCPC, MORDA, RDAs, and WSBs

# Table 4.6.7 Balance between Water Resources and Water Demands in 2030 (LVNCA)

(Unit: MCM/year)

| No. | Sub basin | CA ($km^2$) | Major Domestic Demand Centre | Domestic and Industrial | | | | | | | | | | Irrigation | | | | | | | | Livestock | | | Wildlife | | | Fisheries | | | Summary | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Surface Water | | | | | | | | Surface Water | | | | | | | SW | | | SW | | | SW | | | Surface Water | | | | | |
| | | | | Demand | Demand (Domestic ) | Demand( Industrial) | Deficit | River Water | Dam | Transfer | Small Dam/ Water Pans | Groundwater | Balance | Demand | Deficit | River Water | Dam | Transfer | Small Dam/ Water Pans | Groundwater | Balance | Demand | Small Dam/ Water Pans | Balance | Demand | Small Dam/ Water Pans | Balance | Demand | Small Dam/ Water Pans | Balance | Demand | River Water | Dam | Transfer | Small Dam/ Water Pans | Groundwater | Balance |
| 1 | 1AA | 203 | | 1.7 | 1.7 | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 4.6 | 0.0 | 3.7 | 0.0 | 0.0 | 0.3 | 0.7 | 0.0 | 0.6 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.0 | 7.1 | 4.4 | 0.0 | 0.0 | 1.1 | 1.7 | 0.0 |
| 2 | 1AB | 285 | Malakasi | 7.1 | 6.8 | 0.3 | -0.5 | 4.8 | 0.0 | 0.0 | 1.9 | 0.3 | 0.0 | 4.2 | 0.0 | 3.7 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.7 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.4 | 0.0 | 12.4 | 8.6 | 0.0 | 0.0 | 3.5 | 0.3 | 0.0 |
| 3 | 1AC | 112 | | 1.5 | 1.5 | 0.0 | -0.2 | 0.4 | 0.0 | 0.0 | 0.2 | 0.9 | 0.0 | 2.0 | 0.0 | 1.4 | 0.0 | 0.0 | 0.2 | 0.4 | 0.0 | 0.5 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.0 | 4.2 | 1.9 | 0.0 | 0.0 | 1.1 | 1.3 | 0.0 |
| 4 | 1AD | 254 | Malaba | 6.5 | 6.3 | 0.2 | -0.9 | 3.8 | 0.0 | 0.0 | 0.9 | 1.8 | 0.0 | 4.8 | 0.0 | 3.6 | 0.0 | 0.0 | 0.4 | 0.8 | 0.0 | 0.9 | 0.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.4 | 0.0 | 12.5 | 7.4 | 0.0 | 0.0 | 2.6 | 2.5 | 0.0 |
| 5 | 1AE | 184 | | 1.3 | 1.3 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 1.2 | 0.0 | 4.3 | 0.0 | 2.5 | 0.0 | 0.0 | 0.3 | 1.6 | 0.0 | 0.7 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 6.3 | 2.6 | 0.0 | 0.0 | 1.0 | 2.7 | 0.0 |
| 6 | 1AF | 403 | | 3.5 | 3.4 | 0.0 | -0.1 | 0.5 | 0.0 | 0.0 | 0.1 | 2.9 | 0.0 | 8.2 | 0.0 | 6.2 | 0.0 | 0.0 | 0.6 | 1.4 | 0.0 | 1.5 | 1.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.4 | 0.0 | 13.6 | 6.7 | 0.0 | 0.0 | 2.6 | 4.2 | 0.0 |
| 7 | 1AG | 347 | | 3.1 | 3.0 | 0.0 | -0.1 | 0.5 | 0.0 | 0.0 | 0.1 | 2.4 | 0.0 | 7.7 | 0.0 | 5.2 | 0.0 | 0.0 | 0.6 | 1.9 | 0.0 | 1.2 | 1.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.5 | 0.0 | 12.4 | 5.7 | 0.0 | 0.0 | 2.4 | 4.3 | 0.0 |
| 8 | 1AH | 512 | Busia, Nambale | 21.2 | 20.4 | 0.8 | -4.5 | 12.3 | 0.0 | 0.0 | 4.5 | 4.5 | 0.0 | 8.0 | 0.0 | 4.7 | 0.0 | 0.0 | 0.8 | 2.4 | 0.0 | 1.4 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 0.6 | 0.0 | 31.3 | 17.0 | 0.0 | 0.0 | 7.3 | 6.9 | 0.0 |
| 9 | 1BA | 637 | | 2.2 | 2.1 | 0.1 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 1.2 | 0.0 | 3.7 | 0.0 | 1.2 | 0.0 | 0.0 | 0.8 | 1.7 | 0.0 | 1.6 | 1.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.3 | 0.0 | 7.7 | 2.2 | 0.0 | 0.0 | 2.6 | 2.9 | 0.0 |
| 10 | 1BB | 755 | | 4.2 | 4.0 | 0.2 | 0.0 | 1.7 | 0.0 | 0.0 | 0.0 | 2.6 | 0.0 | 18.4 | 0.0 | 15.2 | 0.0 | 0.0 | 0.9 | 2.3 | 0.0 | 2.1 | 2.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.5 | 0.0 | 25.2 | 16.8 | 0.0 | 0.0 | 3.5 | 4.9 | 0.0 |
| 11 | 1BC | 771 | Kapenguria | 11.3 | 10.9 | 0.4 | -1.1 | 7.1 | 1.1 | 0.0 | 0.0 | 3.1 | 0.0 | 13.7 | 0.0 | 10.5 | 0.0 | 0.0 | 0.9 | 2.3 | 0.0 | 1.9 | 1.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.0 | 27.1 | 17.5 | 1.1 | 0.0 | 3.0 | 5.4 | 0.0 |
| 12 | 1BE | 1,153 | Moi's Bridge | 13.3 | 12.9 | 0.4 | -1.0 | 7.1 | 1.0 | 0.0 | 0.0 | 5.1 | 0.0 | 182.2 | -102.7 | 77.9 | 102.7 | 0.0 | 1.4 | 0.3 | 0.0 | 2.6 | 2.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.3 | 0.0 | 198.4 | 85.0 | 103.7 | 0.0 | 4.2 | 5.4 | 0.0 |
| 13 | 1BD | 687 | Matunda | 7.0 | 6.7 | 0.3 | -1.8 | 3.6 | 0.0 | 0.0 | 1.8 | 1.6 | 0.0 | 13.2 | 0.0 | 12.4 | 0.0 | 0.0 | 0.8 | 0.0 | 0.0 | 2.2 | 2.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.4 | 0.0 | 22.8 | 16.0 | 0.0 | 0.0 | 5.2 | 1.6 | 0.0 |
| 14 | 1BG | 914 | Kiminini, Kitale | 39.1 | 37.4 | 1.6 | -9.4 | 25.6 | 6.4 | 0.0 | 3.0 | 4.0 | 0.0 | 215.6 | -139.9 | 74.6 | 139.9 | 0.0 | 1.1 | 0.0 | 0.0 | 2.7 | 2.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.4 | 0.0 | 257.8 | 100.2 | 146.3 | 0.0 | 7.3 | 4.0 | 0.0 |
| 15 | 1BH | 581 | Kimilili | 28.2 | 27.0 | 1.2 | -3.7 | 19.9 | 3.7 | 0.0 | 4.0 | 0.6 | 0.0 | 6.2 | 0.0 | 5.5 | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 | 1.7 | 1.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.3 | 0.0 | 36.5 | 25.5 | 3.7 | 0.0 | 6.7 | 0.6 | 0.0 |
| 16 | 1CA | 718 | | 4.4 | 4.1 | 0.3 | 0.0 | 2.1 | 0.0 | 0.0 | 0.0 | 2.3 | 0.0 | 8.1 | 0.0 | 6.2 | 0.0 | 0.0 | 1.4 | 0.4 | 0.0 | 2.0 | 2.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.4 | 0.0 | 14.9 | 8.3 | 0.0 | 0.0 | 3.9 | 2.7 | 0.0 |
| 17 | 1CB | 657 | Eldoret | 53.7 | 51.2 | 2.5 | -13.5 | 34.9 | 8.5 | 5.0 | 1.7 | 3.6 | 0.0 | 6.0 | 0.0 | 4.7 | 0.0 | 0.0 | 1.3 | 0.0 | 0.0 | 1.8 | 1.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 0.6 | 0.0 | 62.2 | 39.6 | 8.5 | 5.0 | 5.4 | 3.6 | 0.0 |
| 18 | 1CC | 664 | | 3.0 | 2.9 | 0.1 | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 1.6 | 0.0 | 10.0 | 0.0 | 8.1 | 0.0 | 0.0 | 1.3 | 0.6 | 0.0 | 1.8 | 1.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.7 | 0.7 | 0.0 | 15.4 | 9.5 | 0.0 | 0.0 | 3.8 | 2.2 | 0.0 |
| 19 | 1CD | 517 | | 2.6 | 2.6 | 0.0 | 0.0 | 0.9 | 0.0 | 0.0 | 1.0 | 0.6 | 0.0 | 11.8 | 0.0 | 10.8 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 1.7 | 1.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.3 | 0.0 | 16.5 | 11.7 | 0.0 | 0.0 | 4.1 | 0.6 | 0.0 |
| 20 | 1CE | 258 | Lumakanda | 4.0 | 3.9 | 0.2 | -1.0 | 1.5 | 1.0 | 0.0 | 1.2 | 0.3 | 0.0 | 110.0 | -16.4 | 93.0 | 16.4 | 0.0 | 0.5 | 0.0 | 0.0 | 0.9 | 0.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.0 | 115.1 | 94.5 | 17.4 | 0.0 | 2.8 | 0.3 | 0.0 |
| 21 | 1DA | 528 | Webuye | 14.3 | 13.7 | 0.5 | -0.5 | 9.3 | 0.5 | 0.0 | 3.7 | 0.7 | 0.0 | 80.8 | -33.8 | 46.0 | 33.8 | 0.0 | 1.0 | 0.0 | 0.0 | 2.3 | 2.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.0 | 97.4 | 55.3 | 34.3 | 0.0 | 7.1 | 0.7 | 0.0 |
| | Reference Point (1DA02) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 22 | 1DB | 728 | | 7.2 | 7.1 | 0.1 | 0.0 | 3.2 | 0.0 | 0.0 | 3.1 | 0.9 | 0.0 | 24.1 | 0.0 | 22.7 | 0.0 | 0.0 | 1.4 | 0.0 | 0.0 | 2.3 | 2.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 0.6 | 0.0 | 34.3 | 25.9 | 0.0 | 0.0 | 7.5 | 0.9 | 0.0 |
| 23 | 1DC | 351 | | 4.4 | 4.3 | 0.1 | 0.0 | 1.7 | 0.0 | 0.0 | 2.3 | 0.5 | 0.0 | 15.9 | 0.0 | 15.2 | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 | 1.5 | 1.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.0 | 21.9 | 16.8 | 0.0 | 0.0 | 4.6 | 0.5 | 0.0 |
| 24 | 1DD | 368 | Bungoma, Chwele | 19.4 | 18.6 | 0.8 | -1.9 | 13.7 | 1.9 | 0.0 | 3.3 | 0.5 | 0.0 | 17.2 | 0.0 | 16.4 | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 | 1.4 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.5 | 0.0 | 38.5 | 30.2 | 1.9 | 0.0 | 6.0 | 0.5 | 0.0 |
| 25 | 1EA | 441 | Malava | 4.2 | 4.0 | 0.2 | 0.0 | 1.4 | 0.0 | 0.0 | 2.2 | 0.6 | 0.0 | 18.9 | 0.0 | 18.1 | 0.0 | 0.0 | 0.8 | 0.0 | 0.0 | 1.5 | 1.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.0 | 24.7 | 19.5 | 0.0 | 0.0 | 4.7 | 0.6 | 0.0 |
| 26 | 1EB | 382 | Kakamega | 28.4 | 25.2 | 3.2 | -0.2 | 22.3 | 0.0 | 0.0 | 5.7 | 0.5 | 0.0 | 32.9 | 0.0 | 32.2 | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 | 1.8 | 1.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.8 | 0.8 | 0.0 | 64.0 | 54.5 | 0.0 | 0.0 | 9.0 | 0.5 | 0.0 |
| 27 | 1EC | 237 | | 2.4 | 2.4 | 0.1 | 0.0 | 0.6 | 0.0 | 0.0 | 1.5 | 0.3 | 0.0 | 11.4 | 0.0 | 10.9 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 1.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.4 | 0.0 | 15.3 | 11.5 | 0.0 | 0.0 | 3.4 | 0.3 | 0.0 |
| 28 | 1ED | 131 | Mumias | 24.9 | 23.8 | 1.1 | -7.1 | 15.0 | 0.0 | 0.0 | 9.7 | 0.1 | 0.0 | 0.8 | 0.0 | 0.5 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.6 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.0 | 26.5 | 15.6 | 0.0 | 0.0 | 10.8 | 0.1 | 0.0 |
| 29 | 1EE | 395 | | 2.6 | 2.6 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 1.8 | 0.4 | 0.0 | 126.6 | -64.5 | 61.4 | 64.5 | 0.0 | 0.7 | 0.0 | 0.0 | 1.4 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.3 | 0.0 | 130.9 | 61.8 | 64.5 | 0.0 | 4.2 | 0.4 | 0.0 |
| 30 | 1EG | 554 | Ugunja, Butere | 10.7 | 10.3 | 0.3 | -1.3 | 5.1 | 0.0 | 0.0 | 2.2 | 3.4 | 0.0 | 39.4 | -15.9 | 22.5 | 15.9 | 0.0 | 1.0 | 0.0 | 0.0 | 2.2 | 2.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.7 | 0.7 | 0.0 | 52.9 | 27.6 | 15.9 | 0.0 | 6.1 | 3.4 | 0.0 |
| 31 | 1EF | 426 | Ukwala, Port Victoria | 6.7 | 6.6 | 0.1 | -0.4 | 3.8 | 0.0 | 0.0 | 0.4 | 2.5 | 0.0 | 54.3 | 0.0 | 51.0 | 0.0 | 0.0 | 0.8 | 2.6 | 0.0 | 1.2 | 1.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.5 | 0.0 | 62.7 | 54.8 | 0.0 | 0.0 | 2.9 | 5.1 | 0.0 |
| 32 | 1FA | 238 | Burnt Forest | 2.3 | 2.2 | 0.1 | -0.2 | 1.4 | 0.0 | 0.0 | 0.2 | 0.7 | 0.0 | 5.0 | 0.0 | 3.5 | 0.0 | 0.0 | 0.4 | 1.2 | 0.0 | 0.6 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.3 | 0.0 | 8.3 | 4.9 | 0.0 | 0.0 | 1.5 | 1.8 | 0.0 |
| 33 | 1FB | 370 | | 1.6 | 1.6 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 | 1.2 | 0.0 | 8.0 | 0.0 | 7.2 | 0.0 | 0.0 | 0.6 | 0.2 | 0.0 | 1.3 | 1.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.0 | 11.1 | 7.6 | 0.0 | 0.0 | 2.1 | 1.4 | 0.0 |
| 34 | 1FC | 272 | Kapsabet | 21.0 | 20.1 | 1.0 | -3.5 | 15.2 | 0.0 | 0.0 | 3.9 | 1.9 | 0.0 | 4.3 | 0.0 | 3.8 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 1.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.0 | 26.4 | 19.0 | 0.0 | 0.0 | 5.5 | 1.9 | 0.0 |
| 35 | 1FD | 476 | Nandi Hills | 4.4 | 4.2 | 0.1 | 0.0 | 2.6 | 0.0 | 0.0 | 0.0 | 1.8 | 0.0 | 8.3 | 0.0 | 6.9 | 0.0 | 0.0 | 0.8 | 0.6 | 0.0 | 1.3 | 1.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.0 | 14.0 | 9.5 | 0.0 | 0.0 | 2.2 | 2.4 | 0.0 |
| 36 | 1FE | 661 | | 7.0 | 6.9 | 0.1 | 0.0 | 1.9 | 0.0 | 0.0 | 1.9 | 3.2 | 0.0 | 32.0 | 0.0 | 31.0 | 0.0 | 0.0 | 1.1 | 0.0 | 0.0 | 3.4 | 3.4 | 0.0 | 0.0 | 0.0 | 0.0 | 1.1 | 1.1 | 0.0 | 43.4 | 32.8 | 0.0 | 0.0 | 7.4 | 3.2 | 0.0 |
| 37 | 1FF | 273 | Vihiga, Luanda | 42.7 | 40.8 | 1.9 | -18.9 | 18.1 | 0.0 | 0.0 | 20.9 | 3.7 | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 2.3 | 2.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.9 | 0.9 | 0.0 | 46.4 | 18.1 | 0.0 | 0.0 | 24.6 | 3.7 | 0.0 |
| | Reference Point (1FF02) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 38 | 1FG | 970 | Yala, Siaya | 20.0 | 19.3 | 0.7 | 0.0 | 14.4 | 0.0 | 0.0 | 0.0 | 5.5 | 0.0 | 235.8 | -75.0 | 153.9 | 75.0 | 0.0 | 1.5 | 5.4 | 0.0 | 3.3 | 3.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.8 | 0.8 | 0.0 | 259.8 | 168.3 | 75.0 | 0.0 | 5.6 | 11.0 | 0.0 |
| | | | | 443.1 | 423.8 | 19.2 | -71.9 | 260.7 | 24.2 | 5.0 | 83.2 | 70.0 | 0.0 | 1,358.8 | -448.2 | 854.2 | 448.2 | 0.0 | 29.6 | 26.8 | 0.0 | 60.8 | 60.8 | 0.0 | 0.0 | 0.0 | 0.0 | 15.6 | 15.6 | 0.0 | 1,878.3 | 1,114.9 | 472.4 | 5.0 | 189.3 | 96.7 | 0.0 |

Note: 1BC: Siyoi Dam, 1BE: Moi's Bridge Dam, 1BG: Nzoia(34B) Dam, 1CB, 1CE: Kibolo Dam, 1EE, 1EG, 1FG: Nzoia(42A) Dam, 1BH,1DA: Teremi Dam

Source: JICA Study Team

**Table 4.6.8 Naturalised River Flow, Reserve, Water Demand, Yield and Water Supply Reliability at Reference Points (LVNCA)**

| Catch-ment Area | Reference Point | River Name | Catchment Area at Reference Point ($km^2$) | Naturalised River Flow (1/10 Drought Discharge) *3 | Reserve ($m^3/s$) *1 | Present (2010) Water Demand ($m^3/s$) *2 | | Future (2030) Water Demand ($m^3/s$) *2 | | Yield of Water Resources Development ($m^3/s$) | Present (2010) Water Supply Reliability | Future (2030) Water Supply Reliability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Upstream of Reference Point | Downstream of Reference Point | Upstream of Reference Point | Downstream of Reference Point | | | |
| LVNCA | 1DA02 | Nzoia | 8,417 | 15.8 | 15.9 | 1.8 | 0.3 | 22.6 | 2.7 | 23.2 | 1/7 | 1/5 |
| | 1FG01 | Yala | 2,388 | 6.5 | 6.7 | 0.7 | 0.1 | 3.7 | 4.4 | 7.3 | 1/7 | 1/10 |

Note: *1 = Reserve was set at 95% value of the naturalized present daily flow duration curve with a probability of once in 10 years.
*2 = Water demand was estimated by averaging the monthly demands of all water users during active irrigation period.
*3 = 1/10 drought discharge is the 355-day (97.3%) value of the naturalized daily flow duration curve with a probability of once in 10 years.

Source: JICA Study Team

## Table 5.2.1 Cost Estimate for Proposed Urban Water Supply Development (LVNCA)

| | Urban Centre | Service Population in 2030 | Water Demand in 2030 ($m^3$/day) | Rehabilitation Works ($m^3$/day) | Development Capacity ($m^3$/day) | Project Cost (KSh million) | | | | | O&M Cost (KSh million/year) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Total | Rehabilitation Works | Major Dam/ Major Transmission | Intake/ Minor Transmission | Distribution | |
| 1 | Eldoret | 1,105,499 | 131,554 | 48,200 | 83,354 | 18,760 | 2,773 | | 2,664 | 13,322 | 778 |
| 2 | Vihiga | 597,496 | 71,102 | 60 | 71,042 | 13,629 | 3 | | 2,271 | 11,354 | 663 |
| 3 | Kitale | 534,528 | 63,609 | 10,000 | 53,609 | 10,857 | 575 | | 1,714 | 8,568 | 500 |
| 4 | Mumias | 503,318 | 59,895 | 16,680 | 43,215 | 9,248 | 960 | | 1,381 | 6,907 | 403 |
| 5 | Kimilili | 477,847 | 56,864 | 5,000 | 51,864 | 10,235 | 288 | | 1,658 | 8,289 | 484 |
| 6 | Kakamega | 461,945 | 54,971 | 16,000 | 38,971 | 8,395 | 921 | | 1,246 | 6,229 | 364 |
| 7 | Kapsabet | 436,952 | 51,997 | 3,800 | 48,197 | 9,462 | 219 | | 1,541 | 7,703 | 450 |
| 8 | Bungoma | 281,225 | 33,466 | 7,000 | 26,466 | 5,479 | 403 | | 846 | 4,230 | 247 |
| 9 | Busia | 261,664 | 31,138 | 7,400 | 23,738 | 4,978 | 426 | | 759 | 3,794 | 222 |
| 10 | Luanda | 248,400 | 29,560 | 0 | 29,560 | 5,669 | 0 | | 945 | 4,724 | 276 |
| 11 | Item/Tambach | 212,992 | 25,346 | 1,100 | 24,246 | 4,713 | 63 | | 775 | 3,875 | 226 |
| 12 | Webuye | 208,119 | 24,766 | 7,000 | 17,766 | 3,810 | 403 | | 568 | 2,839 | 166 |
| 13 | Kapenguria | 171,382 | 20,394 | 1,680 | 18,714 | 3,686 | 97 | | 598 | 2,991 | 175 |
| 14 | Bondo | 168,472 | 20,048 | 1,125 | 24,136 | 6,376 | 186 | | 772 | 3,858 | 225 |
| 15 | Siaya | 61,452 | 7,313 | 2,100 | | | | | | | |
| 16 | Yala | 32,277 | 3,841 | 2,400 | 8,141 | 0 | 0 | | 260 | 1,301 | 76 |
| 17 | Ugunja | 36,455 | 4,338 | 385 | | | | | | | |
| 18 | Ukwala | 26,110 | 3,107 | 360 | | | | | | | |
| 19 | Malaba | 108,112 | 12,865 | 2,200 | 10,665 | 2,172 | 127 | | 341 | 1,705 | 100 |
| 20 | Malakisi | 85,993 | 10,233 | 0 | 10,233 | 1,963 | 0 | | 327 | 1,636 | 96 |
| 21 | Chwele | 72,115 | 8,582 | 1,200 | 7,382 | 1,485 | 69 | | 236 | 1,180 | 69 |
| 22 | Butere | 64,332 | 7,656 | 0 | 7,656 | 1,468 | 0 | | 245 | 1,224 | 71 |
| 23 | Kiminini | 60,330 | 7,179 | 0 | 7,179 | 1,377 | 0 | | 229 | 1,147 | 67 |
| 24 | Usenge | 58,861 | 7,004 | 0 | 7,004 | 1,343 | 0 | | 224 | 1,119 | 65 |
| 25 | Moi's Bridge | 58,266 | 6,934 | 0 | 6,934 | 1,330 | 0 | | 222 | 1,108 | 65 |
| 26 | Nandi Hills | 50,942 | 6,062 | 0 | 6,062 | 1,163 | 0 | | 194 | 969 | 57 |
| 27 | Lumakanda | 44,681 | 5,317 | 1,200 | 4,117 | 859 | 69 | | 132 | 658 | 38 |
| 28 | Matunda | 37,643 | 4,480 | 0 | 4,480 | 859 | 0 | | 143 | 716 | 42 |
| 29 | Port Victoria | 33,027 | 3,930 | 0 | 3,930 | 754 | 0 | | 126 | 628 | 37 |
| 30 | Nambale | 24,872 | 2,960 | 0 | 2,960 | 568 | 0 | | 95 | 473 | 28 |
| 31 | Burnt Forest | 24,792 | 2,950 | 0 | 2,950 | 566 | 0 | | 94 | 472 | 28 |
| 32 | Malava | 20,488 | 2,438 | 0 | 2,438 | 468 | 0 | | 78 | 390 | 23 |
| | Major Water Sourece Works | | | | | | | | | | |
| | Siyoi | | | | | 2,907 | | 2,907 | | | 15 |
| | Moi's Bridge | | | | | 563 | | 563 | | | 3 |
| | Nzoia (34B) | | | | | 0 | | 0 | | | 0 |
| | Kibolo | | | | | 2,336 | | 2,336 | | | 12 |
| | Teremi | | | | | 3,614 | | 3,614 | | | 18 |
| | Nzoia (42A) | | | | | 0 | | 0 | | | 0 |
| | Transmission (to Eldoret) | | | | | 3,069 | | 3,069 | | | 15 |
| | Total | 6,570,585 | 781,900 | 134,890 | 647,010 | 144,158 | 7,578 | 12,488 | 20,682 | 103,410 | 6,101 |

Source: JICA Study Team

## Table 5.2.2 Cost Estimate for Proposed Large Scale Rural Water Supply Development (LVNCA)

| | Item | Service Population in 2030 | Water Demand in 2030 ($m^3$/day) | Rehabilitation Works ($m^3$/day) | Development Capacity ($m^3$/day) | Project Cost (KSh million) | | | | | O&M Cost (KSh million/year) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Total | Rehabilitation Works | Major Dam/ Major Transmission | Intake/ Minor Transmission | Distribution | |
| 1 | Urban Pop. | 1,134,510 | 135,007 | 9,216 | 125,791 | 24,656 | 528 | | 4,021 | 20,106 | 1,174 |
| 2 | Rural Pop. | 648,906 | 49,317 | 5,380 | 43,937 | 8,427 | 0 | | 1,404 | 7,022 | 410 |
| | Total | 1,783,416 | 184,324 | 14,596 | 169,728 | 33,082 | 528 | | 5,425 | 27,129 | 1,584 |

Source: JICA Study Team

**Table 5.2.3 Cost Estimate for Proposed Sewerage Development (LVNCA)**

| Major Urban Area | | Service Population in 2030 | Required Capacity in 2030 ($m^3$/day) | Current Capacity in 2010 ($m^3$/day) | Capacity to be developed ($m^3$/day) | Project Cost (KSh million) | | | O&M Cost (KSh million/year) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Total | Rehabilitation Works | Expansion/ New Construct. | |
| 1 | Eldoret | 1,105,499 | 84,239 | 4,800 | 79,439 | 13,790 | 245 | 13,545 | 741 |
| 2 | Vihiga | 597,496 | 45,529 | 0 | 45,529 | 7,762 | 0 | 7,762 | 425 |
| 3 | Kitale | 534,528 | 40,731 | 800 | 39,931 | 6,848 | 41 | 6,807 | 373 |
| 4 | Mumias | 503,318 | 38,353 | 0 | 38,353 | 6,538 | 0 | 6,538 | 358 |
| 5 | Kimilili | 477,847 | 36,412 | 0 | 36,412 | 6,208 | 0 | 6,208 | 340 |
| 6 | Kakamega | 461,945 | 35,200 | 2,700 | 32,500 | 5,679 | 138 | 5,541 | 303 |
| 7 | Kapsabet | 436,952 | 33,296 | 2,500 | 30,796 | 5,378 | 128 | 5,250 | 287 |
| 8 | Bungoma | 281,225 | 21,429 | 4,500 | 16,929 | 3,116 | 230 | 2,886 | 158 |
| 9 | Busia | 261,664 | 19,939 | 3,000 | 16,939 | 3,041 | 153 | 2,888 | 158 |
| 10 | Luanda | 248,400 | 18,928 | 0 | 18,928 | 3,227 | 0 | 3,227 | 177 |
| 11 | Item/Tambach | 212,992 | 16,230 | 0 | 16,230 | 2,767 | 0 | 2,767 | 151 |
| 12 | Webuye | 208,119 | 15,859 | 2,700 | 13,159 | 2,381 | 138 | 2,243 | 123 |
| 13 | Kapenguria | 171,382 | 13,059 | 0 | 13,059 | 2,226 | 0 | 2,226 | 122 |
| 14 | Bondo | 168,472 | 12,838 | 0 | 12,838 | 2,189 | 0 | 2,189 | 120 |
| 15 | Malaba | 108,112 | 8,238 | 0 | 8,238 | 1,404 | 0 | 1,404 | 77 |
| 16 | Malakisi | 85,993 | 6,553 | 0 | 6,553 | 1,117 | 0 | 1,117 | 61 |
| 17 | Siaya | 72,115 | 5,495 | 0 | 5,495 | 937 | 0 | 937 | 51 |
| 18 | Moi's Bridge | 58,266 | 4,440 | 0 | 4,440 | 757 | 0 | 757 | 41 |
| 19 | Matunda | 37,643 | 2,868 | 0 | 2,868 | 489 | 0 | 489 | 27 |
| Total | | 6,031,965 | 459,636 | 21,000 | 438,636 | 75,855 | 1,074 | 74,781 | 4,094 |

Source: JICA Study Team

## Table 5.2.4 Cost Estimate for Proposed Irrigation Development (LVNCA)

| Category | Irrigation Area in 2030 (ha) | Project Cost* (KSh million) | | | Annual O&M Cost (KSh million) |
|---|---|---|---|---|---|
| | | Irrigation System | Multipurpose Dam Cost Allocation** | Total Project Cost | |
| Large Scale Irrigation | 78,370 | 62,716 | 19,478 | 82,194 | 247 |
| Small Scale Irrigation | 47,122 | 30,451 | - | 30,451 | 152 |
| Private Irrigation | 43,421 | 84,178 | - | 84,178 | 842 |
| Total | 168,913 | 177,345 | 19,478 | 196,823 | 1,241 |

Note: *: Project cost includes direct construction cost, contingency, engineering services and related indirect costs.
**: Refer to Sectoral Report (G)

Source: JICA Study Team, based on data from relevant government authorities

**Table 5.2.5 Cost Estimate for Proposed Hydropower Projects (LVNCA)**

| Catchment Area | No. | Name of Plan | Installed Capacity | Estimated Cost: Dam Allocation Cost (KSh million) | Estimated Cost: Hydropower Component cost (KSh million) | Estimated Cost: Total Project Cost (KSh million) | Estimated Cost: Annual O&M Cost (KSh million) | Purpose |
|---|---|---|---|---|---|---|---|---|
| LVNCA | 1 | Nzoia (34B) Multipurpose Dam Development Plan | 16 MW | 401 | 546 | 947 | 5 | Water Supply, Irrigation, Flood Control, Hydropower |
| | 2 | Nzoia (42A) Multipurpose Dam Development Plan | 25 MW | 895 | 2,523 | 3,418 | 17 | Flood Control, Hydropower |
| | 3 | Nandi Forest Multipurpose Dam Development Plan | 50 MW | 5,285 | 16,792 | 22,077 | 110 | Water Supply, Irrigation, Hydropower |
| | Total | | 91 MW | 6,581 | 19,861 | 26,442 | 132 | |

Source: JICA Study Team based on information from MORDA, KenGen and Regional Development Authorities

**Table 5.2.6 Cost Estimate for Proposed Dams and Water Transfer (LVNCA)**

Dams

| | Name of Dam | Sub-basin | Purpose 1) | Effective Storage (MCM) | Study Stage 2) | Cost (KSh million) |
|---|---|---|---|---|---|---|
| 1 | Siyoi | 1BC | W | 4.1 | D/D to be completed in 2013 | 2,898 |
| 2 | Moi's Bridge | 1BE | W, I | 214.0 | NWMP 2030 | 5,114 |
| 3 | Nzoia (34B) | 1BG | I, P, F | 203.7 | D/D to be completed in 2013 | 4,006 |
| 4 | Kibolo | 1CE | W, I | 40.0 | NWMP 2030 | 5,455 |
| 5 | Teremi | 1DB | W | 3.0 | NWMP 2030 | 3,580 |
| 6 | Nzoia (42A) | 1EE | I, P, F | 395.0 | D/D to be completed in 2013 | 8,694 |
| 7 | Nandi Forest | 1FD | W, I, P | 220.0 | D/D completed | 17,474 |
| Total | | | | 1,079.8 | | 47,221 |

Note: 1) W=Domestic and industrial water supply, I=Irrigation, P=Hydropower, F=Flood control
2) D/D=Detailed Design, F/S=Feasibility Study, Pre-F/S=Pre-Feasibility Study, M/P=Master Plan

Water Transfer

| | Wter Transfer Scheme | Purpose | Capacity, Dimensions | Cost (KSh million) |
|---|---|---|---|---|
| 1 | Moiben Dam to Eldoret/ Iten (Expansion) | W | Capacity of 5 MCM/year, Pipeline of 600 mm dia, 60 km long | 3,069 |
| 2 | Nandi Forest Dam to LVSCA | W, I, P | Capacity of 189 MCM/year | (Included in dam cost) |
| Total | | | | 3,069 |

Source: JICA Study Team based on NWMP (1992) and data from NWCPC, MORDA, RDAs, and WSBs

## Table 5.2.7 Cost Estimate for Proposed Water Resources Management Plan (LVNCA)

**Development Cost** (Unit: KSh thousand)

| No. | Item | LVNCA | | | |
|---|---|---|---|---|---|
| | | Unit cost | Q'ty | Unit of Q'ty | Cost |
| **1) Monitoring** | | | | | **117,300** |
| | Installation/Rehabilitation of River Gauging Stations | 240 | 10 | nos. | 2,400 |
| | Installation/Rehabilitation of Rainfall Gauging Stations | 100 | 17 | nos. | 1,700 |
| | Installation of Dedicated Boreholes for Groundwater Monitoring | 2,000 | 19 | nos. | 38,000 |
| | Replacement of iron post for river gauge to concrete post | 100 | 24 | nos. | 2,400 |
| | Upgrade manual gauge to automatic (surface water level) | 1,000 | 24 | nos. | 24,000 |
| | Upgrade manual gauge to automatic (groundwater level) | 200 | 19 | nos. | 3,800 |
| | Upgrade manual gauge to automatic (rainfall) | 1,000 | 42 | nos. | 42,000 |
| | Flood Discharge Measurement Equipment (each sub-region) | 1,000 | 3 | nos. | 3,000 |
| | | | | | |
| **2) Evaluation** | | | | | **30,000** |
| | Hydromet DB Upgrade (Software + Hardware) including training | 2,500 | 12 | nos. | 30,000 |
| | Establishment of additional Water Quality Test Laboratory (Lodwar, Kapenguria, Mombasa, Garissa, Marsabit, Wajir) - Building and Utility | 6,750 | 0 | nos. | 0 |
| | Laboratory Equipment and Reagents | 2,105 | 0 | nos. | 0 |
| | | | | | |
| **3) Permitting** | | | | | |
| | PDB Upgrade (Software + Hardware) including training | 1,500 | 12 | nos. | 18,000 |
| | | | | | |
| **4) Watershed Conservation** | | | | | |
| | Forestation to achieve 10% of Forest Cover | 79 | 234,000 | ha | 18,486,000 |
| | | | | | |
| | **Total** | | | | **18,651,300** |

**Recurrent Cost (Annual)** (Unit: KSh thousand)

| No. | Item | LVNCA | | | |
|---|---|---|---|---|---|
| | | Unit cost | Q'ty | Unit of Q'ty | Cost* |
| **1) Monintoring and Analysis** | | | | | **126,900** |
| | Surface Water Monitoring (Daily) | 12 | 288 | nos. | 3,456 |
| | River Discharge Measurement (Monthly) | 80 | 288 | nos. | 23,040 |
| | Groundwater Monitoring (Monthly) | 12 | 228 | nos. | 2,736 |
| | Rainfall Monitoring (Daily) | 12 | 504 | nos. | 6,048 |
| | Flood Discharge Measurement (Three times a year) | 100 | 864 | nos. | 86,400 |
| | Surface Water Quality Monitoring (Monthly) | 30 | 60 | nos. | 1,800 |
| | Surface Water Quality Monitoring (Quarterly) | 30 | 76 | nos. | 2,280 |
| | Gruondwater Quality Monitoring (Twice a year) | 30 | 38 | nos. | 1,140 |
| | | | | | |
| **2) Others** | | | | | |
| | Catchment Forum Operation (Venue and Allowances to WRUAs) | 500 | 2 | times | 1,000 |
| | | | | | |
| | **Total** | | | | **127,900** |

Note: * Recurrent cost includes operation and maintenance costs
Source: JICA Study Team, based on data from relevant government authorities

## Table 5.2.8 Cost Estimate for Proposed Flood Disaster Management Plan (LVNCA)

| CA | No. | Description | Project Cost for Structure (KSh million) | Project Cost for Non-Structure (KSh million) | Recurrent Cost* (KSh million /year) | Source | Remarks |
|---|---|---|---|---|---|---|---|
| LVN | N1 | Yala Swamp | 0.00 | 60.00 | 0.30 | | |
| | A | N1.1 Construction of Multipurpose Dam | - | | - | | Nzoia 34B Dam, Nzoia 42A Dam |
| | B | N1.2 River Training Works | (977.82) | | - | | US$11.47 million (WKCDD&FMP) |
| | C | N1.3 Establishment of Flood Forecasting and Warning System | | 30.00 | 0.15 | | 10M/M, Training cost only |
| | G | N1.4 Formulation of Flood Fighting Plan | | 30.00 | 0.15 | | 10M/M |

Note: 1. US$1.0 = KSh 85.24 (as of November 1, 2012)
2. Cost for non-structural measures was estimated by multiplying Nyando MP (2006)'s cost by 1.95.
3. Cost for urban drainage implementation was estimated by multiplying NWMP (1992)'s cost by 1.25 (MUV Index) as pro forma amount.
4. Cost for river training works except for Yala Swamp and Kano Plain is estimated as cost for F/S including necessary surveys. (Table 6.2.2 of Sectoral Report (J))
5. Cost for Community-based Disaster Management is estimated by multiplying Nyando MP (2006)'s cost by the percentage of Nyando inundation area and sub-locations (15/55).

* Recurrent cost includes operation and maintenance costs

Source: JICA Study Team, based on existing master plan studies

## Table 5.2.9 Cost Estimate for Proposed Environmental Management Plan (LVNCA)

| Description | | Development Cost: River and Lake Environment Survey (KSh million) | Development Cost: Setting of Environmental Flow Rate (KSh million) | Recurrent Cost* (KSh million /year) |
|---|---|---|---|---|
| 1. Environmental River Flow | | | | |
| 1.1 | Nzoia River | 15.0 | 2.1 | - |
| 1.2 | Yala River | 16.7 | 1.6 | - |
| 2. Environmental Monitoring | | | | |
| 2.1 | Nzoia River | - | - | 0.0 |
| 2.2 | Yala River | - | - | 0.0 |
| 2.3 | Lake Victoria | - | - | 0.8 |

Note: Basic conditions for cost estimate are as follows:

1. Unit costs used for cost estimate were based on hearing of environmental experts in Kenya.
2. Unit cost of field survey team, including environmental experts, survey assistants, and others, for setting of environmental flow rate is assumed at KSh 130,000/day.
3. Necessary days for field survey were calculated at a rate of one day/10 km of river length, 10 days/ a lake (Lake Turkana was assumed to be 20 days).
4. Personnel costs for data analysis of field survey was assumed to be KSh 2,000,000/water body, but Tana River and Athi River was assumed to be KSh 4,000,000).
5. Overhead cost for field survey, including transportation, accommodation, survey tool and others, was assumed to be 30% of direct personnel costs.
6. Cost for stakeholder meeting for setting of environmental flow rate was assumed to be KSh 200,000/time (3 times/setting point).
7. Cost for the latest data collection and analysis for setting of environmental flow rate was assumed to be KSh 200,000/setting point.
8. Environmental monitoring cost was assumed to be KSh 150,000/time /monitoring point.
9. Environmental monitoring points of the Nzoia and Yala rivers are same as monitoring points of water quality and quantity in the Water Resource Management Plan. Thus, the monitoring cost was included in the cost of Water Resource Management Plan.

* Recurred cost includes operation and maintenance costs

Source: JICA Study Team, based on information from environmental experts

# *Figures*

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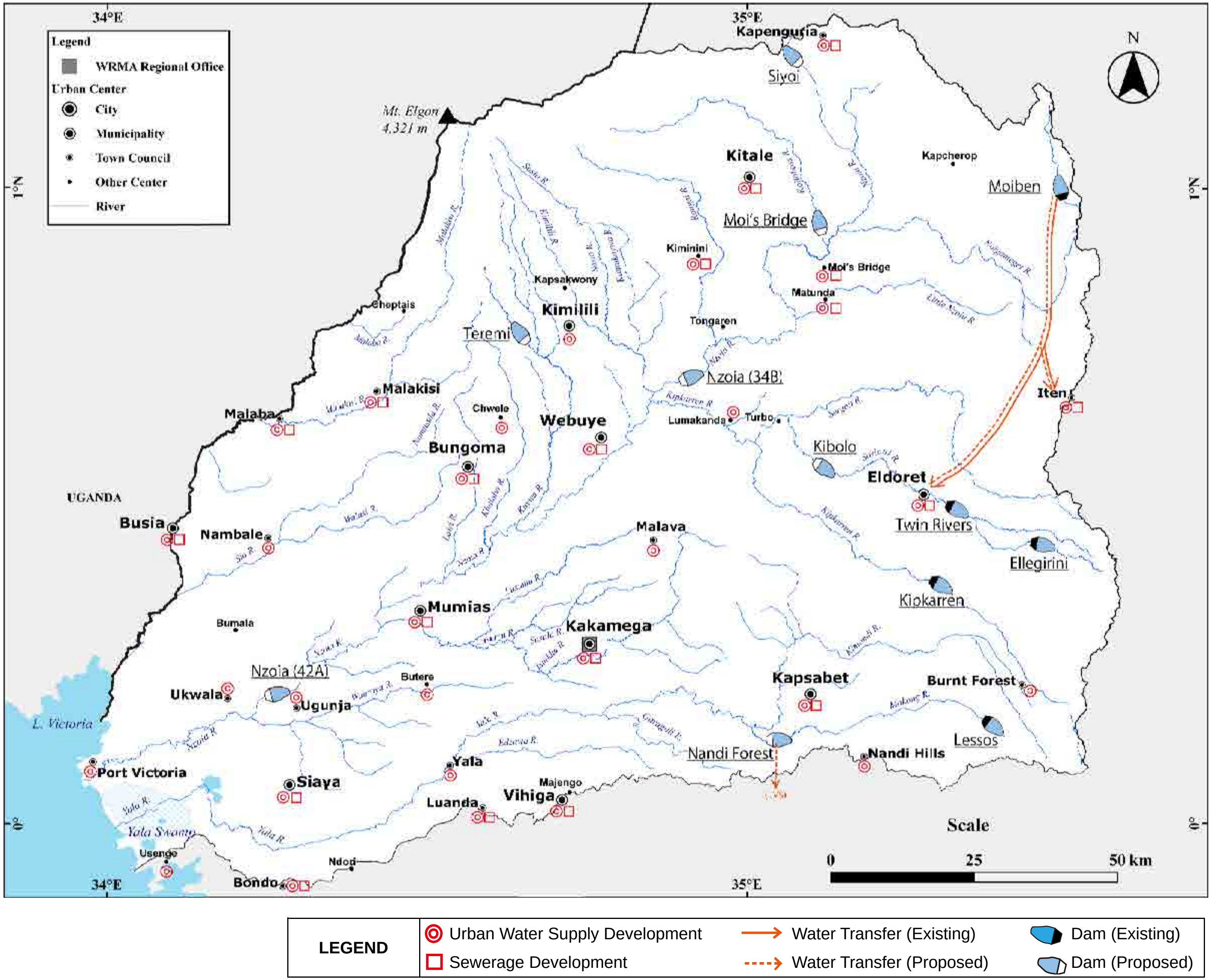
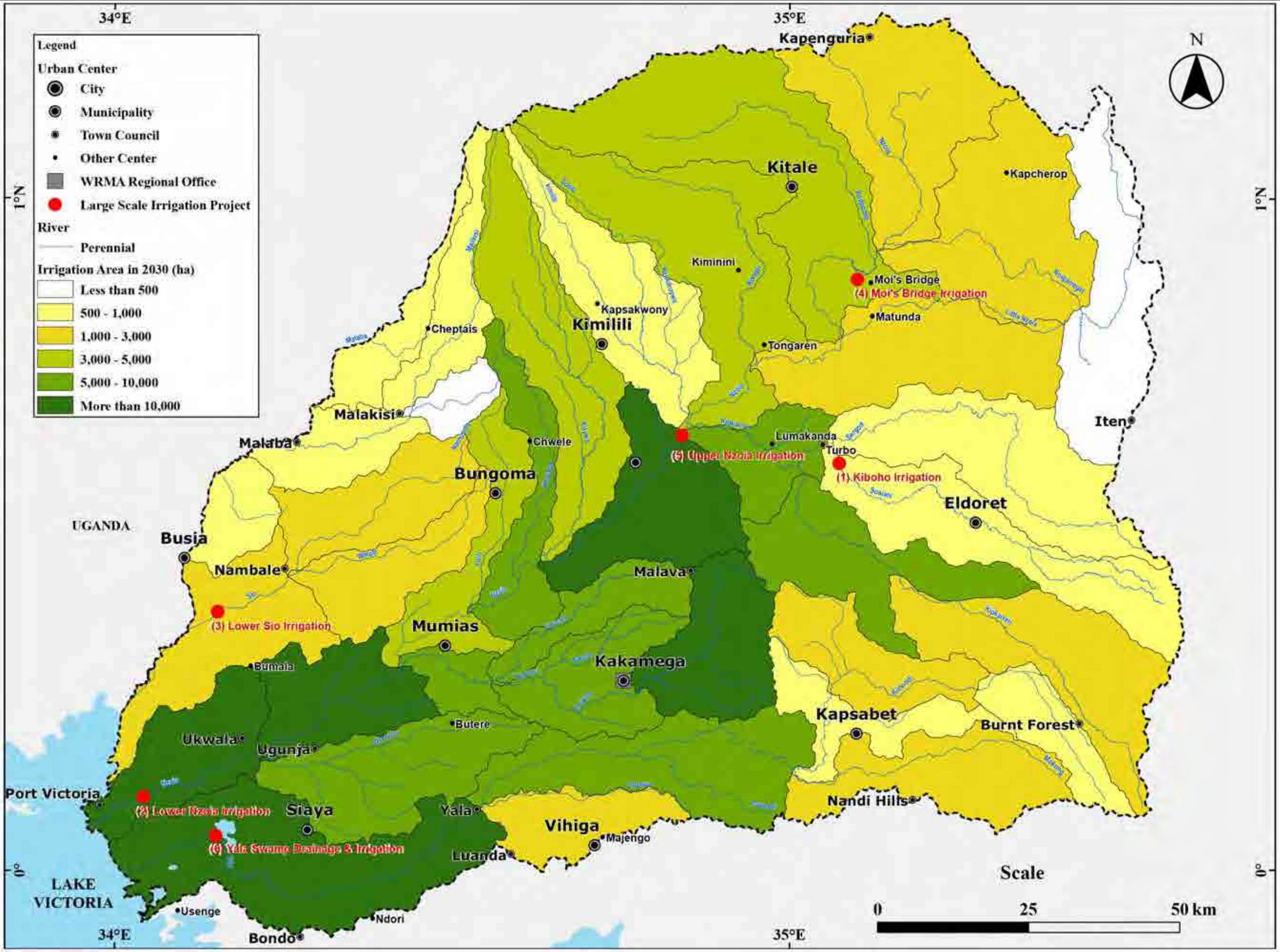
**Figure 4.2.1**
**Proposed Urban Water Supply and Sewerage Development Plans (LVNCA)**

Source: JICA Study Team






Source: JICA Study Team

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JAPAN INTERNATIONAL COOPERATION AGENCY

**Figure 4.4.1**
**Proposed Irrigation Development Plan (LVNCA)**

Source: JICA Study Team

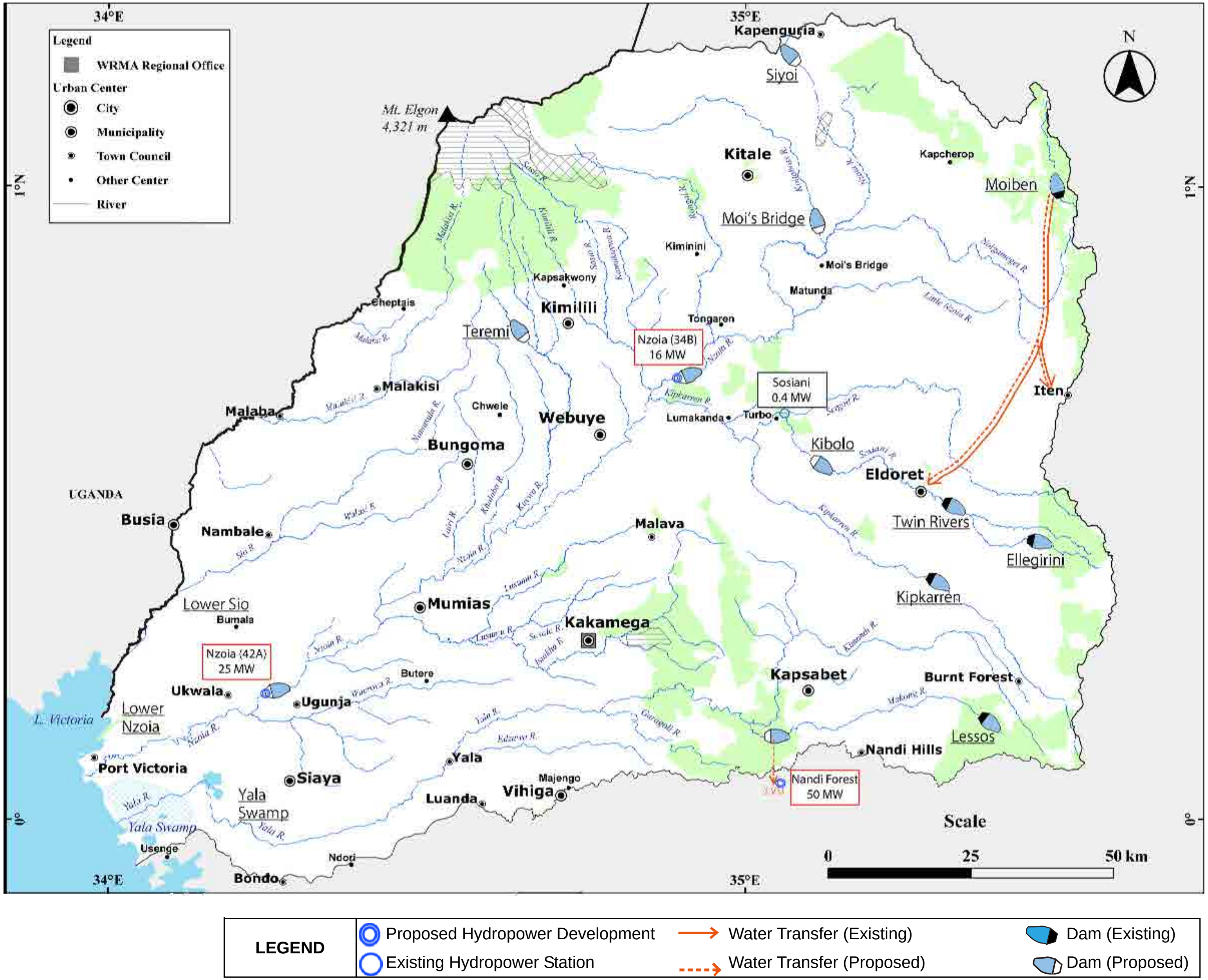


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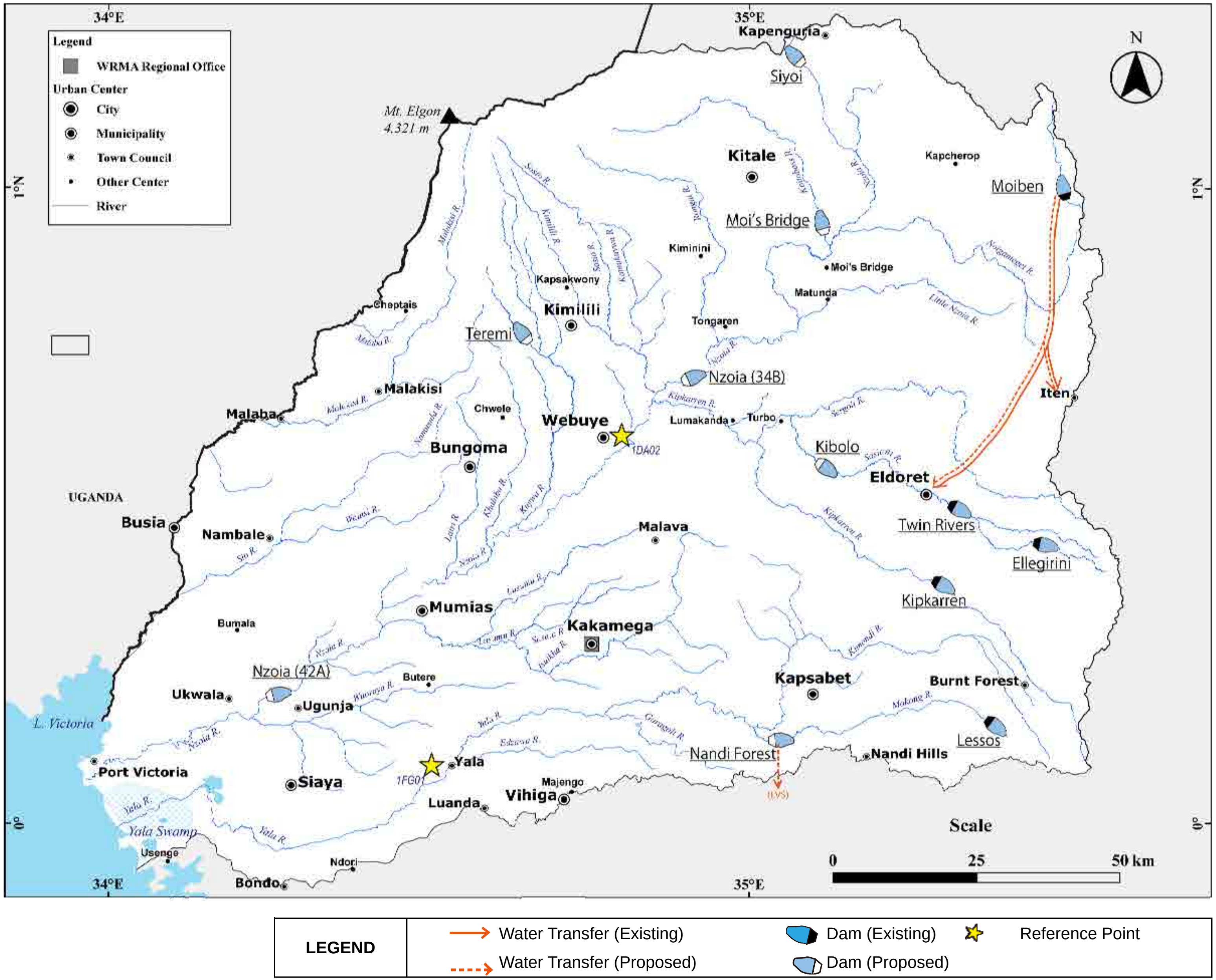
Figure 4.5.1
Existing Hydropower Stations and
Proposed Hydropower Development Plan
(LVNCA)




Source: JICA Study Team

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**Figure 4.6.1**
**Existing and Proposed Dams and Water Transfer Facilities (LVNCA)**

Source: JICA Study Team

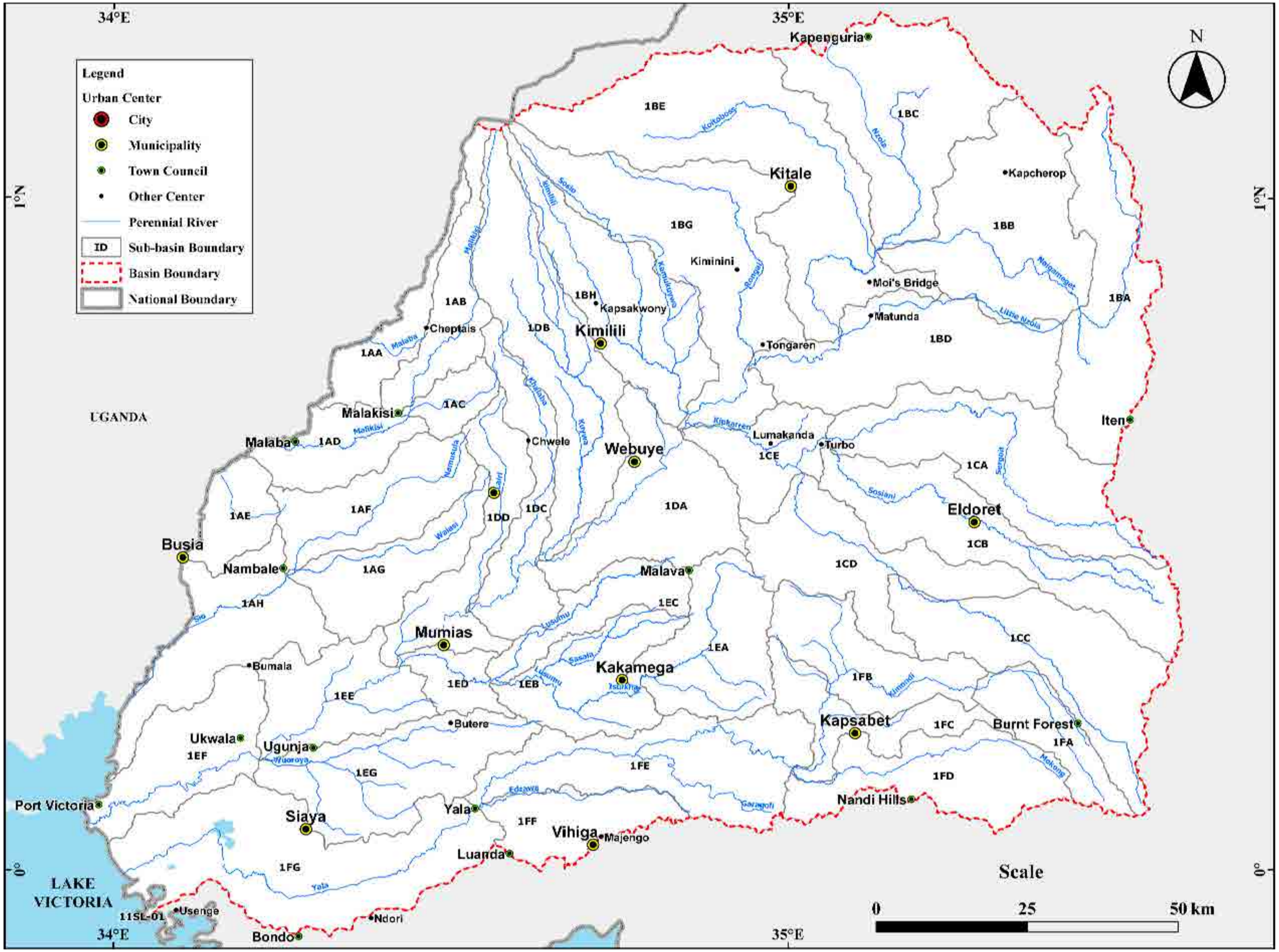


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**Figure 4.6.2**
**Sub-basin Division Map (LVNCA)**

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THE NATIONAL WATER MASTER PLAN 2030

Source: JICA Study Team

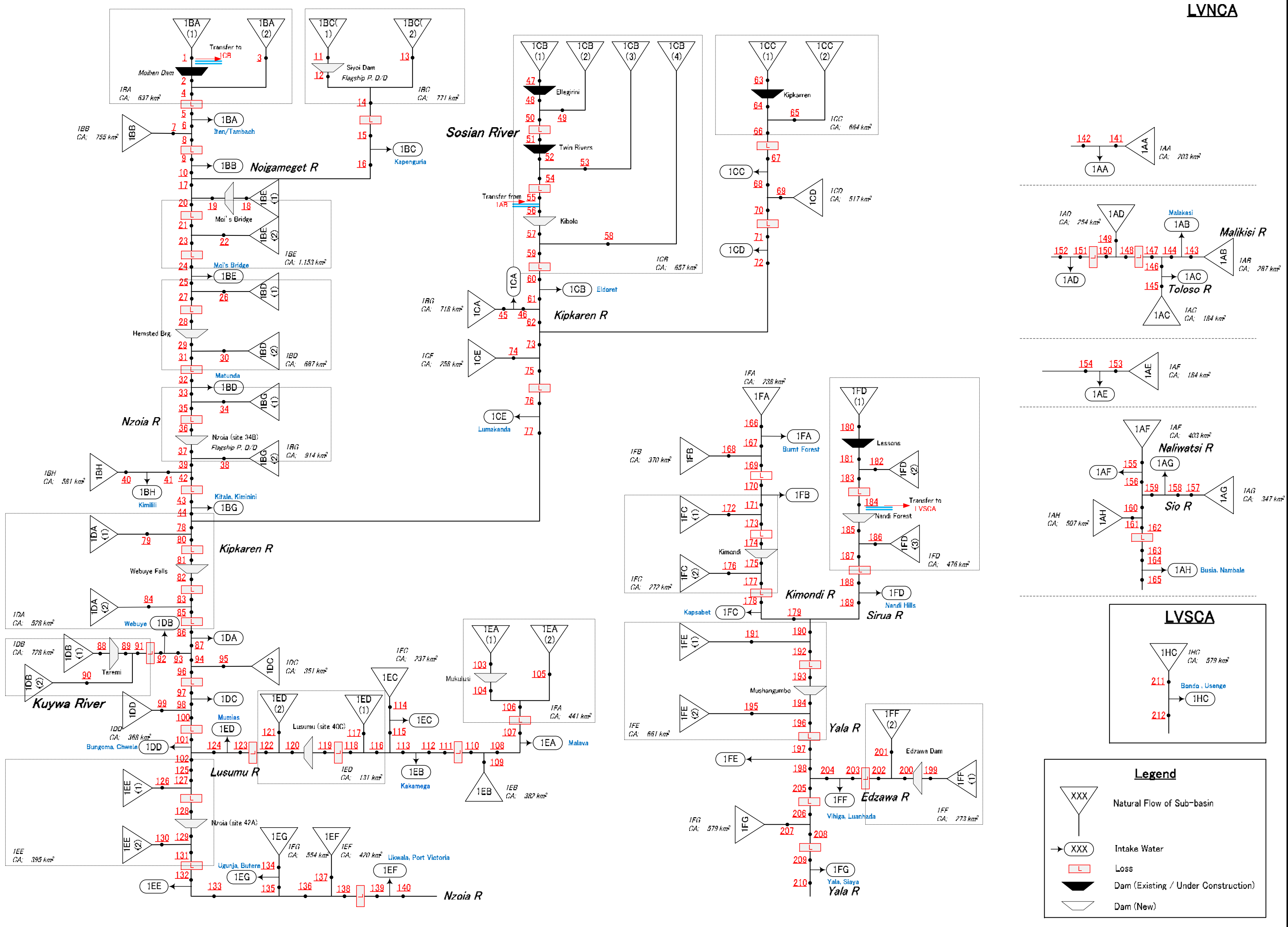
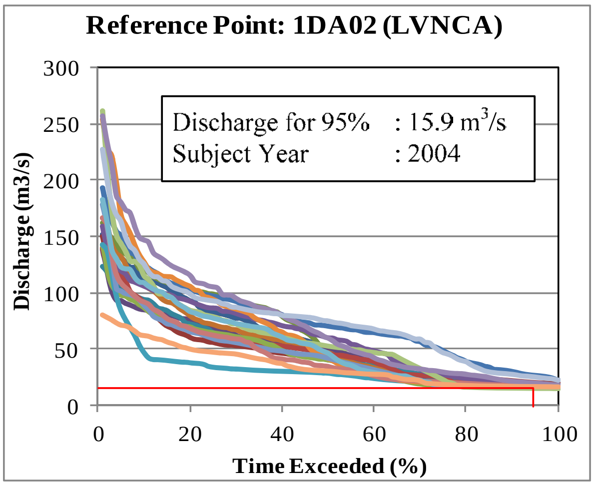
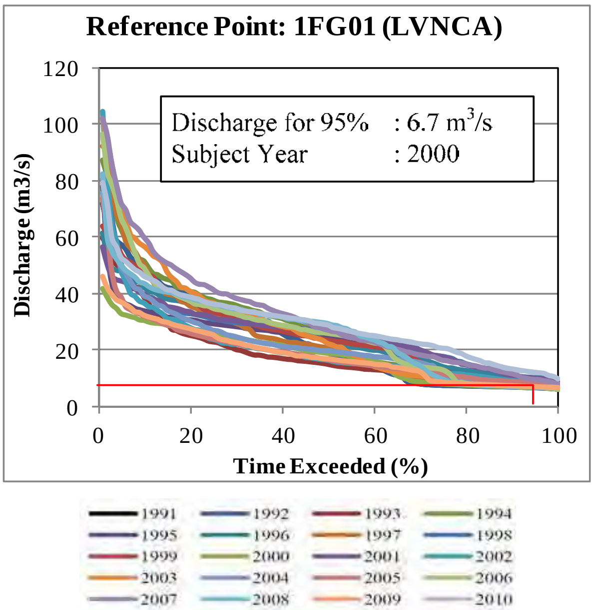



Figure 4.6.3
Surface Water Balance Calculation Model
(LVNCA)



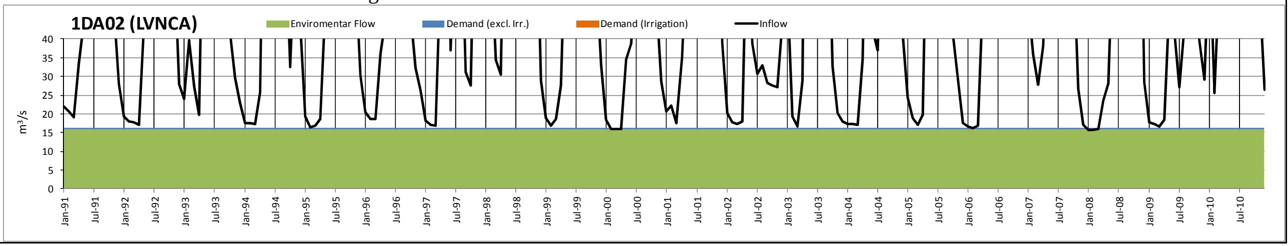




Source: JICA Study Team

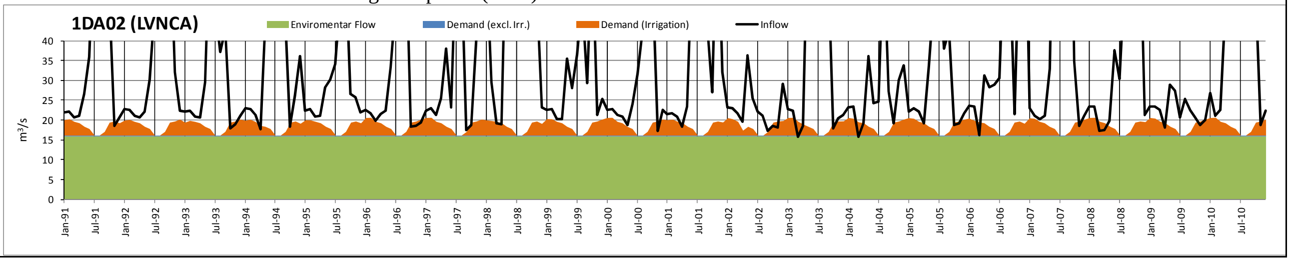
| THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030 | **Figure 4.6.4** Simulated Flow Duration Curves for Estimate of Reserve at Reference Points (LVNCA) |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | |

River Name: Nzoia River (LVNCA)
Reference Point: 1DA02

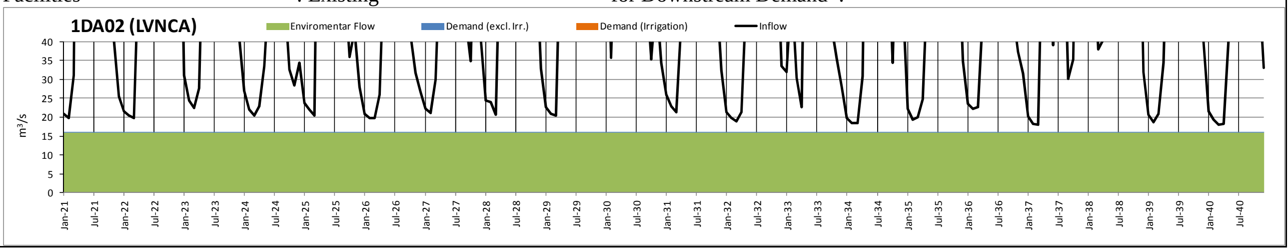
| | | | | |
|---|---|---|---|---|
| River Flow | : Present (1991-2010) | Reserve: | 15.9 | ($m^3$/s) |
| Water Demand | : 2010 | Required Discharge to be maintained | 0.2 | ($m^3$/s) |
| Facilities | : Existing | for Downstream Demand*: | | |



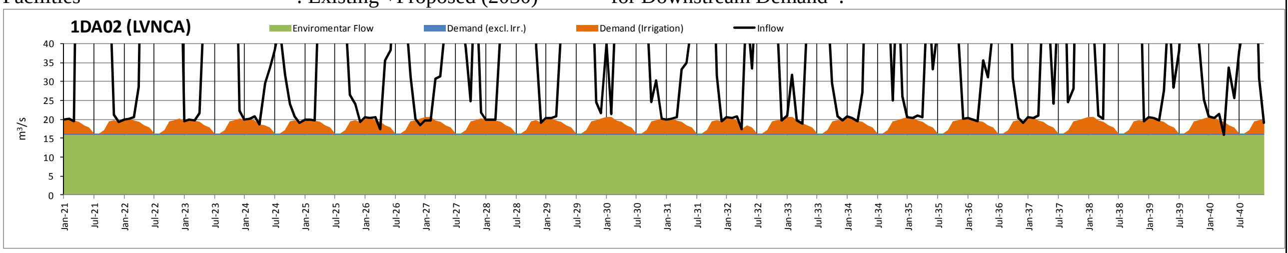

| | | | | |
|---|---|---|---|---|
| River Flow | : Present (1991-2010) | Reserve: | 15.9 | ($m^3$/s) |
| Water Demand | : 2030 | Required Discharge to be maintained | 3.6 | ($m^3$/s) |
| Facilities | : Existing +Proposed (2030) | for Downstream Demand*: | | |




| | | | | |
|---|---|---|---|---|
| River Flow | : Future (2021-2040) | Reserve: | 15.9 | ($m^3$/s) |
| Water Demand | : 2010 | Required Discharge to be maintained | 0.2 | ($m^3$/s) |
| Facilities | : Existing | for Downstream Demand*: | | |




| | | | | |
|---|---|---|---|---|
| River Flow | : Future (2021-2040) | Reserve: | 15.9 | ($m^3$/s) |
| Water Demand | : 2030 | Required Discharge to be maintained | 3.6 | ($m^3$/s) |
| Facilities | : Existing +Proposed (2030) | for Downstream Demand*: | | |



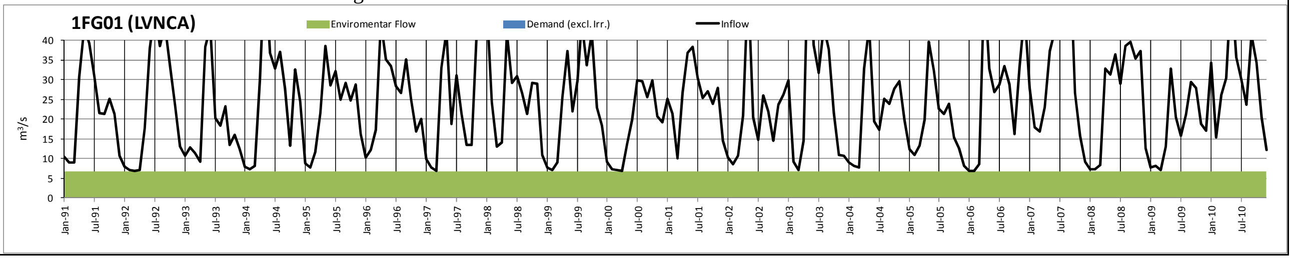

Note: * Irrigation water demand is the average irrigation water demand during March, April, May and June.

Source: JICA Study Team

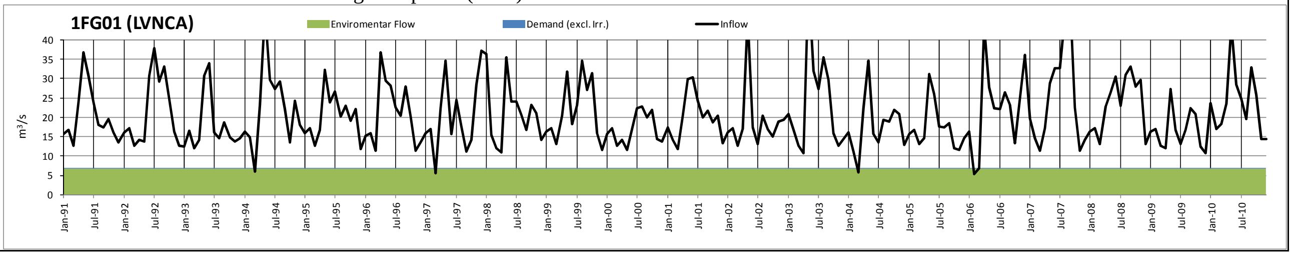
| | |
|---|---|
| **THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030** | **Figure 4.6.5 River Flow at Reference Point 1DA02 under Present and Future Water Demands and Facilities Conditions (LVNCA) (1/2)** |
| **JAPAN INTERNATIONAL COOPERATION AGENCY** | |

River Name: Yala River (LVNCA)
Reference Point: 1FG01

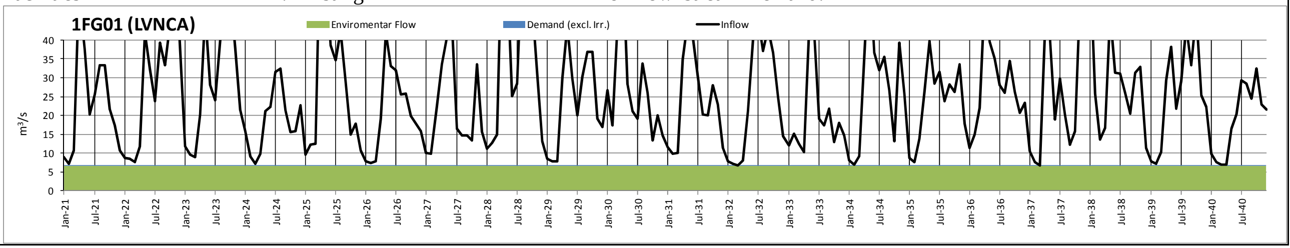
| | | | | |
|---|---|---|---|---|
| River Flow | : Present (1991-2010) | Reserve: | 6.7 | ($m^3$/s) |
| Water Demand | : 2010 | Required Discharge to be maintained | 0.1 | ($m^3$/s) |
| Facilities | : Existing | for Downstream Demand: | | |



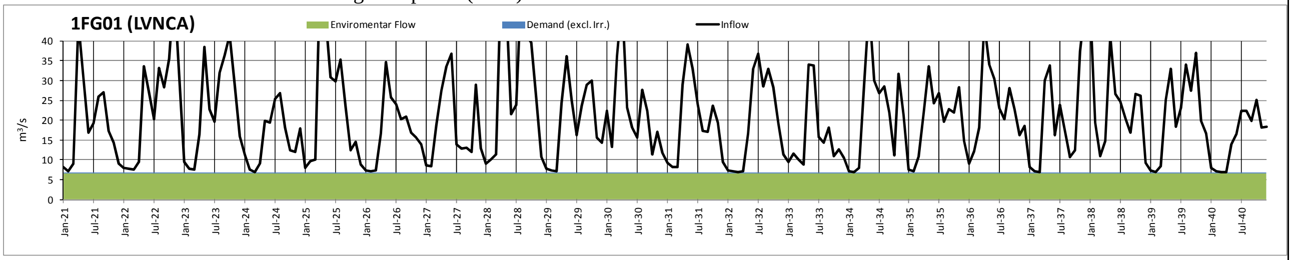

| | | | | |
|---|---|---|---|---|
| River Flow | : Present (1991-2010) | Reserve: | 6.7 | ($m^3$/s) |
| Water Demand | : 2030 | Required Discharge to be maintained | 0.2 | ($m^3$/s) |
| Facilities | : Existing +Proposed (2030) | for Downstream Demand: | | |




| | | | | |
|---|---|---|---|---|
| River Flow | : Future (2021-2040) | Reserve: | 6.7 | ($m^3$/s) |
| Water Demand | : 2010 | Required Discharge to be maintained | 0.1 | ($m^3$/s) |
| Facilities | : Existing | for Downstream Demand: | | |

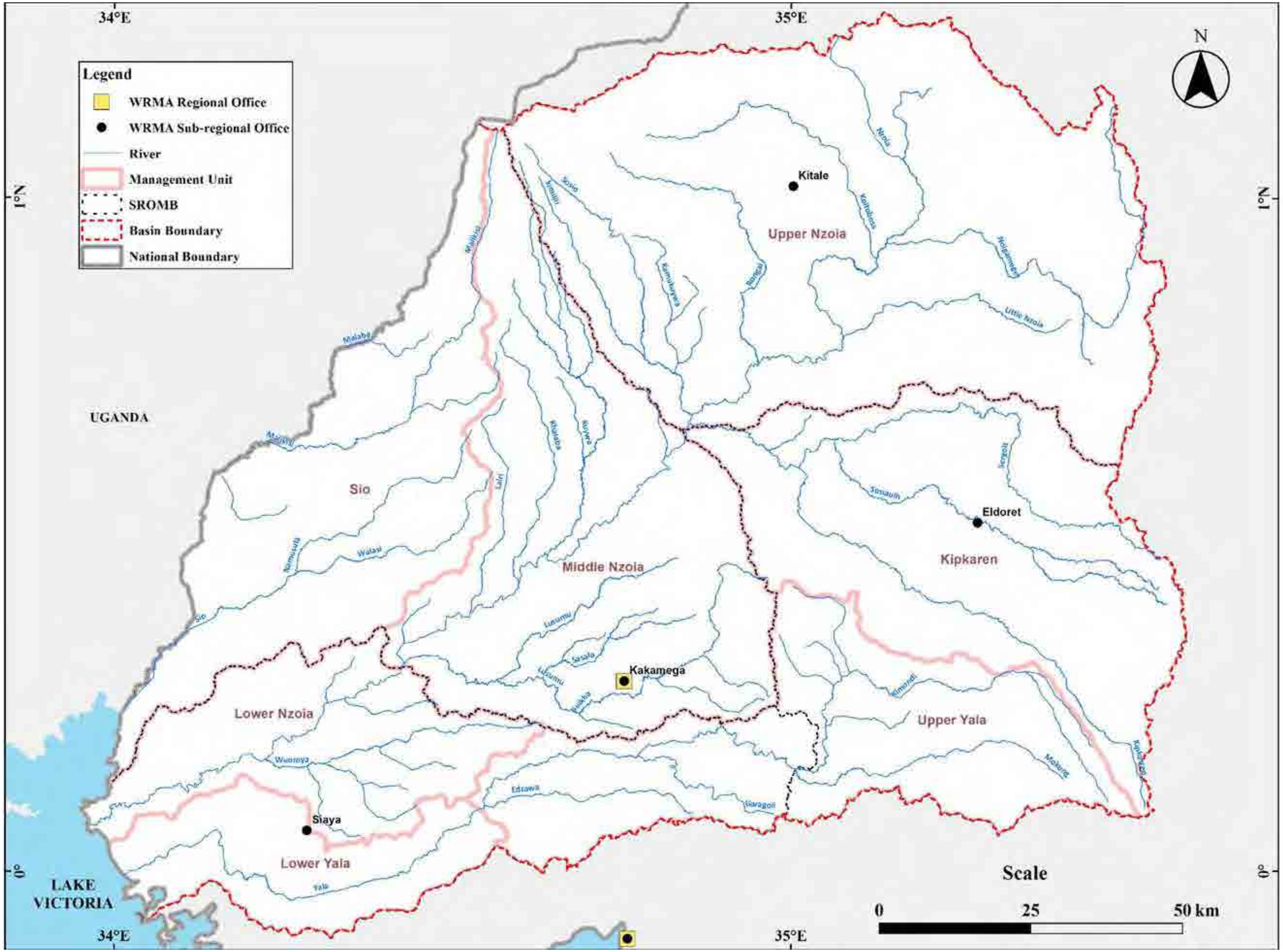



| | | | | |
|---|---|---|---|---|
| River Flow | : Future (2021-2040) | Reserve: | 6.7 | ($m^3$/s) |
| Water Demand | : 2030 | Required Discharge to be maintained | 0.2 | ($m^3$/s) |
| Facilities | : Existing +Proposed (2030) | for Downstream Demand: | | |




Source: JICA Study Team

| | |
|---|---|
| **THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030** | **Figure 4.6.5 River Flow at Reference Point 1FG01 under Present and Future Water Demands and Facilities Conditions (LVNCA) (2/2)** |
| **JAPAN INTERNATIONAL COOPERATION AGENCY** | |




Source: JICA Study Team

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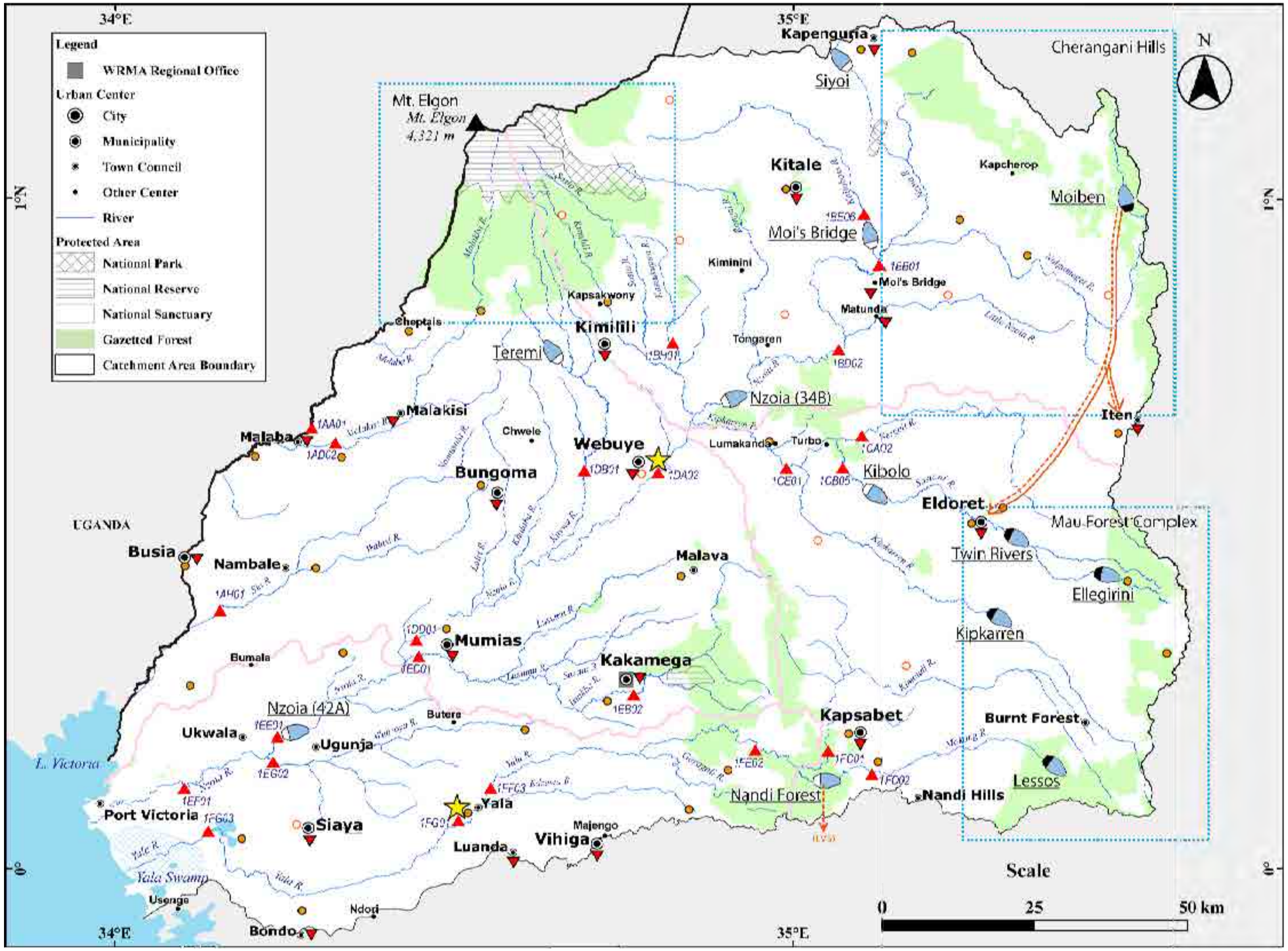
**Figure 4.7.1**
**Rivers and Boundaries for Administration (LVNCA)**




| LEGEND | Surface Water Monitoring Station | 24 locations | Groundwater Monitoring Station | 19 locations |
|---|---|---|---|---|
| | Existing / Newly Proposed | | Proposed Monitoring Station | |
| | Rainfall Monitoring Station | 42 locations | Reference Point | 2 locations |
| | Existing / Newly Proposed | | Proposed Reference Point | |

Source: JICA Study Team

**Figure 4.7.2**
**Proposed Monitoring Stations for Water Resources Management (LVNCA)**

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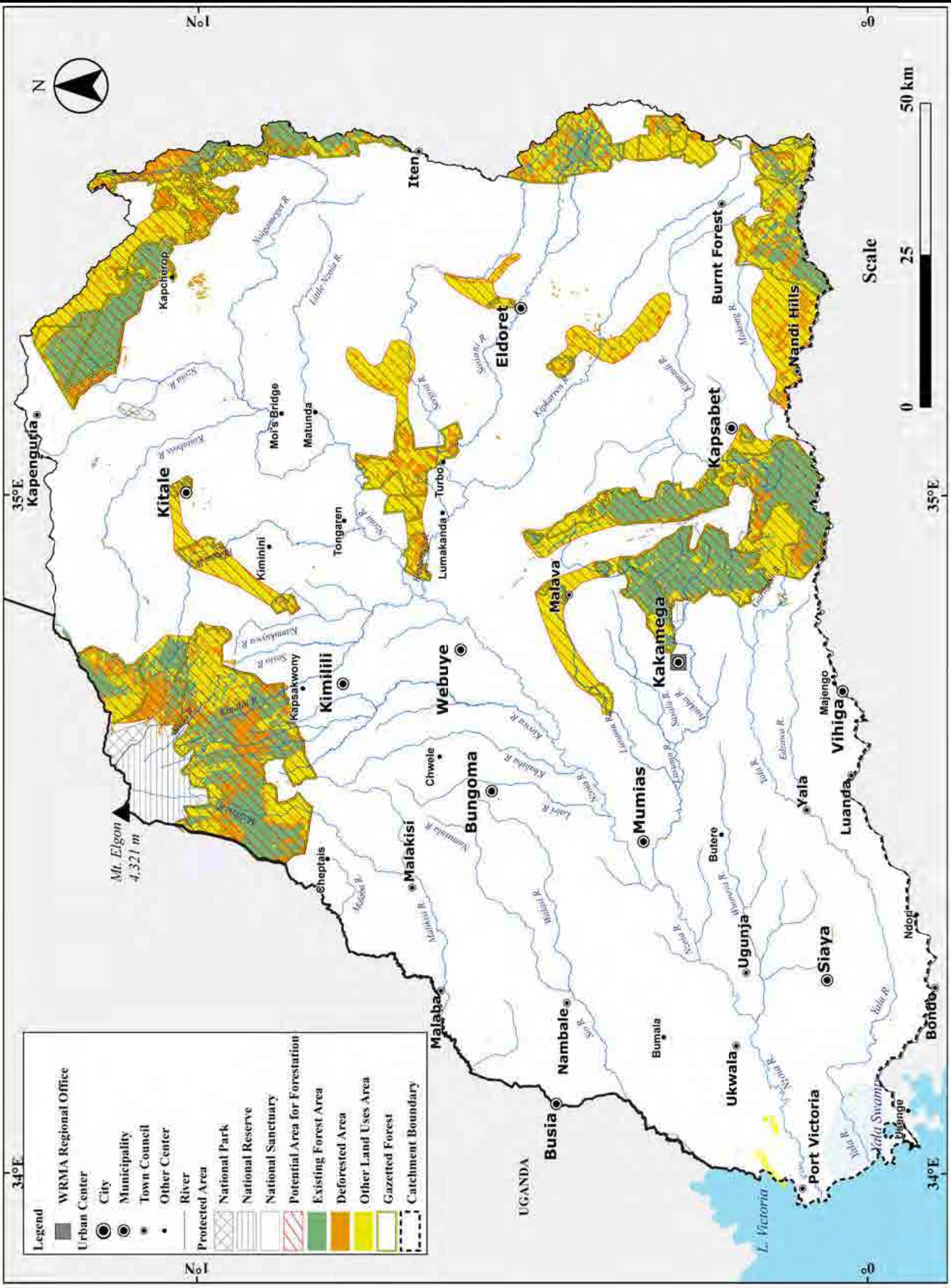



Source: JICA Study Team, based on satellite images

| THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030 | **Figure 4.7.3** **Current Situation of Forest Areas and Potential Forestation Areas (LVNCA)** |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | |

JAPAN INTERNATIONAL COOPERATION AGENCY

THE NATIONAL WATER MASTER PLAN 2030

THE DEVELOPMENT OF

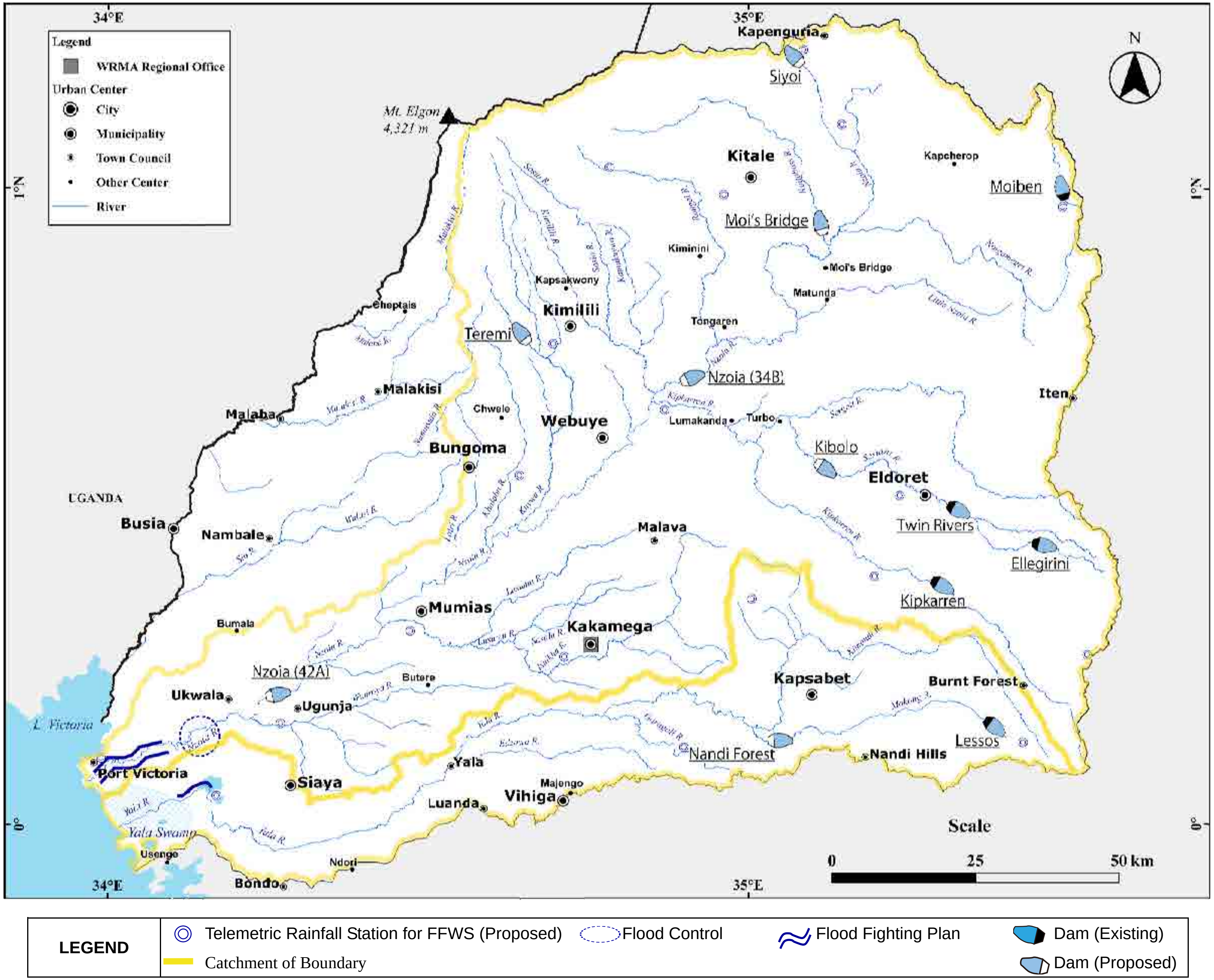
Management Plan (LVNCA)

Proposed Flood and Drought Disaster

Figure 4.8.1

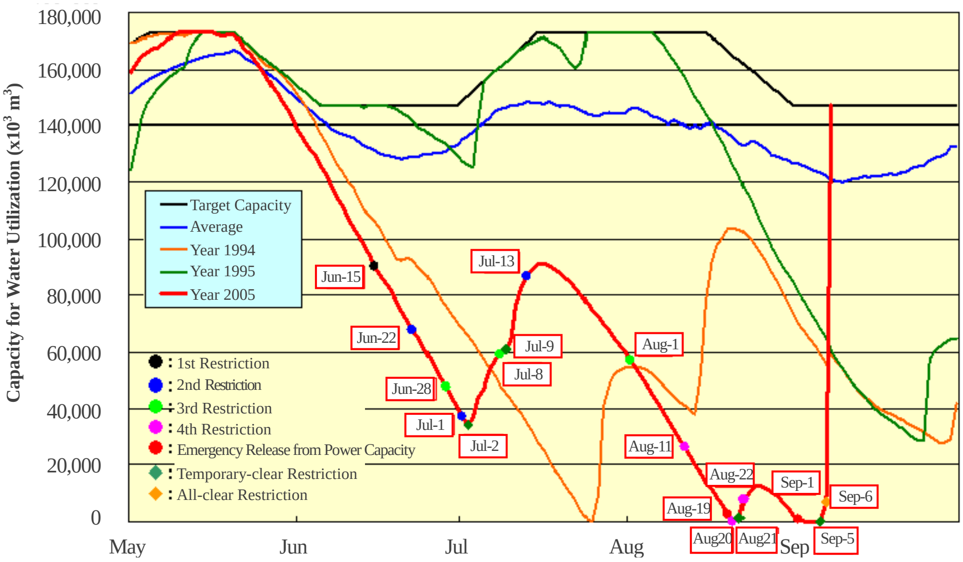
Source: JICA Study Team

Note: The yellow line shows the boundaries of river basin unit for establishment of Basin Drought Conciliation Council in drought disaster management plan.



**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)<br>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<br>[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<br>[Tokushima 15.9% (new 35%), Kagawa 35%] | |
| Jun 28 | 32.40% | 9:00 The third water restriction<br>[Tokushima 17.6% (new 50%), Kagawa 50%] | |
| Jul 1 | 25.10% | 22:00 Ease the second water restriction<br>[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<br>[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<br>[Tokushima 17.2% (new 35%), Kagawa 35%] | |
| Aug 1 | 32.90% | 9:00 The third water restriction<br>[Tokushima 19.0% (new 50%), Kagawa 50%] | |
| Aug 11 | 15.10% | 9:00 The forth water restriction<br>[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<br>[Tokushima 1.85 $m^3/s$, Kagawa 1.81 $m^3/s$] | |
| Aug 20 | 0.00% | 22:00 Temporary ease the forth water restriction<br>[Tokushima 22.0% (new 75%), Kagawa 75%]<br>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<br>[Tokushima 22.4% (new 75%), Kagawa 75%] | |
| Sep 1 (8:00) | 0.5% (0.0%) | 8:00 Start emergency release from power generation capacity<br>[Tokushima 1.85$m^3/s$, Kagawa 1.81$m^3/s$] | |
| Sep 5 | 0.00% | 5:00 Stop emergency release from power generation capacity<br>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)<br>18:00 Breaking up the office (d)<br>18:00 Breaking up the office (c)<br>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 4.8.2 Example for Water Use Restriction of Sameura Dam in 2005 Drought** |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | |

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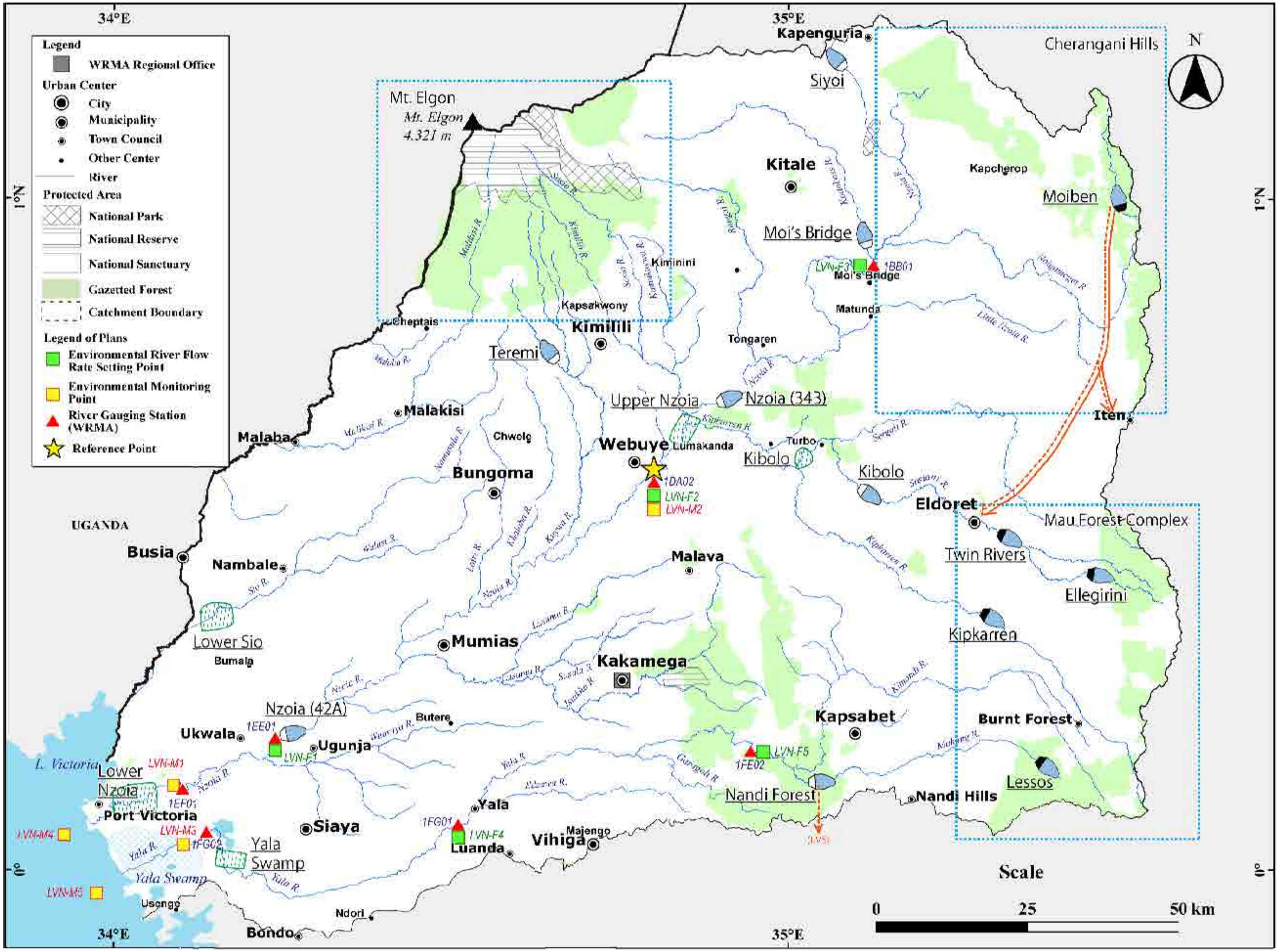
**Figure 4.9.1**
**Proposed Environmental Management Plan (LVNCA)**

Source: JICA Study Team



| WRMA Catchment | No. | Name of Project | Project Status | Capacity to be developed ($m^3$/day) Total | Initial Develop. | Ratio | 2013 13/14 | 2014 14/15 | 2015 15/16 | 2016 16/17 | 2017 17/18 | 2018 18/19 | 2019 19/20 | 2020 20/21 | 2021 21/22 | 2022 22/23 | 2023 23/24 | 2024 24/25 | 2025 25/26 | 2026 26/27 | 2027 27/28 | 2028 28/29 | 2029 29/30 | 2030 30/31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Short Term | | | | | Medium Term | | | | | Long Term | | | | | | | |
| LVN | | Water Resources Development for Urban Water Supply | | | | | | | | ■ | ■ | ■ | ■ | Siyoi Dam | | | | | | | | | | |
| | | | | | | | | | | | | Moi's Bridge Multipurpose Dam | | | | | ■ | ■ | ■ | ■ | | | | |
| | | | | | | | | | | | | | | | Kiboro Multipurpose Dam | | | | ■ | ■ | ■ | ■ | | |
| | | | | | | | | | | | | | | | | | | | | Teremi | ■ | ■ | ■ | ■ |
| | | | | | | | | | | ■ | ■ | ■ | ■ | Transmission to Eldoret | | | | | | | | | | |
| | 1 | Bondo, Siaya (2 UC) | WSB, MTP, F/S | 24,136 | 12,000 | 50% | | | ■ | ■ | ■ | | | | | | | ■ | ■ | ■ | | | | |
| | 2 | Yala, Ugunja, Ukwala (3 UC) | WSB | 8,141 | 2,442 | 30% | | | | ■ | ■ | ■ | | | | | | ■ | ■ | ■ | | | | |
| | 3 | Usenge | WSB, F/S | 7,004 | 4,000 | 57% | | | ■ | ■ | ■ | | | | | | | ■ | ■ | ■ | | | | |
| | 4 | Moi'S Bridge | WSB, MTP | 6,934 | 6,934 | 100% | | | ■ | ■ | ■ | | | | | | | | | | | | | |
| | 5 | Item/Tambach | WSB | 24,246 | 5,000 | 21% | | | | ■ | ■ | ■ | | | | | | ■ | ■ | ■ | | | | |
| | 6 | Port Victoria | WSB | 3,930 | 1,250 | 32% | | | | ■ | ■ | ■ | | | | | | ■ | ■ | ■ | | | | |
| | 7 | Kapenguria | MTP | 18,714 | 5,614 | 30% | | | | | ■ | ■ | ■ | | | | | ■ | ■ | ■ | | | | |
| | 8 | Eldoret | - | 83,354 | 25,006 | 30% | | | | ■ | ■ | ■ | | | | | | ■ | ■ | ■ | | | | |
| | 9 | Vihiga | - | 71,042 | 21,313 | 30% | | | | | ■ | ■ | ■ | | | | | | ■ | ■ | ■ | | | |
| | 10 | Kitale | - | 53,609 | 16,083 | 30% | | | | | ■ | ■ | ■ | | | | | | ■ | ■ | ■ | | | |
| | 11 | Mumias | - | 43,215 | 12,964 | 30% | | | | | | ■ | ■ | ■ | | | | | | | ■ | ■ | ■ | |
| | 12 | Webuye | - | 17,766 | 5,330 | 30% | | | | | | ■ | ■ | ■ | | | | | | | ■ | ■ | ■ | |
| | 13 | Kakamega | - | 38,971 | 11,691 | 30% | | | | | | ■ | ■ | ■ | | | | | | ■ | ■ | ■ | | |
| | 14 | Kapsabet | - | 48,197 | 14,459 | 30% | | | | | | ■ | ■ | ■ | | | | | | ■ | ■ | ■ | | |
| | 15 | Kimilili | - | 51,864 | 15,559 | 30% | | | | | | ■ | ■ | ■ | | | | | | | | ■ | ■ | ■ |
| | 16 | Bungoma | - | 26,466 | 7,940 | 30% | | | | | | ■ | ■ | ■ | | | | | | | | ■ | ■ | ■ |
| | 17 | Chwele | - | 7,382 | 2,215 | 30% | | | | | | | | ■ | ■ | ■ | | | | | | ■ | ■ | ■ |
| | 18 | Busia | - | 23,738 | 7,121 | 30% | | | | | | | | ■ | ■ | ■ | | | | | | ■ | ■ | ■ |
| | 19 | Luanda | - | 29,560 | 8,868 | 30% | | | | | | | | ■ | ■ | ■ | | | | | | ■ | ■ | ■ |
| | 20 | Malaba | - | 10,665 | 3,200 | 30% | | | | | | | | ■ | ■ | ■ | | | | | | ■ | ■ | ■ |
| | 21 | Malakisi | - | 10,233 | 3,070 | 30% | | | | | | | | ■ | ■ | ■ | | | | | | ■ | ■ | ■ |
| | 22 | Butere | - | 7,656 | 2,297 | 30% | | | | | | | | ■ | ■ | ■ | | | | | | ■ | ■ | ■ |
| | 23 | Kiminini | - | 7,179 | 2,154 | 30% | | | | | | | | ■ | ■ | ■ | | | | | | ■ | ■ | ■ |
| | 24 | Nandi Hills | - | 6,062 | 6,062 | 100% | | | | | | | | | | | | ■ | ■ | ■ | | | | |
| | 25 | Lumakanda | - | 4,117 | 4,117 | 100% | | | | | | | | | | | | | | ■ | ■ | ■ | | |
| | 26 | Matunda | - | 4,480 | 4,480 | 100% | | | | | | | | | | | | ■ | ■ | ■ | | | | |
| | 27 | Nambale | - | 2,960 | 2,960 | 100% | | | | | | | | | | | | ■ | ■ | ■ | | | | |
| | 28 | Burnt Forest | - | 2,950 | 2,950 | 100% | | | | | | | | | | | | ■ | ■ | ■ | | | | |
| | 29 | Malava | - | 2,438 | 2,438 | 100% | | | | | | | | | | | | ■ | ■ | ■ | | | | |
| | Rehabilitation for 18 Urban Centres | | | | | | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | | |
| | Total Urban Water Supply Projects | | | 647,010 | 219,516 | 34% | | | | | | | | | | | | | | | | | | |
| | Rural Water Supply Projects | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |

Note: As for "Project Status", "WSB" means a project proposed by WSB, "MTP" means a flagship project proposed in the First Medium Term Plan (2008 – 2019) of Kenya Vision 2030, and "F/S" means a project proposed in completed F/S.

Source: JICA Study Team

| THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030 | **Figure 7.3.1 Implementation Schedule of Proposed Water Supply System Development Plan (LVNCA)** |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | |

| WRMA Catchment | No. | Urban Centre | F/S Status | Capacity to be developed ($m^3$/day) | | | Implementation Schedule | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Short Term | | | | | Medium Term | | | | | Long Term | | | | | | | |
| | | | | Total | Initial Develop. | Ratio | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
| | | | | | | | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 | 19/20 | 20/21 | 21/22 | 22/23 | 23/24 | 24/25 | 25/26 | 26/27 | 27/28 | 28/29 | 29/30 | 30/31 |
| LVN | 1 | Bondo | WSB, D/D | 12,838 | 3,851 | 30% | | | | | | | | | | | | | | | | | | |
| | 2 | Siaya | WSB, D/D | 5,495 | 2,000 | 36% | | | | | | | | | | | | | | | | | | |
| | 3 | Malaba | WSB, F/S | 8,238 | 2,471 | 30% | | | | | | | | | | | | | | | | | | |
| | 4 | Moi's Bridge | WSB, F/S, MTP | 4,440 | 5,000 | 100% | | | | | | | | | | | | | | | | | | |
| | 5 | Matunda | WSB, F/S, MTP | 2,868 | 3,600 | 126% | | | | | | | | | | | | | | | | | | |
| | 6 | Kapenguria | MTP | 13,059 | 3,918 | 30% | | | | | | | | | | | | | | | | | | |
| | 7 | Eldoret | _ | 79,439 | 23,832 | 30% | | | | | | | | | | | | | | | | | | |
| | 8 | Vihiga | _ | 45,529 | 13,659 | 30% | | | | | | | | | | | | | | | | | | |
| | 9 | Kitale | _ | 39,931 | 11,979 | 30% | | | | | | | | | | | | | | | | | | |
| | 10 | Mumias | _ | 38,353 | 11,506 | 30% | | | | | | | | | | | | | | | | | | |
| | 11 | Kimilili | _ | 36,412 | 10,924 | 30% | | | | | | | | | | | | | | | | | | |
| | 12 | Kakamega | _ | 32,500 | 9,750 | 30% | | | | | | | | | | | | | | | | | | |
| | 13 | Kapsabet | _ | 30,796 | 9,239 | 30% | | | | | | | | | | | | | | | | | | |
| | 14 | Bungoma | _ | 16,929 | 16,929 | 100% | | | | | | | | | | | | | | | | | | |
| | 15 | Busia | _ | 16,939 | 16,939 | 100% | | | | | | | | | | | | | | | | | | |
| | 16 | Luanda | _ | 18,928 | 18,928 | 100% | | | | | | | | | | | | | | | | | | |
| | 17 | Item/Tambach | _ | 16,230 | 16,230 | 100% | | | | | | | | | | | | | | | | | | |
| | 18 | Webuye | _ | 13,159 | 13,159 | 100% | | | | | | | | | | | | | | | | | | |
| | 19 | Malakisi | _ | 6,553 | 6,553 | 100% | | | | | | | | | | | | | | | | | | |
| | | Nambale | WSB, F/S | | | | | | | | | | | | | | | | | | | | | |
| | Rehabilitation Works for 7 Urban Centres | | | | | | | | | | | | | | | | | | | | | | | |
| | Total | | | 438,636 | 200,466 | 46% | | | | | | | | | | | | | | | | | | |

Note: As for "Project Status", "WSB" means a project proposed by WSB, "MTP" means a flagship project proposed in the First Medium Term Plan (2008 – 2019) of Kenya Vision 2030, and "F/S" means a project proposed in completed F/S.

Source: JICA Study Team

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JAPAN INTERNATIONAL COOPERATION AGENCY

**Figure 7.3.2**
**Implementation Schedule of Proposed Sewerage System Development Plan (LVNCA)**

| No | Name of Project | County | Irrigation Area (ha) | Multi-purpose Dam | Short Term | | | | | Medium Term | | | | | Long Term | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
| | | | | | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 | 19/20 | 20/21 | 21/22 | 22/23 | 23/24 | 24/25 | 25/26 | 26/27 | 27/28 | 28/29 | 29/30 | 30/31 |
| **A. Large Scale Irrigation Project (New)** | | | | | | | | | | | | | | | | | | | | | | |
| 1 | Lower Nzoia Irrigation | Busia/ Siaya | 10,470 | Nzoia (42A) | | | | | | | | | | Dam | | | | | | | | |
| 2 | Lower Sio Irrigation | Busia | 6,600 | - | | | | | | | | | | | | | | | | | | |
| 3 | Yala Swamp Irrigation | Siaya | 4,600 | - | | | | | P | | | | | | | | | | | | | |
| 4 | Upper Nzoia Irrigation | Bungoma | 24,000 | Nzoia (34B) | | | | | | | | P | | Dam | | | | | | | | |
| 5 | Moi's Bridge Irrigation | Bungoma | 19,800 | Moi's Bridge | | | | | | | | | | P | | | | | Dam | | | |
| 6 | Kibolo Irrigation | Kakamega | 11,500 | Kibolo | | | | | | | | | | | | | P | | | | Dam | |
| | On-going Weir Irrigation | | 1,400 | | | | | | | | | | | | | | | | | | | |
| Total | | | 78,370 | | 14,282 | | | | | 8,788 | | | | | 55,300 | | | | | | | |
| **B. Small Scale Irrigation Project (New)** | | | | | | | | | | | | | | | | | | | | | | |
| 1 | Weir Irrigation | | 41,638 | | 8,328 | | | | | 12,491 | | | | | 20,819 | | | | | | | |
| 2 | Dam Irrigation | | 0 | | 0 | | | | | 0 | | | | | 0 | | | | | | | |
| 3 | Small Dam/Pond/Water Pan Irrigation | | 3,700 | | 740 | | | | | 1,110 | | | | | 1,850 | | | | | | | |
| 4 | Groundwater Irrigation | | 1,784 | | 357 | | | | | 535 | | | | | 892 | | | | | | | |
| **Total for B** | | | 47,122 | | 9,425 | | | | | 14,136 | | | | | 23,561 | | | | | | | |
| **C. Private Irrigation Project (New)** | | | | | | | | | | | | | | | | | | | | | | |
| 1 | Weir Irrigation | | 41,637 | | 8,327 | | | | | 12,491 | | | | | 20,819 | | | | | | | |
| 2 | Groundwater Irrigation | | 1,784 | | 357 | | | | | 535 | | | | | 892 | | | | | | | |
| **Total for C** | | | 43,421 | | 8,684 | | | | | 13,026 | | | | | 21,711 | | | | | | | |
| **Total for LVNCA** | | | 168,913 | | 32,391 | | | | | 35,950 | | | | | 100,572 | | | | | | | |

Note:
- (hatched) F/S and/or D/D
- P Procurement
- (thick bar) Construction of Irrigation System
- (thin bar) Construction of Multipurpose Dam

Source: JICA Study Team

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**Figure 7.3.3**
**Implementation Schedule of Proposed Irrigation Development Plan (LVNCA)**

| WRMA Catchment | No | Name of Project | Purpose | Installed Capacity (MW) | Project Status | Implementation Schedule | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Short Term | | | | | Medium Term | | | | | Long Term | | | | | | | |
| | | | | | | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
| | | | | | | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 | 19/20 | 20/21 | 21/22 | 22/23 | 23/24 | 24/25 | 25/26 | 26/27 | 27/28 | 28/29 | 29/30 | 30/31 |
| LVN | 1 | Nandi Forest Dam | W, I, P | 50 | D/D done | | P | | | | | | | | | | | | | | | | |
| | 2 | Nzoia (34B) Dam | W, I, P, F | 16 | Flagship<br>D/D ongoing | | | | | P | | | | | | | | | | | | | |
| | 3 | Nzoia (42A) Dam | W, P, F | 25 | Flagship<br>D/D ongoing | | | | | | | P | | | | | | | | | | | |

| Legend | |
|---|---|
| | F/S and/or D/D |
| P | Procurement |
| | Construction |

W=Domestic and industrial water supply, I=Irrigation, P=Hydropower, F-Flood control

D/D=Detailed Design, F/S=Feasibility Study, Pre-F/S=Pre-Feasibility Study

Source: JICA Study Team

| THE DEVELOPMENT OF<br>THE NATIONAL WATER MASTER PLAN 2030 | **Figure 7.3.4**<br>**Implementation Schedule of Proposed Hydropower Development Plan (LVNCA)** |
|---|---|
| **JAPAN INTERNATIONAL COOPERATION AGENCY** | |

| WRMA Catchment | No. | Name of Project | Purpose | Effective Storage Volume (MCM) | Project Status | Implementation Schedule | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Short Term | | | | | Medium Term | | | | | Long Term | | | | | | | |
| | | | | | | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
| | | | | | | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 | 19/20 | 20/21 | 21/22 | 22/23 | 23/24 | 24/25 | 25/26 | 26/27 | 27/28 | 28/29 | 29/30 | 30/31 |
| LVN | 1 | Nandi Forest Dam | W, I, P | 220 | D/D done | | P | | | | | | | | | | | | | | | | |
| | 2 | Siyoi Dam | W | 4 | Flagship D/D ongoing | | | P | | | | | | | | | | | | | | | |
| | 3 | Nzoia (34B) Dam | I, P, F | 204 | Flagship D/D ongoing | | | | | P | | | | | | | | | | | | | |
| | 4 | Nzoia (42A) Dam | I, P, F | 395 | Flagship D/D ongoing | | | | | | | P | | | | | | | | | | | |
| | 5 | Moi's Bridge Dam | W, I | 214 | | | | | | | | | | | P | | | | | | | | |
| | 6 | Kibolo Dam | W, I | 40 | | | | | | | | | | | | | P | | | | | | |
| | 7 | Teremi Dam | W | 3 | | | | | | | | | | | | | | | P | | | | |

F/S and/or D/D
P Procurement
Construction

W=Domestic and industrial water supply, I=Irrigation, P=Hydropower, F-Flood control
D/D=Detailed Design, F/S=Feasibility Study, Pre-F/S=Pre-Feasibility Study

Source: JICA Study Team

| THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030 | Figure 7.3.5 Implementation Schedule of Proposed Water Resources Development Plan (LVNCA) |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | |

| No. | Description | Implementation Schedule | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Short Term | | | | | Medium Term | | | | | Long Term | | | | | | | |
| | | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
| | | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 | 19/20 | 20/21 | 21/22 | 22/23 | 23/24 | 24/25 | 25/26 | 26/27 | 27/28 | 28/29 | 29/30 | 30/31 |
| *Development Activities* | | | | | | | | | | | | | | | | | | | |
| (1) | Monitoring | | | | | | | | | | | | | | | | | | |
| M1 | Replacement of iron post for river gauge to concrete post | ■ | ■ | ■ | | | | | | | | | | | | | | | |
| M2 | Upgrade manual gauge to automatic (surface water level) | | | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | |
| M3 | Upgrade manual gauge to automatic (groundwater level) | | | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | |
| M4 | Upgrade manual gauge to automatic (rainfall) | | | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | |
| M5 | Installation of Dedicated Boreholes for Groundwater Monitoring | ■ | ■ | ■ | | | | | | | | | | | | | | | |
| M6 | Installation/Rehabilitation of River Gauging Stations | ■ | ■ | | | | ■ | ■ | | | | ■ | ■ | | | | | | |
| M7 | Installation/Rehabilitation of Rainfall Gauging Stations | ■ | ■ | | | | ■ | ■ | | | | ■ | ■ | | | | | | |
| M8 | Flood Discharge Measurement Equipment (Each SRO) | | ■ | ■ | ■ | | | | | | | | ■ | ■ | ■ | | | | |
| (2) | Evaluation | | | | | | | | | | | | | | | | | | |
| E1 | Hydromet DB Upgrade (Software + Hardware) | | | ■ | ■ | | | | ■ | ■ | | | | ■ | ■ | | | | |
| (3) | Permitting | | | | | | | | | | | | | | | | | | |
| P1 | PDB Upgrade (Software + Hardware) | | | ■ | ■ | | | | ■ | ■ | | | | ■ | ■ | | | | |
| (4) | Watershed Conservation | | | | | | ■ | ■ | ■ | ■ | | | | | | | | | |
| W1 | Forestation (Gazetted Forest Area) | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | | |
| W2 | Forestation (Non-gazetted Forest Area) | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| *Recurrent Activities* | | | | | | | | | | | | | | | | | | | |
| (1) | Monitoring | | | | | | | | | | | | | | | | | | |
| M1 | Surface Water Level Monitoring | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| M2 | River Discharge Measurement | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| M3 | Groundwaer Level Monitoring | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| M4 | Rainfall Monitoring | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| M5 | Flood Discharge Measurement | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| M6 | Surface Water Quality Monitoring | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| M7 | Groundwater Quality Monitoring | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| (2) | Others | | | | | | | | | | | | | | | | | | |
| O1 | Catchment Forum Operation (Venue and Allownce to WURAs) | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |

Source: JICA Study Team

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

**Figure 7.3.6**
**Implementation Schedule of Proposed Water Resources Management Plan (LVNCA)**

*Flood Disaster Management Plan*

| WRMA Catchment | No. | Description | Implementation Schedule | | | | | | | | | | | | | | | | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Short Term | | | | | Medium Term | | | | | Long Term | | | | | | | | |
| | | | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | |
| | | | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 | 19/20 | 20/21 | 21/22 | 22/23 | 23/24 | 24/25 | 25/26 | 26/27 | 27/28 | 28/29 | 29/30 | 30/31 | |
| LVN | N1 | Yala Swamp | | | | | | | | | | | | | | | | | | | |
| | | N1.1 Construction of Multipurpose Dam | | | | | | | | | | | | | | | | | | | Nzoia 34B Dam, Nzoia 42A Dam |
| | | N1.2 River Training Works | | | | | | | | | | | | | | | | | | | |
| | | N1.3 Establishment of Flood Forecasting and Warning System | | | | | | | | | | | | | | | | | | | |
| | | N1.4 Formulation of Flood Fighting Plan | | | | | | | | | | | | | | | | | | | |

*Drought Disaster Management Plan*

| No. | Description | Implementation Schedule | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Short Term | | | | | Medium Term | | | | | Long Term | | | | | | | |
| | | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
| | | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 | 19/20 | 20/21 | 21/22 | 22/23 | 23/24 | 24/25 | 25/26 | 26/27 | 27/28 | 28/29 | 29/30 | 30/31 |
| 1 | Preparation of Water Use Restriction Rule for Reservoirs | | | | | | | | | | | | | | | | | | |
| 2 | Establishment of Basin Drought Conciliation Councils | | | | | | | | | | | | | | | | | | |
| 3 | Development of Drought Early Forecast System | | | | | | | | | | | | | | | | | | |

Legend: Establishment Update / Expansion

Source: JICA Study Team

| THE DEVELOPMENT OF<br>THE NATIONAL WATER MASTER PLAN 2030 | **Figure 7.3.7**<br>**Implementation Schedule of Proposed Flood and Drought Disaster Management Plan (LVNCA)** |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | |

| WRMA Catchment | No. | Name of Project | Target | Related Project (Dams and Irrigation) | Implementation Schedule | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Short Term | | | | | Medium Term | | | | | Long Term | | | | | | | |
| | | | | | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
| | | | | | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 | 19/20 | 20/21 | 21/22 | 22/23 | 23/24 | 24/25 | 25/26 | 26/27 | 27/28 | 28/29 | 29/30 | 30/31 |
| LVN | 1 | Setting of Environmental Flow | Nzoia River | Nandi Forest Dam | | Set | | | | | | | | | | | | | | | | |
| | | | Yala River | Siyoi, Nzoia (34B), Nzoia (42B), Moi's Bridge, Kibolo, and Teremi Dams | | | | Set | | | | | | | | | | | | | | |
| | 2 | Environmental Monitoring | Nzoia River | Nandi Forest Dam | | | | | | | | | | | | | | | | | | |
| | | | Yala River | Siyoi, Nzoia (34B), Nzoia (42B), Moi's Bridge, Kibolo, and Teremi Dams | | | | | | | | | | | | | | | | | | |
| | | | L. Victoria | - | | | | | | | | | | | | | | | | | | |

Environmental Survey for Setting Environmental Flow

Set — Setting of Environmental Flow (including Key Stakeholder Meeting)

Environmental Monitoring (including Planning)

Source: JICA Study Team

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

**Figure 7.3.8**
**Implementation Schedule of Proposed Environmental Management Plan (LVNCA)**

# *Part C*
# *Lake Victoria South Catchment Area*


**Location Map (LVSCA)**

**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 C: LAKE VICTORIA SOUTH CATCHMENT AREA



## Table of Contents

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## List of Abbreviations and Acronyms

| | | |
|---|---|---|
| ALRMP | : | Arid Land Resources Management Project |
| ASAL | : | Arid and Semi-arid Land |
| B/C | : | Benefit and Cost |
| BOD | : | Biochemical Oxygen Demand |
| BSAP | : | Biodiversity Strategy and Action Plan |
| CBDM | : | Community-based disaster management |
| CMS | : | Catchment Management Strategy |
| COD | : | Chemical Oxygen Demand |
| D/D | : | Detailed Design |
| DO | : | Dissolved oxygen |
| EIRR | : | Economic Internal Rate of Return |
| FFWS | : | Flood Forecasting and Warning System |
| IUCN | : | International Union for Conservation of Nature |
| JICA | : | Japan International Cooperation Agency |
| KenGen | : | Kenya Electric Generating Company |
| KFS | : | Kenya Forest Service |
| KMD | : | Kenya Meteorological Department |
| KWS | : | Kenya Wildlife Service |
| LBDA | : | Lake Basin Development Authority |
| LCPDP | : | Least Cost Power Development Plan |
| LSRWSS | : | Large Scale Rural Water Supply System |
| LVN | : | Lake Victoria North |
| LVS | : | Lake Victoria South |
| LVSCA | : | Lake Victoria South Catchment Area |
| MDNKOAL | : | Ministry of State for Development of Northern Kenya and Other Arid Lands |
| MORDA | : | Ministry of Regional Development Authority |
| NIB | : | National Irrigation Board |
| NRW | : | Non-Revenue Water |
| NWMP | : | National Water Master Plan |
| O&M | : | Operation and Maintenance |
| Pre-F/S | : | Prefeasibility Study |
| RV | : | Rift Valley |
| SCMP | : | Sub-catchment Management Plan |
| SS | : | Suspended Solids |
| SSRWSS | : | Small Scale Rural Water Supply System |
| T-N | : | Total Nitrogen |
| T-P | : | Total Phosphorus |
| UC | : | Urban Centre |
| WASREB | : | Water Services Regulatory Board |
| WRMA | : | Water Resource Management Authority |
| WRUA | : | Water Resources Users Association |
| WSB | : | Water Service Board |
| WSC | : | Water Service Company / Water and Sewerage Company |
| WSP | : | Water Service Provider |

| | | |
|---|---|---|
| WWF | : | World Wide Fund for Nature |
| WWF-ESARPO | : | World Wide Fund for Nature - Eastern and Southern Africa Region Programme Office |
| WWTP | : | Waste Water Treatment Plant |

# 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

The National Water Master Plan 2030 (NWMP 2030) covers the whole area of Kenya. The plans for water resources development and management were formulated for six catchment areas of Water Resources Management Authority (WRMA) designated by the National Water Resources Management Strategy (2007-2009) for water resources management purposes.

This volume, as Main Report Part C, presents the water master plan for the Lake Victoria South Catchment Area (LVSCA). The water master plan of LVSCA consists of the eight component plans mentioned in Chapter 7 of the Main Report Part A, as follows:

<u>Development plans</u>

1) Water supply development plan
2) Sanitation development plan
3) Irrigation development plan
4) Hydropower development plan
5) Water resources development plan

<u>Management plans</u>

6) Water resources management plan
7) Flood and drought disaster management plan
8) Environmental management plan

The Main Report Part C for LVSCA includes catchment area characteristics, water resources, water demands, development and management plans, water allocation plan, cost estimate, economic evaluation, and implementation programs. The plans were formulated based on water resources assessment, water demand projection, objectives, and overall concepts of respective subsectors presented in the Main Report Part A. The development plans aims to provide a basis for future water demand projection, while the management plans aims to propose frameworks for sustainable water resources management including the aspects of flood, drought, and environment.

# CHAPTER 2 CATCHMENT CHARACTERISTICS

LVSCA is located at the southwestern part of the country. LVSCA borders with the Lake Victoria North Catchment Area (LVNCA) in the north, Rift Valley Catchment Area (RVCA) in the east, Tanzania in the south, and Lake Victoria in the west. The Mau Forest Complex of the Five Water Towers lies in the northeastern part of the area. The total area of LVSCA is 31,734 km$^2$, corresponding to 5.5% of the country. Based on the Census 2009, the population of the area in 2010 is estimated at 7.37 million, or 19.1% of the total population of Kenya. Population density is as high as 232 persons/km$^2$.

The topography of LVSCA varies from Mt. Londiani peak in the Mau Forest of 3,009 m above mean sea level (amsl) to Lake Victoria of 1,134 m amsl. The whole area of LVSCA lies in the highlands of more than 1,000 m amsl.

Major rivers in LVSCA are Nyando, Sondu, Kuja, and Mara rivers originating from the Mau Forest Complex. Nyando, Sondu, and Kuja rivers flow into, Lake Victoria and have drainage areas of 3,604 km$^2$, 3,474 km$^2$, and 6,843 km$^2$, respectively. The total drainage area of these three rivers accounts for 43.9% of LVSCA. The Mara River flows through the Masai Mara National Reserve across the border with Tanzania and finally flows into Lake Victoria in the territory of Tanzania. It has a drainage area of 9,107 km$^2$, or 28.7% of LVSCA. The rest is composed of small river basins along the Winum Gulf of Lake Victoria.

Lake Victoria is the second largest freshwater lake in the world and strides the borders of Kenya, Tanzania, and Uganda.

LVSCA is classified as a humid land, and not as arid and semi-arid land (non-ASAL). The mean annual rainfall ranges between 1,200 mm to 1,800 mm and the catchment area average mean annual rainfall comes to 1,280 mm. The renewable water resources, which are defined by precipitation minus evapotranspiration, are estimated at 7.1 BCM/year in 2010 for LVSCA and the per capita renewable water resources of LVSCA is calculated at 959 m$^3$/year/capita.

Major cities and towns in LVSCA are Kisumu, Kisii, Migori, Kericho, Homa Bay, Molo, and Kehancha. LVSCA includes the whole area of Kisumu, Kericho, Homa Bay, Nyamira, Kisii, Bomet, and Migori counties; and some parts of Siaya, Vihiga, Nandi, Nakuru, and Narrok counties.

Kisumu is the largest city within LVSCA with various kinds of industries such as cement, construction materials, brewing and beverages, food processing, timber and timber products, textiles, printing and light engineering. Tea processing industry is famous in the surrounding areas of Kericho.

# CHAPTER 3 WATER RESOURCES, WATER DEMANDS, AND WATER ALLOCATION

## 3.1 General

Future water demands will increase due to the increase in population and economic activities. On the other hand, available water resources are limited and affected by climate change. The water resources development and management plans in this study must be formulated to have an appropriate allocation of the limited and climate-affected water resources to cater the increasing water demands of various water users in the future.

The available water resources consisting of surface water and groundwater were estimated for the years of 2010 (considered as present) and 2030, as detailed in Chapter 5 of the Main Report Part A and Sectoral Report (B). The estimates for 2030 include climate change impacts.

The present water uses were estimated and future water demands for the year of 2030 were projected for the subsectors of domestic, industrial, irrigation, livestock, wildlife and inland fisheries. Since the available records of actual water uses at present were insufficient, the present water demands were estimated and will be utilised as the water uses. Future water demand projections were based on the socioeconomic frameworks set in Kenya Vision 2030. The estimates and projections are detailed in Chapter 6 of the Main Report Part A and in Sectoral Reports (C) and (E).

The appropriate allocation of available water resources for 2030 was studied through the water balance studies to meet the 2030 water demands. The allocation was based on concepts and strategies for water resources development planning as well as the allocation policies derived from the current situations of the water balance between the present water resources and water demands and future trends as presented in Chapter 7 of the Main Report Part A and in Section 4.6 of this report. Through the allocation study, the water demands were modified to be supplied within the resources capacity.

The following sections briefly explain the available water resources, present water use, future water demands, and proposed water allocation plan for LVSCA, which are the basis for water resources development and management plans.

## 3.2 Available Water Resources

The available water resources consisting of the surface water runoff and sustainable yield of groundwater were estimated in LVSCA for the years of 2010 and 2030 as follows:

**Annual Available Water Resources (LVSCA)**

(Unit: MCM/year)

| Year | Surface Water | Groundwater | Total |
|---|---|---|---|
| 2010 | 4,773 | 203 | 4,976 |
| 2030 | 5,749 | 188 | 5,937 |
| Percentage of 2010 values | 120% | 93% | 119% |

Source: JICA Study Team, (Ref. Main Report Part A, Sub-section 5.2.3)

The sustainable yield of groundwater was derived as 10% of the groundwater recharge in the catchment area excluding river courses and riparian areas with a width of 1 km, where groundwater abstraction will need to be restricted. Climate change impacts were incorporated into the above estimates for 2030. Details of the above values for annual available water resources are presented in Section 5.2 of the Main Report Part A.

The above table shows that the 2030 surface water runoff will increase to 120% of 2010 runoff, while the 2030 sustainable yield of groundwater will decrease to 93% of 2010 yield, both due to climate change impacts, resulting in an increase of 2030 available water resources to 119% of 2010 resources.

The hydrological analysis of this study explained in the Sectoral Report (B) also disclosed that the rainfall may increase in the western highland areas and may be unchanged or decrease in the coastal areas in the long rainy season, but the rainfall may be almost unchanged throughout the country and slightly decrease in the coastal areas in the dry season in the future. This implies that the availability of water resources is expected to be more unevenly distributed spatially and temporally in the future.

## 3.3 Present Water Uses and Future Water Demands under Kenya Vision 2030

The annual water demands were estimated for the year 2010 and projected for 2030 in LVSCA for the domestic, industrial, irrigation, livestock, wildlife and inland fisheries subsectors. The projection for 2030 followed the national development targets of Kenya Vision 2030 and socio-economic framework. Basic conditions of the estimates and projections and their results are described in Chapter 6 of the Main Report Part A.

The annual water demands for 2010 and 2030 are as summarised below.

**Water Demands by Subsector (LVSCA)**

(Unit: MCM/year)

| Year | Domestic | Industrial | Irrigation | Livestock | Wildlife | Fisheries | Total |
|---|---|---|---|---|---|---|---|
| 2010 | 165 | 10 | 155 | 43 | 3 | 9 | 385 |
| 2030 | 464 | 41 | 2,324 | 106 | 3 | 15 | 2,953 |

Source: JICA Study Team, (Ref. Main Report Part A, Section 6.10 and Setoral Report (G), Sub-section 3.3.1 (3))

The total projected water demands of 2,953 MCM/year in 2030 is approximately 7.7 times of the present water demands of 385 MCM/year due to increase in population from 7.37 million to 12.72 million and irrigation areas from 13,218 ha to 200,196 ha mentioned in Chapter 6 of the Main Report Part A. Monthly water demands in 2030 by sub-basin are shown in Table 3.3.1.

## 3.4 Proposed Water Allocation Plan

(1) Water Balance Study

The available water resources and water demands for both of 2010 and 2030 as presented in the preceding sections are compared as follows:

**Available Water Resources and Water Demands (LVSCA)**

(Unit: MCM/year)

| 2010 | | | 2030 | | |
|---|---|---|---|---|---|
| Water Resources | Water Demands | Percentage | Water Resources | Water Demands | Percentage |
| 4,976 | 385 | 8% | 5,937 | 2,953 | 50% |

Source: JICA Study Team

Although the present water demands in 2010 are estimated to be 8% of the available water resources, the water demands for 2030 are expected to increase drastically up to 50% of the 2030 available water resources. The ratio of 50% of water demand to water resources, which is called a water stress ratio, indicates severe situation in the water balance for the catchment area as suggested by the ratio of which the value of more than 40% is regarded as severe water stress.

In order to examine a more detailed situation of future water balance from the spatial and temporal perspectives, a surface water balance study for 2030 was carried out. Since the surface water demands occupy more than 80% of the total demands nationwide, it was judged that the surface water balance would give general situation of water deficits. This study divided the catchment area into 32 sub-basins and applied a study model with the existing dams only as discussed in Section 6.11 of the Main Report Part A. Conditions of the water balance study are described in Subsection 4.6.3 of this report and detailed in Chapter 4 of the Sectoral Report (G).

Results of the surface water balance study showed that most of the sub-basins in LVSCA had water deficits due to increase in water demands for 2030 as seen in Figure 6.11.2 of the Main Report Part A. The water deficits derived from the water balance study for 2010 and 2030, and a comparison with water demands are summarised below.

**Water Demands and Water Deficits (LVSCA)**

(Unit: MCM/year)

| 2010 | | | 2030 | | |
|---|---|---|---|---|---|
| Water Demands | Water Deficits | Percentage | Water Demands | Water Deficits | Percentage |
| 385 | 150 | 39% | 2,953 | 1,304 | 44% |

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

The water deficits for 2030 in the above table suggest requirements for planning to maximise utilisation of water recourses such as maximum development of water resources, introduction of water demand management, and limitation of water demands within the water supply capacity, as detailed in Section 6.11 of the Main Report Part A.

### (2) Modified Future Water Demands

Following the suggested requirements mentioned above, the water demands for 2030 described in Section 3.3 were reduced in terms of irrigation water demand considering water saving and efficient water use measures, and reducing irrigation areas to be planned. The water balance study was carried out between the water resources and the reduced water demands for 2030 with provision of various water storages and supply facilities proposed in the water resources development plan stated in Section 4.6 of this report and Sectoral Report (G).

The modified water demand projections are as summarised below.

**Modified Water Demand Projections for 2030 (LVSCA)**

(Unit: MCM/year)

| Year | Domestic | Industrial | Irrigation | Livestock | Wildlife | Fisheries | Total |
|---|---|---|---|---|---|---|---|
| 2030 | 464 | 41 | 1,158 | 106 | 3 | 15 | 1,787 |

Source: JICA Study Team

The projected demand following Kenya Vision 2030 in Section 3.3 was reduced to 1,787 MCM/year by reducing the irrigation water demand corresponding to the irrigation area reduction to 126,424 ha.

(3) Proposed Water Allocation Plan

Results of the balance study mentioned in the above clause (2) showed the following allocated amount of surface and groundwater to satisfy the 2030 modified water demand projections:

**Water Resources Allocation Plan in 2030 (LVSCA)**

(Unit: MCM/year)

| Subsector | Water Demand | Water Resources Allocation | |
|---|---|---|---|
| | | Surface Water | Groundwater |
| Domestic | 464 | 374 | 90 |
| Industrial | 41 | 21 | 20 |
| Irrigation | 1,158 | 1,107 | 51 |
| Livestock | 106 | 106 | 0 |
| Wildlife | 3 | 3 | 0 |
| Fisheries | 15 | 15 | 0 |
| Total | 1,787 | 1,626 | 161 |

Source: JICA Study Team

The total amount of allocated surface water is 1,626 MCM/year, which is about 91% of the total water demand and about 28% of the available surface water resources. The total amount of allocated groundwater is 161 MCM/year, which is about 9% of the total water demand and about 86% of the available groundwater resources. The above percentages in terms of water resources imply that the water balance situation in 2030 is expected to be rather severe or severe judging from the water stress ratio.

The allocation plan should guide the water resources management in LVSCA.

# CHAPTER 4 DEVELOPMENT AND MANAGEMENT PLANS

## 4.1 General

Based on the overall concepts and framework by subsector as described in Chapter 7 of Main Report Par A, eight component plans were prepared.

The eight component plans are water supply, sanitation, irrigation, hydropower and water resources development plans; and water resources, flood and drought disaster and environmental management plans.

Current situations, development and management strategies, and proposed plans for the above eight component plans are explained in the next section.

## 4.2 Water Supply Development Plan

### 4.2.1 Current Situation of Water Supply

As shown in Section 3.2 of Main Report Part A, the current population of LVSCA in 2010 is estimated to be 7.37 million, which is composed of 1.85 million of urban population and 5.51 million of rural population. The population is concentrated in Kisumu City and Kisii Town. Based on the 2009 Census data, the current situation of water connection of LVSCA was estimated as shown below.

**Current Situation of Water Connection (LVSCA)**

| Type | Piped by WSPs | Spring/Well/Borehole | Water Vendor | Stream, Lake, Pond, Others |
|---|---|---|---|---|
| Urban Population | 26% | 38% | 7% | 29% |
| Rural Population | 7% | 42% | 1% | 50% |
| Total Population | 12% | 41% | 2% | 46% |

Source: JICA Study Team, based on Census 2009 data (Ref. Sectoral Report (C), Sub-section 2.3.4)

The water provided by unregistered water vendors and water abstracted from streams, lakes, and ponds without proper treatment are categorised as an unimproved drinking water sources. Around 48% of the population get drinking water from the said unimproved drinking water sources. Also, around 41% of the population get water from springs, wells, and boreholes. On the other hand, unprotected wells and springs are also categorised as unimproved drinking water sources, but the utilisation ratio of unprotected these is unknown.

It is projected that the urban population will increase by 6.14 million while the rural population will decrease by 0.79 million in 2030, as shown in Section 3.2 of Main Report Part A. Hence, the total population will become 12.72 million in 2030, as shown below.

**Projected Population for LVSCA**

(Unit: million persons)

| Year | Urban population | Rural Population | Total |
|---|---|---|---|
| 2010 | 1.85 | 5.52 | 7.37 |
| 2030 | 7.99 | 4.73 | 12.72 |

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

Currently, the piped water supply covers 26% of the urban population of LVSCA, where the target coverage ratio for 2030 is 100%. Therefore, it is required to implement large-scale urban water supply system developments to cope with the rapid growth of urban population and achieve the target coverage ratio of 100%.

As for registered water service providers (WSPs) in LVSCA, eight urban WSPs, and one rural WSP carry out water supply service. The total water supply capacity is 89,438 $m^3$/day, while the total service population is 1,319,484, so that the average water supply amount per person is 68 L/p/day including non-revenue water (NRW). It is almost the same as the national average of urban water supply amount of 65 L/p/day including NRW (36 L/p/day excluding NRW), and it is almost same as the design standard for water supply amount for non-individual connection. WSPs in LVSCA lacks capacity for individual connection of consumers. High NRW ratios were recorded. Out of the eight urban WSPs, three WSPs have records of more than 50% of NRW. Current situations of the WSPs in LVSCA are shown in Table 4.2.1.

### 4.2.2 Development Strategy

LVSCA is divided into three areas: Kisumu, Kisii, and the surrounding area for urban water supply systems (UWSSs) which are planned considering the characteristics of the three areas as shown below.

**Characteristics of Three Areas (LVSCA)**

| Area | Characteristics |
|---|---|
| Kisumu and Surrounding Areas | Out of 24 urban centres in LVSCA, seven are in this area. It is estimated that the population will be around 40% of the total population (2030). There are many available water sources, such as surface water of rivers from the Mau Forest Complex, which is one of the Five Water Towers in Kenya, and also from Lake Victoria. |
| Kisii and Surrounding Areas | There are 12 urban centres in this area. It is estimated that the population will be around 30% of the total population (2030). There is no available water source from Lake Victoria and the Five Water Towers. Gucha River where Bunyunyu Dam exists is the only major water source in this area. The water source for this area may resort to depend on groundwater. |
| Other Areas | Located outside of the two first two mentioned areas. The area has low population density area and has six urban centres. There are some available surface water sources including Lake Victoria. Rural water supply system, however, depend on groundwater. |

Source: JICA Study Team

Based on the overall concept mentioned in Section 7.3.2 of Main Report Part A, UWSSs are planned for 25 urban centres (UCs) in LVSCA. As for six UCs in Kisumu and its surrounding areas, and seven UCs in Kisii and its surrounding areas, one water supply system is planned to cover all UCs. The remaining 12 UCs are planned to have independent water supply system.

The water supply capacity required for UWSSs in LNSCA is 785,000 $m^3$/day in 2030 against the current water supply capacity (including those under construction) is 120,000 $m^3$/day. This results to an additional capacity of 664,000 $m^3$/day will be developed by 2030, through the following projects:

a) Rehabilitation of existing UWSS

In order to achieve 20% NRW rate or less, water meters will be installed for all households and existing old pipes of UWSS for 21 UCs, which have 120,000 $m^3$/day of water supply capacity, will be replaced. In addition, the rehabilitation includes replacement and repair of mechanical and electrical equipment in water treatment plants and pumping stations.

b) Expansion of UWSS

Expansion of UWSS is planned for the 21 UCs to meet the water demand in 2030. The total expansion will provide an additional 570,000 $m^3$/day, which covers two cities that have no UWSS.

c) Construction of new UWSS

New UWSSs are planned to be constructed for four UCs, which have no existing UWSS. The new construction will provide an additional 94,000 $m^3$/day.

d) Incorporation of existing plans

According to data from WSBs, there are 27 plans of water supply development projects to cover 21 UCs and surrounding areas, which have 301,000 $m^3$/day of total water supply capacity in LVSCA. (Refer to Sectoral Report (C), Section 2.4) These plans are to be incorporated in NWMP 2030.

Based on the overall concept mentioned in Section 7.3.2 of the Main Report Part A, the rural water supply systems are planned to be developed by large-scale rural water supply system (LSRWSS) and small-scale rural water supply system (SSRWSS).

a) Development of LSRWSS

The LSRWSS is proposed mainly for areas with high population density or those having difficulties extracting groundwater for personal or communal uses. The LSRWSS will be developed for 2.67 million residents in 14 counties under LVSCA.

b) Development of SSRWSS

SSRWSS is proposed for 3.79 million residents in 1 county under LVSCA, and it includes the construction and improvement of boreholes, wells, and springs for personal and communal uses, which will be implemented by individuals or communities.

### 4.2.3 Proposed Water Supply Development Plan

Based on the development strategy mentioned above, the proposed UWSS is presented in Table 4.2.2, while the proposed LSRWSS and SSRWSS are in Tables 4.2.3 and 4.2.4, respectively. The proposed water supply development plan for LVSCA is outlined below.

**Proposed Water Supply Development Plan (LVSCA)**

| Type of Project | | Target Area | Target Capacity ($m^3$/day) | Target Population (million persons) |
|---|---|---|---|---|
| Urban Water Supply | Rehabilitation | 21 UCs | 120,000 | 6.26 |
| | Expansion | 21 UCs | 571,000 | |
| | New Construction | 4 UCs | 94,000 | |
| | Total | 25 UCs | 785,000 | |
| Rural Water Supply | LSRWSS | 14 Counties | 277,000 | 6.46 |
| | SSRWSS | 14 Counties | 208,000 | |
| | Total | 14 Counties | 485,000 | |

Source: JICA Study Team based on Tables 4.2.2 to 4.2.4

Through the abovementioned water supply development, the water supply situation of LVSCA in 2030 will be as follows:

**Water Supply Situation in 2030 (LVSCA)**

| Items | | Urban Water Supply | Large-scale Rural Water Supply | Small-scale Rural Water Supply | Total |
|---|---|---|---|---|---|
| Service Population (million) | 2010 | 0.88 | | 3.02 | 3.90 |
| | 2030 | 6.26 | 2.67 | 3.79 | 12.72 |
| Water Supply Capacity ($m^3$/day) | 2010 | 120,000 | 26,000 | 150,000 | 296,000 |
| | 2030 | 785,000 | 277,000 | 208,000 | 1,270,000 |
| Operating Body | | Registered WSPs | Registered WSPs | Individual, Community, etc. | -- |
| Target Towns/ Areas | | 25 UCs | 14 Counties | | -- |

Source: JICA Study Team (Figures for 2010 were referred to Sectoral Report (C), Section 2.3. Figures for 2030 were based on Tables 4.2.2 to 4.2.4.)

In order to ensure water sources required for the water supply systems mentioned above, it is proposed to construct nine new dams in LVSCA and one new dam in LVNCA, as the result of the water balance study. (Ref. Sectoral Report (G), Chapter 4.5)

## 4.3 Sanitation Development Plan

### 4.3.1 Current Situation of Sanitation Development

Based on the Census 2009 data, the current situation of access to sanitation facilities in LVSCA was estimated as shown below.

**Current Situation of Access to Sanitation Facilities (LVSCA)**

| Type | Sewerage System | Septic Tank, Pit Latrine, Cesspool (On-site Treatment Facilities) | Bush, etc (No Treatment) |
|---|---|---|---|
| Urban Population | 4% | 89% | 7% |
| Rural Population | 0% | 80% | 20% |
| Total Population | 1% | 82% | 17% |

Source: JICA Study Team, based on Census 2009 data (Ref. Sectoral Report (D), Sub-section 2.3.3.)

Sewerage system has been developed in the limited areas in LVSCA and current sewerage coverage ratio is only 1%. There are four small-scale wastewater treatment plants (WWTPs), of which total treatment capacity of about 20,531 $m^3$/day. Around 82% of the population use on-site sanitation facilities such as septic tanks. These on-site sanitation facilities include unimproved ones, and the ratio of unimproved facilities is unknown. Around 17% of the population does not have any treatment facilities, and resort to unsanitary waste disposal.

### 4.3.2 Development Strategy

Based on the overall planning concept and framework described in Section 7.4.2 of the Main Report Part A, sewerage system development is planned for 19 UC in LVSCA. The sewerage system development will be conducted through three types of projects as follows:

a) Rehabilitation of existing sewerage system

The rehabilitation includes repair and replacement of mechanical and electrical equipments of WWTPs and pumping stations, and replacement of damages sewer pipes in three UCs. The rehabilitation will be carried out for existing sewerage systems with the capacity of 22,000 $m^3$/day.

b) Expansion of sewerage system

In order to cover the demand in 2030, the capacities of existing sewerage systems of three UCs will be expanded. This type of project includes the expansion and construction of sewerage pipes, pumping stations, and WWTPs. The expansion will provide an additional capacity of 171,000 $m^3$/day.

c) Construction of New Sewerage System

There are no sewerage systems in 16 UCs. New sewerage systems will be constructed in the concerned UCs that will provide an additional capacity of 292,000 $m^3$/day to meet the demand in 2030.

d) Incorporation of existing plan

According to data from WSBs, there are seven plans of sewerage development projects to cover seven urban centres, which have 53,000 $m^3$/day of total treatment capacity in LVSCA. (Refer to Sectoral Report (D), Section 2.4) These plans are to be incorporated in NWMP 2030.

For those outside the sewerage service area, the improved on-site treatment facilities will be provided for the remaining 6.70 million residents in 2030. Currently, 6.09 million residents (or 82% of the entire population) are using the existing on-site treatment facilities, while unimproved ones will be improved with new housing. Development of on-site sanitation facilities is planned for 14 counties in LVSCA.

### 4.3.3 Proposed Sanitation Development Plan

The sewerage development plan is shown in Table 4.3.1, and the on-site treatment development plan is shown in Table 4.3.2. The proposed sanitation development plan for LVSCA is outlined below.

**Proposed Sanitation Development Plan (LVSCA)**

| Type of Project | | Target Area | Target Capacity ($m^3$/day) | Target Population (million persons) |
|---|---|---|---|---|
| Sewerage System (Off-site Treatment) | Rehabilitation | 3 UCs | 22,000 | 6.02 |
| | Expansion | 3 UCs | 171,000 | |
| | New Construction | 16 UCs | 292,000 | |
| | Total | 19 UCs | 484,000 | |
| On-site Treatment Facilities | | 11 Counties | -- | 6.70 |

Source: JICA Study Team based on Tables 4.3.1 and 4.3.2.

Out of the 7.99 million of the urban population in LVSCA, 75% (8.15 million) are expected to be covered by the sewerage system. The ratio of LVSCA is little lower than the national target of 80%, because there are a few large-scale UCs, which have priority for sewerage development. Through the abovementioned sanitation development plans, the sanitation situation of LVSCA in 2030 will be as follows:

**Sanitation Situation in 2030 (LVSCA)**

| Items | | Sewerage System | Septic Tank, etc (On-site Treatment Facilities) |
|---|---|---|---|
| Service Population (million) | 2010 | 0.07 | 6.04 |
| | 2030 | 6.02 | 6.70 |
| Required Treatment Capacity ($m^3$/day) | 2010 | 22,000 | ----- |
| | 2030 | 484,000 | ----- |
| Operating Body | | Registered WSPs | Individual, Community, etc. |
| Target Towns/ Areas | | 19 UCs | 14 Counties |

Source: JICA Study Team (Figures for 2010 above are referred to Sectoral Report (D), Section 2.3, and figures for 2030 above are based on Tables 4.3.1 and 4.3.2.)

## 4.4 Irrigation Development

### 4.4.1 Current Situation of Irrigation Development

The northern half of LVSCA has ample annual rainfall (1000-1600 mm) and has a wet climate, while the southern half has a semi-arid climate. The total cropping area in 2011 was 553,655 ha which are mostly under rainfed conditions but have lower productivity. The total existing irrigation area in LVSCA in 2010 was 13,218 ha, consisting of 1,800 ha (14%) of public irrigation schemes, 10,225 ha (77%) of smallholder irrigation schemes, and 1193 ha (9%) of private schemes. The share of irrigation area against cropping area is 2.4% only. Most of all existing irrigation systems need rehabilitation of deteriorated facilities due to insufficient maintenance.

### 4.4.2 Development Strategy

Following the overall concept and frameworks for irrigation development mentioned in Section 7.5 of the Main Report Part A, the strategy for irrigation development in LVSCA was set as follows:

a) In order to utilise available water resources efficiently for the maximisation of irrigation development, the water-saving irrigation methods should be introduced to improve water productivity of all irrigation areas;

b) In order to strengthen the agricultural sector in LVSCA, irrigation should be expanded in rainfed agricultural areas to increase agricultural productivity and production; and

c) Owing to the sufficient land and water resources available for irrigation in LVSCA, the priority to maximise the irrigation area should be given to both dam irrigation and weir irrigation, and then to small-scale dam and groundwater irrigation as far as water resources are available.

### 4.4.3 Proposed Irrigation Development Plan

As a result of the water balance study for each sub-basin in LVSCA, the maximum irrigation development areas under the application of water-saving irrigation methods were estimated as summarised below.

**Proposed Irrigation Areas in 2030 (LVSCA)**

(Unit: ha)

| Category | Existing Irrigation Area in 2010 | New Irrigation Area in 2030 | | | | | | Total Irrigation Area in 2030 |
|---|---|---|---|---|---|---|---|---|
| | | Surface Water Irrigation | | | Ground-water Irrigation (Borehole) | Water Harvesting Irrigation (Small Dam/ Water Pan) | Total New Irrigation Area | |
| | | Weir | Dam | Total | | | | |
| Large-scale | 1,800 | 1,800 | 73,772 | 75,572 | 0 | 0 | 75,572 | 77,372 |
| Small-scale | 10,225 | 14,477 | 0 | 14,477 | 3,434 | 4,590 | 22,501 | 32,726 |
| Private | 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 |

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

Against the provisional target of new irrigation development area of 186,978 ha (distributed to LVSCA for the national target of 1.2 million ha) mentioned in Section 7.5 of the Main Report Part A, the possible new irrigation development area comes to 113,206 ha (decrease of 73,772 ha) even with maximum water resources development presented in Section 4.6 due to limitation of available water resources.

As for the large-scale irrigation projects (more than 500 ha), seven projects proposed by the government authorities and three projects proposed in this study listed in Table 7.5.1 in Main Report Part A were taken up for the water balance study and eight projects were selected for implementation by 2030 as suitable projects to contribute to the maximisation of irrigation area in LVSCA as shown in Table 4.4.1 and their locations are shown in Figure 4.4.1. They are listed below.

a) Kano Plain Irrigation Project (15,000 ha, Magwagwa multipurpose dam);
b) Lower Kuja Irrigation Project (40,500 ha, Weir and Katieno multipurpose dam);
c) Ahero and West Kan Irrigation Project (1800 ha, Weir and pump);
d) Nandi Forest Dam Irrigation Project (7272 ha, Nandi Forest multipurpose dam);
e) Nyando Dam Irrigation Project (3000 ha, Nyando multipurpose dam);
f) Amala Dam Irrigation Project (5000 ha, Amala multipurpose dam); and
g) Ilooiterre Dam Irrigation Project (3000 ha, Ilooiterre multipurpose dam).

The irrigation water demands necessary for the abovementioned new irrigation projects were estimated at 1,107 MCM/year for surface irrigation area and 51 MCM/year for groundwater irrigation area as shown in Table 6.5.7 in the Main Report Part A.

## 4.5 Hydropower Development Plan

### 4.5.1 Current Situation of Hydropower Stations

(1) Existing Hydropower Station

There are three existing hydropower stations in the catchment area, namely Gogo Falls, Sondu/Miriu and Sangoro power stations.

The Gogo Falls Hydropower Station is located in the downstream reaches of the Gucha River. The station has an installed capacity of 2 MW. There is an expansion plan for Gogo Falls Hydropower Station, however, detailed features of the expansion have not yet been determined.

Sondu/Miriu and Sangoro power stations are located in the downstream reach of the Sondu River. Sondu/Miriu Hydropower Station has a run-of-river scheme with an installed capacity of 60 MW. Sangoro Hydropower Station uses the tailwater of Sondu/Miriu Hydropower Station, and also uses the remaining head between Sondu/Miriu Hydropower Station and the Sondu River to generate an additional 21 MW.

All the above power stations are of run-of-river type hydropower station without reservoirs. They retrieve water by weirs that cross the rivers and generate power. Therefore, power output decreases during the dry season when the river water level is low. These power stations do not have functions as to control flood or to supply water during the dry season.

Locations of existing hydropower stations are as shown in Figure 4.5.1

(2) Multipurpose Dam Development Project by MORDA

There is a proposed multipurpose dam project called Magwagwa Dam, which is located in the upstream of Sondu/Miriu Hydropower Station. The dam is designed for hydropower, irrigation, and water supply. According to the Investment Plan Report by the Ministry of Regional Development Authorities (MORDA) in July 2011, its hydropower component has an installed capacity of 115 MW. Average annual power generation from the Magwagwa Hydropower Station is estimated at about 570 GWh. Furthermore, as Magwagwa Dam regulates the flow of the Sondu River, it provides an additional 130 GWh to the annual power generation of Sondu/Miriu and Sangoro hydropower stations.

### 4.5.2 Development Strategy

Following the overall planning concept and framework as mentioned in Section 7.6 of the Main Report Part A, the following strategies will be applied for development:

a) Apply development plans based on the Least Cost Power Development Plan (LCPDP).
b) Apply hydropower components of multipurpose dam development schemes.

The above strategy will be applied to LVSCA as follows:

c) LCPDP projects: There are no plans proposed for LCPDP.
d) Multipurpose dam development schemes: Magwagwa Multipupose Dam has a hydropower component, which will be taken up as a proposed plan.

### 4.5.3 Proposed Hydropower Development Plan

Based on the development strategy as mentioned in Subsection 4.5.2, the following hydropower development plans will be taken up for NWMP 2030:

(1) Magwagwa Multipurpose Dam

As one of the proposed multipurpose dam projects by MORDA, Magwagwa Dam is considered as a candidate project for NWMP 2030. MORDA conducted preliminary design and investment plan, which were completed in July 2011. According to the investment plan, MORDA plans to construct the Magwagwa Dam in the middle reach of the Sondu River, which will have an installed capacity of 115 MW.

**Proposed Hydropower Development Schemes (LVSCA)**

| No. | Name of Scheme | Installed Capacity (MW) | Purpose | Source of Information |
|---|---|---|---|---|
| 1 | Magwagwa Multipurpose Dam | 115 | Water Supply, Irrigation, and Hydropower | Investment Plan Report, July 2011, MORDA |

Source: JICA Study Team based on information from MORDA and LBDA

Locations of hydropower development projects are as shown in Figure 4.5.2.

(2) Other Projects

KenGen has plans to expand Gogo Falls Dam from the current installed capacity of 2 MW to a maximum of 60 MW. Since a concrete plan for expansion has not yet been decided as of November 2012, this plan will not be taken up for NWMP 2030 at present. Furthermore, the National Irrigation Board (NIB) is also interested in the redevelopment of Gogo Falls Dam to expand the irrigation area downstream. For this, coordination between KenGen as power generator and NIB as irrigation developer is required. Once the detailed and agreed development plans are prepared, the scheme will be taken up as a candidate for NWMP 2030.

## 4.6 Water Resources Development Plan

### 4.6.1 Current Situation of Water Resources Development

LVSCA has a total catchment area of 31,734 $km^2$, and an annual average rainfall of 1280 mm. The main rivers in LVSCA are Nyando, Sondu, Kuja, and Amala rivers. The available water resources estimated in LVSCA for the year 2010 (present) are 4,773 MCM/year for surface water and 203 MCM/year for groundwater.

The present water demands in LVSCA were estimated to be 385 MCM/year based on the population of 7.37 million and irrigation area of 13,218 ha as presented in Chapter 3. The existing water resources structures and facilities, except for direct intake facilities from rivers, that satisfy the present water demands are listed below. The locations of dams are shown in Figure 4.6.1.

**Existing Water Resources Structures and Facilities (LVSCA)**

| Existing Structures/ Facilities | Name of Structures/ Facilities | Purposes | Notes |
|---|---|---|---|
| Dam | Gogo Falls Dam | Hydropower (2 MW) | - |
| Dam | Sondu/Miriu Dam | Hydropower (81 MW) | Storage volume of 1 MCM |
| Intra- or Inter-basin Water Transfer | - | - | - |
| Small Dam/Water Pan | Total No.= 544 | Domestic and livestock water supply | Total storage volume of 5.3 MCM, average volume per facility of 10,000 $m^3$ |
| Borehole | Total No.= 489 | Domestic water supply mainly | Total abstraction volume of 36 MCM/year |

Source: JICA Study Team based on NWMP (1992) and data from MWI, WRMA, NWCPC, and KenGen

The total storage volume of the existing water resources structures and facilities in LVSCA is approximately 6 MCM summing the volumes of dams and small dams/ water pans listed in the above table. Out of the 26 existing dams nationwide as described in Chapter 2 of the Secoral Report (G), two dams are found in LVSCA, which are for hydropower generation purposes. There is no dam being constructed at present. The Bunyunyu Dam (by NWCPC for domestic water supply and hydropower) and Magwagwa Dam (by MORDA for domestic and irrigation water supply, hydropower, and flood control) have completed their detailed designs. The dams being planned or designed in LVSCA are Itare Dam (domestic water supply) and Nyando Dam (domestic and irrigation water supply, hydropower, and flood control) by NWCPC.

There are 544 small dams and water pans, and their total storage volume is 5.3 MCM, which is 84% of the total storage volume in LVSCA. There are 489 boreholes in LVSCA, which is approximately 4% of the national total 12,444 boreholes (MWI). These boreholes supply around 22% of the domestic water demands in LVSCA.

The values of present water supply reliability in LVSCA were estimated by the water balance study to be 1/2 at the reference point of Ahero (1GD03) in Nyando River, 1/5 at Sondu (1JG05) in Sondu River, 1/2 at Rongo (1KB03) in Gucha River, 1/3 at Migori (1KC03) in Migori River, and 1/20 at Masai-Mara (1LA04) in Mara River under the condition of existing water resource structures/facilities mentioned above. The water supply reliability of 1/2, 1/3, 1/5 or 1/20 means that the present water demands are satisfied with the available water resources with existing water resources structures under drought condition with probability of once in 2, 3, 5 or 20 years.

### 4.6.2 Development Strategy

The water demands projected for the year 2030 as well as the estimated present water demands in LVSCA are explained in Chapter 3 and summarised as follows:

**Present and Future Water Demands (LVSCA)**

(Unit: MCM/year)

| Subsector | Present Water Demand (2010) | Future Water Demand (2030) |
|---|---|---|
| Domestic | 165 | 464 |
| Industrial | 10 | 41 |
| Irrigation | 155 | 1,158 |
| Livestock | 43 | 106 |
| Wildlife | 3 | 3 |
| Fisheries | 9 | 15 |
| Total | 385 | 1,787 |

Source: JICA Study Team (Ref. Main Report Part A, Chapter 6 and Table 6.10.1)

The water demand projections for 2030 show a great increase by about 4.6 times compared with the present demands due to considerable expected increase in population to 12.72 million and irrigation areas to 126,424 ha as mentioned in Chapter 6 of the Main Report Part A.

Judging from the estimated 2030 water deficits discussed in Section 3.4 (1), it is certain that the existing water resources structures and facilities will not be able to satisfy the great increase in water demand by 2030, therefore, new structures and facilities must be developed. As the estimated available surface water of 5,749 MCM/year in 2030 is larger than groundwater of 188 MCM/year in the catchment area, the development will focus on the surface waters.

Strategies for the water resources development in LVSCA were set as enumerated below, following the overall planning concept and framework as stated in Chapter 7 of the Main Report Part A, and based on the current situation of the catchment area and future water demand projections.

a) Since surface water is abundant all over the catchment area, the development plan focuses on the maximum abstraction of surface water.

b) The inter-basin water transfer facility from Itare and Londiani dams to RVCA is developed to supply domestic water to the Greater Nakuru where heavily concentrated domestic water demands are expected in 2030, however, both surface and groundwater resources are insufficient. The inter-basin water transfer plans from the Amala dam to RVCA and from the Nandi Forest dam in LVNCA to LVSCA are also taken into account for hydropower generation, irrigation and domestic water supply purposes. The volumes of water transferred from Itare, Londiani and Amala dams to RVCA are included in the water demands mentioned in Sub-section 4.6.2 of the Main Report Part D for RVCA. The volume of water transferred from Nandi Forest Dam to LVSCA is included in the water demands mentioned in the above table for LVSCA.

c) Dam development is essential and will be promoted to satisfy the increased future large water demands such as domestic, industrial and irrigation water demands in the entire catchment area. Candidate dam development projects for maximising surface water abstraction include i) dams proposed by the NWMP (1992), and ii) dams being designed and planned by the government including the Kenya Vision 2030 flagship projects.

d) Small dams and/or water pans will be developed in small rivers over the catchment area for small and scattered demands including rural domestic, livestock, small scale irrigation, wildlife and inland fisheries water supply purposes at locations where suitable dam sites are not expected for large dams but the surface water is available.

e) The groundwater is to be exploited for domestic, industrial and irrigation uses where the surface water is not available or insufficient.

### 4.6.3 Proposed Water Resources Development Plan

(1) Water Balance Study

The water balance study was carried out for the year 2030 between the available water resources and water demand projections in order to assess the magnitudes of water shortage and to quantify the water resources volumes to be stored or transferred. Estimated figures of the available 2030 water resources consisting of the surface water and groundwater cover the period of 20 years from 2021 to 2040, and the water demand projections are for the year 2030. The available 2030 water resources are shown by sub-basin in Table 4.6.1 in terms of monthly mean surface water and annual mean groundwater. The 2030 water demands are shown by water use sub-sectors and by sub-basin in Table 4.6.2.

The water balance study followed the policies of the water allocation as stated in Section 7.2 of the Main Report Part A. The summary of which are tabulated 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 surface water balance study for 2030 was conducted on the monthly basis by dividing the catchment area into sub-basins as shown in Figure 4.6.2 and by applying the surface water resources and demands to a computation model developed for LVSCA as shown in Figure 4.6.3. Prior to the surface water balance study, the amount of water demand to be supplied by groundwater was subtracted from the total water demand as explained in Section 4.3 of the Sectoral Report (G). Water demands for livestock, wildlife and inland fisheries to be supplied by surface water were excluded from the surface water demand applied for the balance study. It is because these demands are small in amount representing about 2% of the surface water resources nationwide, and are distributed widely apart from rivers. The livestock, wildlife, and fishery demands are to be supplied by surface water with small dams and water pans.

Conditions of the surface water balance study are explained in Section 4.3 of the Sectoral Report (G) and summarised that i) the model consists of 32 sub-basins, water demand points, existing water resource infrastructures, and candidates for future development such as dams and water transfer facilities; ii) monthly mean values of the naturalised water resources and demands are applied; iii) the amount of the reserve is determined as 95% value of the naturalised present daily flow duration curve in Figure 4.6.4 with the probability of once in 10 years as shown in Table 4.6.3; and iv) return flow rates of 25%, 5%, and 100% for urban domestic water supply, paddy irrigation, and hydropower generation are applied.

Although most dam candidate sites studied by the government or proposed by the NWMP (1992) were incorporated in the water balance study, some of the dams were compared and selected as follows:

a) Nyando Dam and Awasi Dam: Nyando Dam site (catchment area of 1286 $km^2$) and Awasi Dam site (catchment area of 1509 $km^2$) are closely located along the Nyando River. Nyando Dam was included in the water balance study, since Awasi Dam was not proposed in the NWMP (1992) due to its less storage efficiency. Moreover, government studies on Nyando Dam are being conducted at present.

b) Katieno Dam and Namba Kodero Dam: Katieno Dam site (catchment area of 3002 $km^2$) along the Kuja River and Namba Kodero Dam site (catchment area of 2769 $km^2$) along the Migori River are closely located. Katieno Dam was included in the water balance study since it has a larger storage efficiency compared with Namba Kodero Dam. Moreover, some government studies on Katieno Dam are being conducted at present.

Lists of the dams studied by the government or proposed by NWMP (1992) are given in Table 4.6.4. Lists of the water transfer candidates are shown in Table 4.6.5.

(2) Proposed Water Resources Development Plan

Based on the results of the water balance study for 2030 as described in the preceding clause (1), the required new water resources structures and facilities in LVSCA are as follows:

1) Dams

Proposed storage volumes of the dams for domestic, industrial and irrigation uses as tabulated below were derived from the water balance study as the volumes from which water would be supplied to the deficits caused by the respective water demands.

**Proposed Dams (LVSCA)**

(Unit: MCM)

| Name of Dams | Storage Volume for Domestic/ Industrial | Storage Volume for Irrigation | Storage Volume for Hydropower | Flood Control Space | Total Storage Volume | Remarks |
|---|---|---|---|---|---|---|
| Londiani Dam | 25.0 | 0.0 | 0.0 | 0.0 | 25.0 | Flagship Project, Pre-F/S done (NWCPC) |
| Nyando (Koru) Dam | 14.0 | 19.0 | 0.0 | 53.6 | 86.6 * | Flagship Project, Preliminary design ongoing (NWCPC) |
| Kibos Dam | 26.0 | 0.0 | 0.0 | 0.0 | 26.0 | |
| Itare Dam | 20.0 | 0.0 | 0.0 | 0.0 | 20.0 | Flagship Project |
| Magwagwa Dam | 3.0 | (442.0) | 442.0 | 0.0 | 445.0 * | D/D completed (MORDA) |
| Bunyunyu Dam | 6.3 | 0.0 | 0.0 | 0.0 | 6.3 * | Flagship Project, Final design completed (NWCPC) |
| Katieno Dam | 0.0 | 201.0 | 0.0 | 0.0 | 201.0 | Pre-F/S done (NIB) |
| Ilooiterre Dam | 4.0 | 9.6 | 0.0 | 0.0 | 13.6 * | Pre-F/S done (ENSDA) |
| Sand River (Naikara) Dam | 1.0 | 0.0 | 0.0 | 0.0 | 1.0 | |
| Amala Dam | 1.0 | 174.0 | 0.0 | 0.0 | 175.0 | |
| Total | 100.3 | 403.6 | 442.0 | 53.6 | 999.5 | |

Note : * Total storage volumes planned or designed by the government.
D/D=Detailed design, Pre-F/S=Prefeasibility study
Source: JICA Study Team, based on information from relevant government agencies

The development plan is formulated for domestic and industrial water supply to ensure the supply for 10-year probable drought and irrigation water supply for 5-year probable drought as stated in Section 7.1 of the Main Report Part A. The storage volumes determined are the volume of the second largest estimated in the water balance study for 20 years for domestic and industrial use, and that of the fourth largest for irrigation use.

The respective total storage volumes of Nyando, Magwagwa, Bunyunyu and Ilooiterre dams followed the designs which are on-going or completed or pre-feasibility study as shown in the above table.

The storage volume of hydropower use for Magwagwa Dam was estimated by subtracting the volume of estimated domestic/industrial use from the total storage volume proposed by MORDA. Water for irrigation use will be supplied after hydropower generation.

The flood control space of Nyando Dam was estimated by subtracting the volumes of estimated domestic, industrial and irrigation uses from the effective storage volume proposed by NWCPC, as a space in which floods can be stored.

Table 4.6.6 presents details of the proposed dams, and Figure 4.6.1 shows the location of the proposed dams.

2) Water Transfers

The proposed amount of inter-basin water transfer from Itare and Londiani dams to Nakuru in RVCA as mentioned below was derived from the water balance study as the amount to meet domestic water demands in Nakuru. The proposed amount of inter-basin water transfer from Amala Dam to Ewaso Ng'iro South River followed the amount of Amala Transfer studied by ENSDA. The amount of inter-basin water transfer from Nandi Forest Dam to LVSCA followed designs of MORDA.

**Proposed Water Transfers (LVSCA)**

(Unit: MCM/year)

| Structures | Amount for Domestic | Amount for Hydropower/ Irrigation | Total Water Transfer Amount | Remarks |
|---|---|---|---|---|
| Inter-basin Water Transfer from Itare and Londiani Dams to Nakuru, RVCA | 41 | 0 | 41 | |
| Inter-basin Water Transfer from Amala Dam to Ewaso Ng'iro South River | 0 | 82 | 82 | (ENSDA) |
| Inter-basin Water Transfer from Nandi Forest Dam to LVSCA | 16 | 173 | 189 | D/D completed, (MORDA) |

Source: JICA Study Team, based on information from relevant government agencies

Table 4.6.6 presents details of the proposed water transfers, and Figure 4.6.1 shows the location of the proposed water transfers.

3) Small Dams and Water Pans

The proposed storage volumes of small dams/water pans for domestic use were estimated based on water deficits calculated after the supply of available water from dams and boreholes. The storage volumes for irrigation use were estimated considering the conditions of the irrigation subsector.

The proposed storage volumes of small dams/water pans for livestock, wildlife and fisheries are volumes of their water demands for 2030.

**Proposed Small Dams and Water Pans (LVSCA)**

(Unit: MCM)

| Structures | Volume for Domestic | Volume for Irrigation | Volume for Livestock | Volume for Wildlife/ Fisheries | Total Storage Volume | Remarks |
|---|---|---|---|---|---|---|
| Small Dam/ Water Pan | 33 | 37 | 106 | 18 | 194 | Total No. of small dams/ Water pans = 3,880 |

Note : Excluding the 5 MCM storage volume of the existing small dams and water pans.

Source: JICA Study Team

The total number of the small dams / water pans of 3,880 was estimated by applying the volume per dam/ pan of 50,000 $m^3$ as the minimum capacity following the volume applied in NWMP (1992) and assumed based on the existing volumes.

4) Boreholes

The proposed groundwater abstraction volumes of boreholes for domestic and industrial uses were estimated by applying assumed percentages to the total water demands. The percentages of 5%, 50%, 100% and 50% were assumed for urban domestic, large rural domestic, small rural domestic and industrial water supply respectively as explained in Sub-section 4.3.1 (1) of the Sectoral Report (G). In the case that some water deficits were calculated in the surface water balance study and only groundwater was available, the deficits were added to the groundwater abstraction volumes estimated above.

The proposed groundwater abstraction volume of boreholes for irrigation use was estimated considering the conditions of the irrigation subsector mentioned in Section 7.5 of the Main Report Part A. The estimated volumes are as follows:

**Proposed Boreholes (LVSCA)**

(Unit: MCM/year)

| Facilities | Volume for Domestic/ Industrial | Volume for Irrigation | Total Abstraction Volume | Remarks |
|---|---|---|---|---|
| Borehole | 74 | 51 | 125 | Total No. of boreholes = 1,250 |

Note : Excluding the 36 MCM/year abstraction volume of existing boreholes.

Source: JICA Study Team

The total number of the boreholes of 1,250 was estimated by applying the capacity per borehole of 100,000 $m^3$/year assumed based on the existing data.

(3) Evaluation of Proposed Water Resources Development Plan

Results of the water balance between water demand and supply for 2030 in LVSCA are summarised in Table 4.6.7 showing 2030 water demands, water supply from river water and new water resources structures such as dams, water transfers, small dams/water pans and groundwater (boreholes), and water balance between demand and supply. This table proves that 2030 water demands will be satisfied by the river water and new water resources structures under the target water supply reliabilities of 1/10 for domestic and industrial uses and 1/5 for irrigation use.

The water supply reliability for 2030 at the reference points proposed for water resources management in LVSCA is summarised below as well as that for 2010:

**Water Supply Reliability at Reference Point (LVSCA)**

| Reference Point | Present (2010) Water Supply Reliability | Future (2030) Water Supply Reliability |
|---|---|---|
| Nyando River (1GD03), Ahero | 1/2 | 1/5 |
| Sondu River (1JG05), Sondu | 1/5 | 1/20 |
| Gucha River (1KB03), Rongo | 1/2 | 1/10 |
| Migori River (1KC03), Migori | 1/3 | 1/5 |
| Mara River (1LA04), Masai-Mara | 1/20 | 1/10 |

Source: JICA Study Team (Ref. Sectral Report (G), Sub-section 4.4.3 (3) and Table 4.4.4)

The future water supply reliability at the reference points of Ahero in Nyando River and Migori in Migori River is estimated at 1/5, since water demand downstream of the reference points is irrigation use mainly. The future water supply reliability at the reference points of Rongo in Gucha River and Masai-Mara in Mara River is estimated at 1/10, since water demand downstream of the reference points is domestic use only. The estimated future water supply reliability at the reference point of Sondu in Sondu River is 1/20 due to constant water release from Magwagwa Dam for hydropower generation. The future reliability will decrease at Masai-Mara compared with the present one due to large increase of the water demands, although the estimated future reliability conforms to the target value mentioned in Section 7.1 of the Main Report Part A. Appropriate water resources development and management will be required to maintain the target reliability.

The naturalised surface water resources, reserves, water demands, yields of the water resources development structures, and water supply reliabilities estimated at the reference points are tabulated in Table 4.6.8.

Figure 4.6.5 shows estimated river flow for 2010 and 2030 at the reference points in LVSCA under 2010 and 2030 surface water resources, demands and structures conditions.

## 4.7 Water Resources Management Plan

### 4.7.1 Current Situation of Water Resources Management

LVSCA has an annual basin mean rainfall of 1,277 mm, which is the second highest among six catchment areas of WRMA, and its available water resource is abundant. The catchment area includes major cities such as Kisumu, Kisii, and Kericho. LVSCA is one of the most populated areas in Kenya with its population density of 232 persons/km$^2$. High water demands are expected in the future that will be catered by domestic and industrial water supply as well as irrigation water uses.

There are four major rivers in LVSCA, namely, Nyando, Sondu, Gucha-Migori, and Mara. The Nyando, Sondu, and Gucha-Migori rivers flow into Lake Victoria, while the Mara River is an international river that flows across the national border into Tanzania. WRMA has its Lake Victoria South Regional Office in Kisumu. Under the regional office, there are three subregional offices of Kisumu that cover the northern part (northern shore of the Lake Victoria and Nyando River); Kisii that covers south-western part (southern shore of the Lake Victoria and Kuja River); and Kericho that covers south-eastern part (Sondu and Mara Rivers) of the catchment. Figure 4.7.1 shows the management unit boundary and subregional office management boundary.

The following table shows the current monitoring targets of WRMA, numbers of operational stations and their achievement ratio for surface water and groundwater, water quality, and rainfall. Surface water quality and groundwater monitoring stations are not well maintained.

**Current Monitoring Situations of Water Resources (LVSCA)**

(Unit: nos)

| Item | Surface Water Level | Groundwater Level | Surface Water Quality | Groundwater Quality | Rainfall |
|---|---|---|---|---|---|
| Target | 39 | 30 | 61 | 17 | 65 |
| Operational | 34 | 15 | 47 | 13 | 53 |
| Achievement (%) | 87 | 50 | 77 | 76 | 82 |

Source: WRMA Performance Report 1 (July 2010)

The current situations of water permit issuance and management by WRMA are as shown below. The rate of valid permits against issued permits is relatively high.

**Current Situations of Water Permits Issuance (LVSCA)**

(Unit: nos)

| Item | Application | Authorised | Issued Permits | Valid Permits | Rate of Validity (%) |
|---|---|---|---|---|---|
| Surface Water | 1,790 | 1,303 | 283 | 227 | 80 |
| Groundwater | 1,361 | 1,326 | 35 | 34 | 97 |
| Total | 3,151 | 2,629 | 318 | 261 | 82 |

Source: WRMA Performance Report 1 (July 2010)

It is important to conduct watershed conservation on Mau Forest Complex, which is a major water source of the major rivers in LVSCA. Deforestation and forest degradation are rampant in these water source forests such as the Mau Forest Complex and private forests in the middle to upper reaches of the Migori River.

According to the results of satellite image analysis in this study, the forest area in LVSCA in 2010 was about 159,000 ha, which corresponded to 5.0% of forest cover in the catchment area. The deforested areas during the last two decades were about 107,000 ha, which meant the decrease of about 40% of the forest areas in 20 years since 1990.

According to interviews with stakeholders of watershed conservation including WRMA and KFS in LVSCA, there were deteriorations on small water sources such as 20 springs and 58 wetlands.

WRMA pointed out that the deforestation and forest degradation caused soil erosion that affected the inflow into rivers, which was one of the causes of flood. There were other causes of soil erosion and inflow into rivers such as sheet erosion from cultivated areas. As detailed information on soil erosion areas such as location, magnitude, water use, water quality, vegetation, and method of management are unknown, further study is required.

### 4.7.2 Management Strategy

Based on the overall planning concept and framework as mentioned in Section 7.8 of the Main Report Part A, water resources management strategy for LVSCA is set for major components of i) monitoring, ii) evaluation, iii) water permit issuance and control, and iv) watershed conservation, as follows:

(1) Monitoring

Monitoring strategies are described for five monitoring items, which are i) surface water level, ii) surface water quality, iii) groundwater level, iv) groundwater quality, and v) rainfall.

1) Surface Water Level

The Nyando, Sondu, Gucha-Migori and Mara rivers were selected as representative rivers for capturing runoff characteristics of the basin. The Nyando, Sondu and Gucha-Migori rivers drain into Lake Victoria, while the Mara River flows across the border to Tanzania (refer to Figure 4.7.1). Surface water level monitoring stations were reviewed to determine the major reference points of these four rivers.

The surface water level of Lake Victoria, being a major lake in the catchment, should be monitored. There are no major springs to be monitored in LVSCA.

2) Surface Water Quality

Surface water quality monitoring points were also selected from the four representative rivers. For these four rivers, selected monitoring points should be located downstream of pollution sources such as major cities and irrigation schemes. Such points should be monitored monthly.

In addition, other surface water level monitoring points are selected for water quality monitoring on a quarterly basis. Such monitoring data is required as reference water quality for the evaluation of water permit application in the relevant basin.

3) Groundwater Level

Groundwater monitoring points were set at locations where significant groundwater uses are expected in the future. Such points are in urban centres which have both water supply and sanitation plans. In the selected monitoring points, groundwater levels are monitored monthly with dedicated boreholes. It is important to monitor and confirm that the groundwater levels are recoverable in an annual cycle for sustainable use.

4) Groundwater Quality

Groundwater quality is monitored at the same points of groundwater level monitoring.

5) Rainfall

The rainfall station density should be considered by climatic regions for arid, semi-arid, or other areas. As most of LVSCA belongs to humid areas, a criterion of one station in 500 $km^2$

to 1,000 $km^2$ is applied for the selection of rainfall monitoring stations. There are areas that belong to semi-arid areas in the south-eastern part of LVSCA, where the criterion of one station in 3,000 $km^2$ to 5,000 $km^2$ was applied.

(2) Evaluation

1) Water Resources Quantity Evaluation

The water resources quantity evaluation is conducted annually based on i) monitoring data for surface water, groundwater, and rainfall, and ii) records of water permit issuance. Abstraction survey data will be used, as needed, to grasp the actual water use status. For surface water resources evaluation, the Nyando, Sondu, Gucha-Migori and Mara river should be focused as these are the representative rivers in LVSCA.

2) Water Resources Quality Evaluation

The water resources quality evaluation is also conducted annually based on monitoring data for surface water and groundwater quality.

(3) Water Permit Issuance and Control

Prior to future impeding water demand in the basin, water permits should be duly controlled and issued based on the actual status of water use. For this, the latest version of issued permits should be controlled. In addition, water allocation guidelines should be revised considering the future demand and water resources development plans. To conduct these activities, the enforcement of water rights officers should be considered by reflecting the current situation of staffing.

(4) Watershed Conservation

All three major items on a) recovery of forest areas; b) conservation of small water sources; and c) control of soil erosion should be considered in LVSCA.

1) Recovery of Forest Areas

Forest recovery will be implemented through reforestation focusing on the Five Water Towers of Kenya, such as the Mau Forest Complex.

2) Conservation of Small Water Sources

Conservation of small water sources in the catchment area will be considered.

3) Control of Soil Outflow Caused by Deforestation

Preventive measures for soil erosion caused by deforestation in the catchment area will be considered.

### 4.7.3 Proposed Water Resources Management Plan

Based on the management strategy described in Subsection 4.7.2, the water resources management plan in LVSCA will be as follows:

(1) Monitoring

Monitoring plans are described for five monitoring items, which are i) surface water level, ii) surface water quality, iii) groundwater level, iv) groundwater quality, and v) rainfall. Locations of proposed monitoring stations are as shown in Figure 4.7.2.

1) Surface Water Level

Surface water level is observed twice a day by an honorarium gauge reader. 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. There are five monitoring points selected as representative points for the Nyando River, five for the Sondu River, four for the Gucha-Migori River, and three for the Mara River. In addition, there are five monitoring points along small rivers located in the northern and southern shores of the Winum Gulf, and one monitoring point for recording the water level of Lake Victoria. In total, 23 monitoring points were selected for daily basis monitoring. For the major four rivers, the following reference points were selected as follows:

a) 1GD03 is located in the lower reaches of the Nyando River. Monitoring started in 1967.
b) 1JG05 is located in the lower reaches of the Sondu River. Monitoring started in 1946.
c) 1KB03 is located in the middle reaches of the Gucha River. Monitoring started in 1965.
d) 1KC03 is located in the middle reaches of the Migori River. Monitoring started in 1951.
e) 1LA04 is located in the middle reaches of the Mara River. Monitoring started in 1970.

All the abovementioned reference points were set to check the flow regime of the river after satisfying water demand in the upper reaches, and to confirm the available discharge to satisfy the downstream demands. For that purpose, based on the management strategy described in Subsection 4.7.2, normal discharge values are set at the above five reference points as shown below. These normal discharge values are used for low water management.

**Normal Discharge at Reference Point (LVSCA)**

(Unit: $m^3$/sec)

| Reference Point | Normal Discharge (Reserve + Water Demand for the Downstream of Reference Point) | |
|---|---|---|
| | 2030 | 2030 |
| Nyando River (1GD03) | 2.0 (=1.6+0.4) | 6.1 (=1.6+4.5) |
| Sondu River (1JG05) | 10.6 (=10.4+0.2) | 15.8 (=10.4+5.4) |
| Gucha River (1KB03) | 1.3 (=0.4+0.9) | 1.4 (=0.4+1.0) |
| Migori River (1KC03) | 1.9 (=1.5+0.4) | 3.8 (=1.5+2.3) |
| Mara River（1LA04） | 4.4 (=4.3+0.1) | 4.4 (=4.3+0.1) |

Source: JICA Study Team (Ref. Sectral Report (G), Sub-section 4.4.3 (3) and Table 4.4.4)

The above normal discharges are to be reviewed and revised as necessary in the "Water Resources Quantity Evaluation" based on monitoring, which is to be mentioned in the following clause. Such review and revision works are to be made based on issued water permits (water demand) and reserve of that year. In case the observed discharge at a reference point is lower than the normal discharge, it is probable that there would be over-abstraction of water in the upstream or decreased reserve caused by an extreme drought. In such a case it is necessary to identify the reason and take measures such as increase of the level of oversight for water abstraction or drought conciliation.

2) Surface Water Quality

Stations with monthly basis monitoring

Based on the management strategy, the five reference points monitored the water quality on a monthly basis, as discussed below. This monitoring is for watching and detecting possible pollutant sources that may affect the water usage in the relevant rivers.

a) 1GD03 (downstream area of the Nyando River near Ahero Town): To monitor the impacts on river water quality caused by urban effluent from major towns of Londiani, Kipkelion and Mohoroni, as well as effluent from irrigation.
b) 1JG05 (downstream area of the Sondu River near Sondu Town): To monitor the impacts on river water quality caused by urban effluent from major towns of Kericho and Sotik, and effluent from irrigation schemes.
c) 1KB03 (in the middle reaches of the Gucha River): To monitor the impacts on river water caused by urban effluent from major towns of Kisii and Ogembo, as well as effluent from irrigation schemes.
d) 1KC03 (in the downstream reaches of the Migori River): To monitor the impacts on river water caused by urban effluent from Kehancha and Migori towns.
e) 1LA04 (in the middle reaches of the Mara River near the gate to Masai Mara National Reserve): To monitor the impacts on river water caused by urban effluent from Bomet Town.

Stations with quarterly basis monitoring

Apart from the above five monitoring stations, water quality will also be monitored on a quarterly basis (January, April, July and October in every year) by 18 other surface water monitoring stations . Such data are being used as reference when WRMA issues water permits. The 18 monitoring stations are:

1GC04, 1JF08, 1LA03, 1GB06A, 1GD07, 1GG01, 1HA14, 1HB04, 1HB05, 1HD03, 1HD05, 1HE01, 1JA02, 1JD03, 1JG04, 1KA09, 1KB05 and 1LB02

Locations of the abovementioned monitoring points are shown in Figure 4.7.2.

3) Groundwater Level

Based on the management strategy, 19 points were selected for groundwater level monitoring through dedicated boreholes for monthly basis monitoring. These points are located near urban centres where there are both water supply and sanitation plans with expected high growth of groundwater demand in the future. The 19 points are in the towns of:

Kisumu, Ahero, Awasi, Mohoroni, Kipkelion, Londiani, Kericho, Homa Bay, Oyugis, Nyamira, Suneka, Kisii, Rongo, Koroka, Bomet, Awendo, Migori, Kehancha and Kendu Bay

Locations of above points are shown also in Figure 4.7.2.

4) Groundwater Quality

Groundwater quality is monitored at the same locations where groundwater level monitoring stations are located. As groundwater quality does not change so frequently compared with surface water, monitoring is conducted twice a year (once in the rainy season and once in the dry season).

5) Rainfall

Most of the areas in LVSCA belong to regions experiencing heavier rainfall. As was described in the overall concept, the distribution of rainfall monitoring stations was reviewed with criteria of one location in 500 $km^2$ to 1,000 $km^2$. For the areas that belong to semi-arid areas in the southeastern part of LVSCA, review was made with a criterion of one station in 3,000 $km^2$ to 5,000 $km^2$. As a result of the review, 50 rainfall monitoring stations were selected for daily basis monitoring.

(2) Evaluation

1) Water Resources Quantity Evaluation

Based on the management strategy, water resources quantity evaluation is conducted annually based on i) monitoring data for surface water, groundwater, and rainfall and ii) water permit issuance data. For this, a water resources evaluation team was formed consisting of: i) one chief hydrologist from Kisumu Regional Office and ii) one assistant hydrologist each for subregional office of Kisumu, Kericho, and Kisii. Water resources evaluation works are done for the whole LVSCA on both surface and groundwater.

2) Water Resources Quality Evaluation

Based on the management strategy, water resources quality evaluation is also conducted annually based on monitoring data for surface water and groundwater quality. For this, a chief water quality expert is assigned in the water quality test laboratory in Kisumu.

(3) Water Permit Issuance and Control

Based on the management strategy, the following activities are proposed:

a) Control of the latest version of issued water permits
   - Periodical update of water permit database
   - Establishment and enhancement of notification system for expired permits

b) Revision of guidelines for water allocation

- Formulation of water allocation plans considering future water demand

c) Increase of the number of water right officers as shown below for smooth implementation of water permit issuance and control.

**Number of Required Water Right Officers (LVSCA)**

| Offices | Number of Water Right Officers | | |
|---|---|---|---|
| | Current | Required | Future |
| Kisumu RO | 0 | +1 | 1 |
| Kisumu SRO | 1 | +1 | 2 |
| Kericho SRO | 1 | +1 | 2 |
| Kisii SRO | 2 | No change | 2 |
| Total | 4 | +3 | 7 |

Note : RO=Regional Office, SRO=Subregional Office
Source: JICA Study Team, based on interview with WRMA Regional Office

(4) Watershed Conservation

Based on the management strategy, the following activities are proposed for watershed conservation.

1) Recovery of Forest Areas

As for forest recovery for watershed conservation, about 410,000 ha of forestation is proposed in LVSCA to achieve the target of Kenya Vision 2030. Current situations of the forest areas in LVSCA and potential areas for forestation are as shown in Figure 4.7.3.

The following steps were applied in preparing Figure 4.7.3.

a) Identify present forest areas and deforested areas (in this master plan, the satellite image analysis was used), and overlay the gazette forest areas,

b) Identify the important forest areas including deforested areas as water source forests;

c) Delineate the potential forestation areas on those located in step b), and formulate the area with consideration of significant forest area; and

d) Connect the isolated small gazetted forest areas by corridor and delineate the potential forestation area with the combination of these two areas.

Of the target forests, the gazetted forest is supposed to be recovered by the Kenya Forest Service (KFS).

2) Conservation of Small Water Sources

As for conservation of small water sources, it is proposed to carry out a survey on small water sources, which includes location, scale, water use, water quality, vegetation condition, management method, and major issues.

3) Control of Soil Erosion

As for control of soil erosion, it is proposed to carry out a survey on damaged areas where soil erosion occurred in the catchment area. The survey should investigate location, scale of current situation, and required countermeasures.

### 4.8 Flood and Drought Disaster Management Plan

#### 4.8.1 Current Situation of Flood Disaster Management

(1) Flood Situation

LVSCA has suffered from severe flood damages over the years. The 1997/1998 flood was the consequence of El Nino-related long and intensive rainfall during October and November. Almost the entire Kano Plain in the Nyando River basin was flooded and agricultural crops were completely washed out. The floods also caused extensive damages to 240 river gauging facilities due to severe bank erosion. The dikes were overtopped and breached at several places. In November 2006, due to the bank overflow and dike breach of the Nyando River, the areas in Wangaya, Nyangoma, and Ombei towns were submerged in flood waters. In October to November 2008, heavy rains in the Nyanza Region damaged the bank of the Nyando River causing massive flooding in the area. The most recent urban flood was in Kisumu City, which occurred in September 2009.

In the Sondu and Kuja river mouth areas, which were the target areas of NWMP (1992), it was confirmed that an average inundation duration in the time of normal flood occurred is around five days annually, according to the damage survey.

(2) Flood Disaster Management

The Nyando River basin had the most severe damage in LVSCA. Because of this, an integrated flood management plan for the Nyando River basin was formulated in 2009 with the technical and financial assistance of JICA. Following this, the Programme for Community-based Flood Disaster Management to Adapt to Climate Change in the Nyando River Basin was carried out from September 2009 to August 2011, and the said management system has been developed in the Nyando River basin. The programme included small-scale structural and non-structural measures. The communities have completed their preparation on mitigating flood damages on their own initiatives by constructing evacuation areas and formulating evacuation plans. However, in the current system, while the occurrence of flood is identified based on visual judgement of river water level, the issue is that enough lead time for evacuation activities has not been secured because flood propagation time in LVSCA is relatively short.

WRMA’s flood management is implemented only in the Nyando River basin. No particular flood management has been done in other flood prone areas such as the Sondu and Kuja river mouth areas.

Dikes have been constructed with a total length of 15.1 km on both banks along the Nyando River. These infrastructures have contributed to flood control against normal floods, however, it was recorded that these dikes were breached and overtopped by the massive flood in 2006. At the time, it is even said that inadequate flood fighting activities have resulted in the expansion of inundated areas. In recent years, river improvement works of 4.5 km and dredging works of 9.3 km were implemented along the Nyando River by NWCPC. Also, revetment works of 0.6 km were done along the Sondu River. NWCPC’s activities in terms of river improvement are in progress mainly in the Nyando River as of November 2012. The improvement works in the Nyando River include new dike construction, and river training and desiltation. The study on urban drainage in Kisumu City is ongoing as of June 2011.

### 4.8.2 Current Situation of Drought Disaster Management

(1) Drought Situation

Although drought damages have not been reported in LVSCA, the future water balance is expected to have problems because irrigation and domestic water demands will largely increase, according to the water balance study for NWMP 2030.

(2) Drought Management

There are two existing dams for hydropower purposes, namely Gogo Falls and Sondu/Miriu dams. However, drought disaster management including water use restriction of the reservoirs has not been implemented.

### 4.8.3 Flood Disaster Management Strategy

As explained in the concept and framework e) mentioned in Section 7.9 of Main Report Part A, the proposed examination areas in LVSCA are the Kano Plain, Sondu River mouth, Kuja River mouth and Kisumu. Kano Plain lies almost in the lower part of the Nyando River basin.

Out of the abovementioned areas, the Kano Plain/Nyando River basin has been prepared with an integrated flood management plan that was formulated in 2009 through the JICA project mentioned in Subsection 2.4.2 (2) of Sectoral Report (J). The study reported that the number of affected people in the case of 20 years probable flood is estimated at 250,000, as of 2006. Judging from the frequency of flood occurrence and the number of affected people in the area, this area shall be protected by flood control structural measures including multipurpose dam as proposed in the plan. In addition, to minimise inundation area by avoiding dike breaching or overtopping, a flood fighting plan shall be prepared for the existing dikes. Meanwhile, the existing community-based disaster management (CBDM) system shall be improved in order to mitigate persons affected by extraordinary floods. In the existing system, forecasting and confirmation of flood occurrence is judged by visual check of river water level. This method does not provide enough lead time for evacuation because propagation time of flood is relatively short due to the topography of the area. To secure a longer lead time, telemetric flood forecasting and warning systems should be developed in the area.

In the Sondu and Kuja river mouth areas, flood control measures will not be required because these are sparsely-populated areas, according to the satellite images. Therefore, the basic strategy for Sondu and Kuja is to develop CBDM systems by installing a simplified flood forecasting system based on water level observations in the upper reaches of the Sondu and Kuja rivers. This strategy for Kuja River mouth is also in line with the policy of JICA Technical Assistance Project on Capacity Development for Effective Flood Management in Flood Prone Areas, which is being implemented from 2011 to 2014.

The floods that occurred in Kisumu are not caused by the rivers, but rather due to urban drainage issues. In consideration of the high population density in Kisumu, the drainage system should be improved.

The following are basic policies to formulate the flood disaster management plan in LVSCA:

a) Implementation of flood control measures, which were planned in the Nyando master plan,
b) Establishment of flood forecasting and warning systems in the Nyando River basin,
c) Preparation of flood fighting plan for the existing dikes along the lower reaches of the Nyando River,
d) Establishment of CBDM system in Sondu and Kuja river mouth areas, and
e) Implementation of urban drainage measures in Kisumu.

### 4.8.4 Drought Disaster Management Strategy

Based on the overall concepts mentioned in Section 7.9 of the Main Report Part A, drought management strategy for LVNCA will cover i) the preparation of rules on water use of existing and proposed reservoirs, ii) establishment of basin drought conciliation councils, and iii) establishment of drought early warning systems.

### 4.8.5 Proposed Flood Disaster Management Plan

In line with the abovementioned management strategies, the flood disaster management plan for LVSCA is proposed as illustrated in Figure 4.8.1, which are as follows:

(1) Implementation of Flood Control Measures in the Nyando River Basin

The master plan on Nyando River basin includes various flood control measures such as i) raising road elevation for evacuation, ii) dike construction, iii) river training, iv) desiltation, v) retarding basins and dam development, and vi) catchment conservation. It is proposed to incorporate the existing plans into NWMP 2030. The arrangement of structural measures is illustrated in Figure 4.8.2.

(2) Establishment of FFWS in the Nyando River Basin

In addition to structural measures as mentioned above, non-structural measures were also proposed in the master plan for the Nyando River basin since structural measures have limited safety against extraordinary floods. Therefore, the plan includes the establishment of a telemetric flood forecasting and warning systems in the Kano Plain and Nyando River basin as part of the medium-term plan. It is also proposed to incorporate this plan into NWMP 2030. The proposed network system is illustrated in Figure 4.8.2.

Although flood analysis system is not clearly defined in the Nyando River basin master plan, the WRMA LVS Regional Office shall conduct inundation analysis using rainfall and river water level data, which are observed by telemetric monitoring facilities installed within the basin. Also, the WRMA LVS Regional Office shall issue a warning based on river water level and probable flood area forecasts in the lower reaches that are obtained from the analysis result.

(3) Preparation of Flood Fighting Plan for the Nyando River

Flood fighting plan for the existing dikes along the lower reaches of the Nyando River shall be prepared by the WRMA LVSCA Regional Office. The target section for the flood fighting plan is 15.1 km on both banks of the Nyando River.

The flood fighting plan of NWMP 2030 shall aim mainly at avoiding the expansion of inundated areas caused by dike breaching and overtopping. The contents of the flood fighting plan should focus on institutionalisation of flood fighting corps, activities during normal times, and flood fighting engineering methods including but not limited to:

(4) Establishment of CBDM System in Sondu River mouth and Kuja River mouth

In the Sondu and Kuja river mouth areas, CBDM system were proposed by referring to the system that has been already developed in the Nyando River basin.

It is proposed that the CBDM system includes various activities by community involvement, namely, i) systematisation of communities and establishment of a monitoring procedure, information dissemination, and evacuation in cooperation with the WRMA LVSCA Regional Office, Kisii Subregional Office and local government offices; ii) construction of evacuation centres and evacuation routes by community involvement; iii) voluntary monitoring by the community using simple rain and water level gauges; iv) community involvement in flood fighting activities; and v) construction of small-scale structural measures such as a small revetments and culverts.

These areas shall basically adopt a simplified flood forecasting system by using the observed river water level in the upper reaches. The communities themselves will recognise occurrence of flood and carry out necessary activities in accordance with the hazard map and evacuation plan, which should be prepared in advance also by themselves.

(5) Implementation of Urban Drainage Measures in Kisumu

It is proposed to implement urban drainage measures in Kisumu. The work is the responsibility of local authorities, namely, the Kisumu County and Kisumu Urban Centre. The following section will show the preliminarily cost estimates on drainage works composed of gravity drains based on NWMP (1992). However, it is noted that in some cases, drainage works involve major associated works such as pumping stations, retarding basin, and improvement of receiving river channels, which should be planned in detail in the future.

### 4.8.6 Proposed Drought Disaster Management Plan

(1) Preparation of Water Use Restriction Rule for Reservoirs

1) Target Dam

It is proposed to prepare water use restrictions for the respective reservoirs. The name of target dams are shown in the table below. It is noted in the list below that there are two existing and ten proposed dams in LVSCA.

**Target Dams for Water Use Restriction Rules (LVSCA)**

| River System | No. | Dam Name | Status | |
|---|---|---|---|---|
| | | | Existing | Proposed |
| Nyando | 1 | Londiani | | O |
| | 2 | Nyando (Koru) | | O |
| Kibos | 3 | Kibos | | O |
| Sondu | 4 | Itare | | O |
| | 5 | Magwagwa | | O |
| | 6 | Sondu | O | |
| Kuja | 7 | Bunyunyu | | O |
| | 8 | Katieno | | O |
| | 9 | Gogo Falls | O | |
| | 10 | Ilooiterre | | O |
| Amala | 11 | Sand River (Naikara) | | O |
| | 12 | Amala | | O |
| Total | | | 2 | 10 |

Source: JICA Study Team (Ref. Sectoral Report (G), 2.3.1 (1) and Table 4.4.1)

2) Setting of Reference Reservoir Water Level

To clearly understand the timing of necessary actions for water use restriction, three-step reference water level, namely Normal, Alert and Alarm, shall be set for the respective reservoirs. The water level should be originally determined by the percentage of reservoir water storage depending on season and month, water demand for each purpose, past experiences, etc., of each dam. The definitions of each reference water level are as follows:

- Normal: Water level where the Basin Drought Conciliation Council is summoned to discuss actions to be taken when the reservoir water level is expected to become lower than normal.
- Alert: Water level where water use restrictions should commence.
- Alarm: Water level where the reservoir water level shall not be lowered further by controlling the outflow discharge from the reservoir.

3) Determination of Reduction Rate

A method to determine the 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, subsequent water level shall be forecasted by considering future weather forecasts. Then, necessary reduction rate in water intake for whole basins will be determined.
b) Based on clause a), reduction rate shall be determined for the respective intended purposes such as domestic water supply, industry, and agriculture, considering the possibility to save water volume for each purpose. At this time, it is essential to consider priority order that has been conventionally stipulated in Kenya.
c) While referring to the actual data on reduction rates during the past drought, the final reduction rate shall be determined.

Figure 4.8.3 provides an example record of reservoir water use restriction implemented in the Sameura Dam on the Yoshino River in Japan during the severe drought time in 2005.

(2) Establishment of Basin Drought Conciliation Council

1) Jurisdiction of Council

It is proposed to establish a Basin Drought Conciliation Council on the basis of a river basin unit as representing a river system and drainage system.

The table in the previous page shows all the dams, which are incorporated into the water resources development plan of NWMP 2030, and their river systems. One council shall be established for each river system. The number of councils to be established in LVSCA will be five for Nyando, Kibos, Sondu, Kuja, and Amala river systems, as illustrated in Figure 4.8.1.

(3) Drought Early Forecast

Water use restriction should be considered at the early stages, taking into account the weather conditions, water storage in the reservoirs, social impacts in the worst case scenarios, etc.

At present, KMD issues long-term rainfall forecast of 4-day, 7-day, 1-month, and 3-month (seasonal), which are officially released on the website of KMD or published in the newspaper. This information shall be utilised to commence timely water use restriction.

As described in Section 5.1 of Sectoral Report (J), drought early warning system in terms of livelihood zone has been established through ALRMP II using KMD's forecasts for the purpose of preparing communities against drought damage or raising awareness to save water. In a similar way, specialised drought early forecast for water use restriction will be established.

## 4.9 Environmental Management

### 4.9.1 Current Situation of Environmental Management

LVSCA faces the Winum Gulf of Lake Victoria. Six rivers in LVSCA are flowing into the gulf. Water pollution and eutrophication of the gulf are caused by hazardous substances from sewage and industrial wastewater from the rivers and Kisumu City, and nutrients from agricultural lands in the upper reaches. In particular, the Nyando and Sondu rivers, which are regarded as main rivers of LVSCA, transport large pollutions loads to the gulf. In addition, Kisumu City is a central city of LVSCA and has a population of over 400,000. Water pollution by urban and industrial wastes from the City is expected to increase with the future population and economic growth of the city and its surrounding areas.

The Masaai-Mara National Reserve is located in the catchment area and bounds the Serengeti National Park of Tanzania. This reserve is an internationally important area for natural ecosystem such as for migratory gnus over the borders. The Mara River is a main water source in the reserve, is the solitary example of environmental river flow study by World Wide Fund for Nature (WWF). The study is a good practice of water resource management considering both rural people's life and wildlife. WWF-Eastern and Southern Africa Regional Program (WWF-ESARPO) pursued a strategy by using environmental flow study to determine appropriate water resource allocation in the Mara River basin for the preparation of the Biodiversity Strategy and Action Plan (BSAP) for this area. However, conflicts between the rural people and KWS have been caused by water shortage, and excessive grasslands caused by drought are becoming a problem in the recent years.

The Mau Forest Complex is located in the northern part of the catchment area and has been experiencing forest degradation due to illegal logging and encroachment. Deforestation has become a factor for water resources degradation. Thus, strengthening of patrol activities and forestation by the local people are conducted by KFS to conserve the forest. According to KFS, these measures contribute to the end of deforestation, but still are not enough.

LVSCA is the most densely populated areas. It is necessary to consider socio-environmental issues at the time of implementation of development projects.

**Natural Environmental Resources (LVSCA)**

| Protected Area | | Total Area | Number of Wildlife Species | Location |
|---|---|---|---|---|
| National Park (NP) | | | | |
| 1 | Ndere Island NP | 42 $km^2$ | No information | Winum Gullf, Lake Victoria |
| 2 | Ruma NP | 120 $km^2$ | 164 | Suba district, Nyanza Province |
| National Reserve (NR) | | | | |
| 3 | Masai Mara NR | 1,510 $km^2$ | 205 | Near the border with Tanzania |
| National Sanctuary (NS) | | | | |
| 4 | Kisumu Impala NS | 0.34 $km^2$ | No information | Located near the Kisumu town |
| 5 | Lake Simbi NS | 41.7 ha | No information | Nyanza Gulf of Lake Victoria. |
| 6 | Ondago Swamp NS | 24.8 ha | No information | Besides Lake Victoria |
| Five Water Towers | | | | |
| 7 | Mau Forest Complex | 400,000 ha | No information | Central of RVCA |

Source: JICA Study Team based on ProtectedPlanet.net (http://www.protectedplanet.net/about) and Wildlife Bill, 2011

### 4.9.2 Management Strategy

Based on the overall concept and framework mentioned in Section 7.10 of Main Report Part A, it is proposed to set the environmental flow rate and to carry out environmental monitoring for major rivers and lakes in LVSCA.

The water resource development projects in NWMP 2030 are mostly proposed on the Nyando, Sondu, and Gucha-Migori rivers, which are main rivers of the LVNCA. Therefore, the setting of the environmental flow rate and environmental monitoring are proposed for these three rivers. In addition, the setting of environmental flow rate and environmental monitoring are also proposed for the Mara River has a biological importance, as part of the Masai-Mara National Reserve.

Environmental monitoring is proposed for the Winum Gulf of Lake Victoria. In addition, Kisumu City and Homa Bay Town are targets of environmental monitoring because sewage and industrial wastewater will increase due to future population growth.

### 4.9.3 Proposed Environmental Management Plan

Based on the above management strategy and selection criteria for environmental flow rate point and environmental monitoring points mentioned in the overall concept and framework, the environmental flow rate setting and environmental monitoring of environmental management plan for LVSCA proposed at the points are as shown in the following table. Locations of the proposed points are shown in Figure 4.9.1.

**Environmental Flow Rate Setting Points (LVSCA)**

| Target | Environmental Flow Setting Point | | Proposed Major Development Projects | Vegetation | Reserve* ($m^3/s$) | Monitoring Point of WRM |
|---|---|---|---|---|---|---|
| Nyando River | LVS-F1 | Reference point (Ahero Town) | Nyando(Koru) and Londiani dams, Kano Plain Irrigation | Evergreen bushland with wooded grassland | 1.7 | 1GD03 |
| | LVS-F2 | Near Muhoroni Town | | Rain forest | 1.9 | 1GD07 |
| Sondu River | LVS-F3 | Reference point (Upstream of Sondu Dam) | Magwagwa and Itare dams | Rain Forest | 10.5 | 1JG05 |
| | LVS-F4 | Confluence point with the Itare River | | Mountain Forest | 3.7 | 1JF08 |
| Gucha - Migori River | LVS-F5 | Confluence point of both rivers | Bunyunyu, Ilooiterre and Katieno dams, and Lower Kuja Irrigation | Evergreen bushland with wooded grassland | 2.4 | 1KB05 |
| | LVS-F6 | Reference point (Gucha River) | | | 0.4 | 1KB03 |
| | LVS-F7 | Reference point (Migori River) | | | 1.5 | 1KC03 |
| Mara River | LVS-F8 | Reference point (Upstream of the Masai-Mara National Park) | Amala Dam | Evergreen bushland with wooded grassland | 4.3 | 1LA04 |

Note: * Reserve includes the water for ecological needs and basic human needs as mentioned in WRMA Guidelines for Water Allocation.

Source: JICA Study Team (Ref. Sectoral Report (H), Section 3.2(1))

In addition, the environmental survey for setting of the environmental flow rate (current river flow rate, water quality, and river ecosystem) shall be conducted in the Nyando, Sondu, and Gucha-Migori rivers.

## Environmental Monitoring Points (LVSCA)

| Target | Monitoring point | | Reserve* ($m^3/s$) | Monitoring Point of WRM | Selection Criteria |
|---|---|---|---|---|---|
| Nyando River | LVS-M1 | Reference point (Ahero Town ) | 1.7 | 1GD03 | a) Representative point to monitor the river ecosystem |
| | LVS-M2 | Near Muhoroni Town | 1.9 | 1GD07 | b) Points where rare or characteristic ecosystem exists (Mau Forest Complex) |
| Sondu River | LVS-M3 | Reference point (Upstreams of Sondu Dam) | 10.5 | 1JG05 | a) Representative point to monitor the river ecosystem |
| | LVS-M4 | Confluence point with the Itare River | 3.7 | 1JF08 | b) Points where rare or characteristic ecosystem exists (Mau Forest Complex) |
| Gucha - Migori River | LVS-M5 | Confluence point of both rivers | 2.4 | 1KB05 | b) Points where rare or characteristic ecosystem exists |
| | LVS-M6 | Reference point (Gucha River) | 0.4 | 1KB03 | a) Representative point to monitor the river ecosystem |
| | LVS-M7 | Reference point (Migori River) | 1.5 | 1KC03 | a) Representative point to monitor the river ecosystem |
| Mara River | LVS-M8 | Reference point (Upstream of the Masai-Mara National Park) | 4.3 | 1LA04 | d) Upstream points from the protected area, and<br>f) International rivers and lakes. |
| Lake Victoria | LVS-M9 | Near river mouth of the Nyando River | - | - | e) Major lakes in the catchment area, and<br>f) International rivers and lakes. |
| | LVS-M10 | Near river mouth of the Sondu River | - | - | |
| | LVS-M11 | Near river mouth of the Gucha River | - | - | |
| Kisumu City and Homa Bay Town | LVS-M12 | Kisumu City (Main discharge point) (Lower reaches of the Kibos River) | - | - | c) Points where large city or town is located, and<br>d) Upstream points from the protected area. |
| | LVS-M13 | Homa bay Town (Main discharge point) | - | - | |

Note: * Reserve includes the water for ecological needs and basic human needs as mentioned in WRMA Guidelines for Water Allocation.

Source: JICA Study Team (Ref. Sectoral Report (H), Section 3.2(1))

# CHAPTER 5 COST ESTIMATES

## 5.1 Basic Conditions and Methodologies for Cost Estimates

### 5.1.1 Conditions and Methodologies of Cost Estimates for Development Plans

Costs for the projects proposed in the development plans formulated for LVSCA in this study were estimated to determine the cost, to evaluate general economic viability, and to discuss about the general idea of financing for implementation of the proposed projects. Development plans include water supply, sanitation, irrigation, hydropower and other water resources development.

The project costs (construction costs) together with annual operation and maintenance (O&M) costs and replacement costs were estimated for the proposed projects in the respective development plans using the following methods:

(1) Water Supply Development Projects

a) As for the expansion and new construction of water supply systems, the cost estimates were considered on three categories: i) dams and large-scale bulk water transfer systems; ii) water intake, boreholes, and water transmission lines with pump stations; and iii) water distribution systems with water treatment plants and pumping stations, separately. Except for dams and large-scale bulk water transfer systems, the project costs were estimated by applying the unit cost of US$2250/$m^3$. If dams or large-scale water transfer systems are required for water supply system, the costs were estimated separately as described in paragraph e) below. As for the rehabilitation of water supply systems, the project costs were estimated by applying the unit cost of US$675/$m^3$ for water supply capacity of existing water supply system.

b) The above unit costs were derived from the data in the existing reports prepared by WSBs and the Aftercare Study Report with adjustments. The used data include direct and indirect construction costs (administration and engineering services). Land acquisition costs were not estimated because of the marginal amount for water supply projects.

c) The annual O&M costs were estimated for the water supply projects by applying the unit cost of US$0.3/$m^3$ for water production. The unit cost was estimated based on the data in the existing reports prepared by WASREB and WSBs. The replacement costs for electromechanical works were estimated by applying 30% of the project costs. The replacement was assumed to be conducted every 15 years.

(2) Sanitation Development Projects

a) As for the expansion and new development of sewerage systems, the project costs were estimated by applying the unit cost of US$2000/$m^3$ for wastewater treatment capacity required. As for the rehabilitation, the project costs were estimated by applying the unit cost of US$600/$m^3$ for treatment capacity of existing sewerage system. The unit costs were derived from the data in the existing reports prepared by WSBs and the Aftercare Study Report with adjustments. The used data include direct and indirect construction costs (administration and engineering services). Land acquisition costs were not estimated because of the marginal amount for the sewerage projects.

b) The annual O&M costs were estimated for the sewerage projects by applying the unit cost of US$0.2/$m^3$ for treatment capacity. The unit cost was estimated based on the data in the existing reports prepared by WASREB and WSBs. The replacement costs for electromechanical works were estimated by applying 30% of the project costs. The replacement was assumed to be conducted every 15 years.

c) Other sanitation projects

(3) Irrigation Development Projects

a) For the large- and small-scale irrigation projects, the costs for civil works estimated by the government authorities were employed with adjustments, when necessary. The construction costs include the physical contingency at 15% of the direct construction costs. Land acquisition costs were assumed to be KSh100,000/ha based on the actual data for other projects, when data were not available.

b) For the new large- and small-scale irrigation projects having no detailed cost data, the project costs were estimated by applying unit costs per ha and indirect construction costs calculated as above. The unit construction costs were assumed at KSh900,000/ha for large-sale dam irrigation, KSh600,000/ha for small-sale dam irrigation, KSh400,000/ha for weir irrigation, and KSh900,000/ha for groundwater irrigation projects by applying the actual costs of similar projects.

c) For private irrigation projects, the unit project cost was assumed at KSh1.5 million/ha referring to the actual investment cost data for drip irrigation system invested by private sectors. This unit cost includes all indirect costs such as engineering services, technical training, and contingencies.

d) The annual O&M costs were estimated as 0.3% of the direct construction costs for the water source facilities (dam, weir, and borehole) and 1% for irrigation canal systems. Replacement costs such as mechanical works were assumed as 20% of the direct construction costs, which will be conducted every 20 years.

(4) Hydropower Development Projects

a) For the hydropower projects, the project costs were estimated based on the available cost estimates by the government authorities with adjustments. The cost data were regarded to include direct and indirect construction costs. Land acquisition costs were not estimated because of their marginal amounts.

b) Annual O&M costs were estimated as 0.5% of the project costs including replacement costs.

(5) Water Resources Development Projects

a) For dams, project costs were estimated by using a dam project cost curve showing the relationship between the costs and dam embankment volumes in cases where no cost data were available for dam projects. The cost curve was prepared based on the existing costs and dam volume information. In the case that cost data were provided for the planned dams by the Government of Kenya, the data were used and adjusted as project costs.

b) For water transfer facilities, project costs were estimated based on the existing cost data prepared by the Government of Kenya with adjustments depending on pipe size.

c) The abovementioned existing cost data include the direct and indirect construction costs (administration and engineering services). Land acquisition costs for dam and water transfer projects were estimated separately by applying a unit cost of KSh100,000/ha was assumed based on actual data.

d) The annual O&M costs for dam and water transfer projects were estimated as 0.5% of the project costs. The percentage was assumed based on the values in the NWMP (1992) and figures usually used in planning similar projects. The replacement costs were not considered for dams and water transfer facilities.

e) The project costs for small dams for rural water supply purposes were estimated based on actual construction data. The costs of boreholes were estimated in the subsectors of water supply and irrigation.

Other basic conditions applied for cost estimates are as follows:

a) Cost estimates were based on the market price on November 1, 2012.

b) The exchange rate used for the cost estimates was US$1.0 = KSh85.24 dated November 1, 2012.

The project costs estimated in this study are only preliminary to grasp the financial status. Therefore, these cost estimates should not be used for specific purposes of financial arrangements of the said projects.

### 5.1.2 Conditions and Methodologies of Cost Estimate for Management Plans

Costs for the proposed management plans for LVSCA were estimated for the respective water resources management, flood and drought disaster management, and environmental management plans to know the costs and to discuss about the general idea of financing the implementation of the plans.

The costs were estimated with two major items, namely development cost and recurrent cost as usually applied in the management sectors of the Government. The development cost was estimated as the cost of construction or installation of facilities, equipment, and systems for management activities including required studies and surveys. The recurrent cost was estimated as the cost of periodical monitoring and measurement works for management activities, which were required annually, including operation and maintenance costs. Both the development and recurrent costs were estimated based on the prepared implementation programmes.

The development and recurrent costs were estimated for the proposed management plans through the following methods:

a) For water resources management plan, both development and recurrent costs were estimated by applying the unit costs for management activities based on interviews with WRMA staff in charge of related management activities.

b) For flood and drought disaster management plans, development costs were estimated referring to the existing master plan studies such as the Nyando Flood Management Master Plan (2009) and NWMP (1992) with adjustments. The annual recurrent costs were assumed to be 0.5% of the development costs.

c) For environmental management plan, both development and recurrent costs were estimated by applying the unit costs for management activities in terms of required manpower, meetings, surveys, and monitoring.

For water resources management plan, it was assumed that 40% of existing river and rainfall gauging stations require rehabilitation.

As for the cost estimates for flood and drought disaster management plans, the following were noted:

a) The project costs of the with flood control allocation were excluded and were estimated separately in the water resources development plan,

b) The project costs for river improvement works were excluded because there were little basic data necessary for planning and cost estimates for the works, and

c) The project costs for drought management plan were excluded because these were considered to be within WRMA's regular tasks.

Other basic conditions applied for the cost estimates were as follows:

a) The cost estimates were based on the market price on November 1, 2012.

b) The exchange rate used for the cost estimates was US$1.0 = KSh85.24 dated November 1, 2012.

The development and recurrent costs estimated in this study are only preliminary in order to grasp financial status. Therefore, these costs should not be used for specific purposes of financial arrangements for the said plans.

## 5.2 Cost Estimate for Proposed Plans

### 5.2.1 Cost Estimate for Proposed Development Plans

(1) General Scopes of Proposed Plans for Cost Estimate

The general scopes for cost estimate of the proposed development plans include the following:

1) Water Supply Development Plan

The rehabilitation project includes replacement of old pipes, installation and replacement of water meters, and repair and replacement of mechanical and electrical equipment. Source works include construction of water intake facilities and boreholes with pumps. Water transmission system covers pipelines and pumping stations.

2) Sanitation Development Plan

The rehabilitation project includes replacement of old sewers, and repair and replacement of mechanical and electrical equipment. For the cost estimates, waste stabilisation pond was assumed to be adopted for all wastewater treatment works.

3) Irrigation Development Plan

There are three categories of the irrigation projects, namely large-scale, small–scale, and private irrigation. Water sources for irrigation projects include weirs, dams, groundwater, and rainwater harvesting facilities such as small dams and water pans.

4) Hydropower Development Plan

Of the 14 hydropower schemes, 13 are multipurpose dam projects while one is a single-purpose project.

5) Water Resources Development Plan

The cost of dam includes that for the dam and related structures such as spillways, river outlets, and river diversions.

(2) Estimated Costs

The project and annual O&M costs for the projects proposed in the development plans for LVSCA were estimated based on the conditions and methodologies stated in the preceding section. Results of the estimates are shown in Tables 5.2.1 to 5.2.6 and are summarised below.

**Estimated Costs for Proposed Projects in Development Plans (LVSCA)**

(Unit: KSh million)

| Development Plan | Proposed Project | Type | Project Cost | Annual O&M Cost |
|---|---|---|---|---|
| Water Supply* | Urban Water Supply (25 UCs) | Rehabilitation | 6,921 | - |
| | | New construction | 152,947 | 6,289 |
| | | Sub-total | 159,868 | 6,289 |
| | Rural Water Supply (14 Counties) | Rehabilitation | 1,500 | - |
| | | New construction | 48,280 | 2,259 |
| | | Sub-total | 49,780 | 2,259 |
| | Sub-total | | 209,648 | 8,548 |
| Sanitation* | Sewerage System (19 UCs) | Rehabilitation | 1,114 | - |
| | | New construction | 78,781 | 4,313 |
| | Sub-total | | 79,895 | 4,313 |
| Irrigation** | Large-scale Irrigation (75,572 ha) | New construction | 128,257 | 385 |
| | Small-scale Irrigation (22,501 ha) | New construction | 14,540 | 73 |
| | Private Irrigation (15,133 ha) | New construction | 29,338 | 293 |
| | Sub-total | | 172,135 | 751 |
| Hydropower | One project | New construction | 46,055 | 230 |
| Total | | | 507,733 | 13,842 |

Note: UC = Urban Centre

* O&M cost of existing water supply and sewerage facilities to be rehabilitated was not estimated due to lack of data required for cost estimate.

** Rehabilitation cost of existing irrigation facilities was not estimated due to lack of data required for cost estimate though there are needs of rehabilitation of them.

Source: JICA Study Team (Ref. Tables 5.2.1 – 5.2.5)

The costs for the proposed water resources development were estimated to be KSh119,080 million for project cost, and KSh595 million for O&M cost, which include the costs of ten dams and two water transfer systems. The costs had been allocated to the costs for water supply, irrigation, and hydropower subsectors.

### 5.2.2 Cost Estimate for Proposed Management Plans

(1) General Scopes of Proposed Plans for Cost Estimate

The general scopes for cost estimate of the proposed management plans include the following:

1) Water Resources Management Plan

The development costs for the water resources management plan were estimated for the activities of i) monitoring of river stage, groundwater level, and rainfall; ii) evaluation such as upgrading the hydrometeorological database and establishment of additional water quality test laboratory; iii) permitting such as upgrading the permits database; and iv) watershed conservation such as reforestation.

The recurrent costs for the water resources management plan were estimated for the activities of i) monitoring of surface and groundwater, rainfall and water quality, and ii) operation of the catchment forum.

2) Flood and Drought Disaster Management Plan

The development costs for the flood disaster management plan were estimated for the construction of structures, and preparation of hazard maps and evacuation plans.

The recurrent costs for the flood disaster management plan were estimated for the operation and maintenance of the structures, updating of documents and maps, and replacement of equipment.

3) Environmental Management Plan

The development costs for the environmental management plan were estimated for i) the environmental survey for setting of the environmental flow rate, and ii) setting of the environmental flow rate.

The recurrent costs for the environmental management plan were estimated for the environmental monitoring.

(2) Estimated Costs

The development and recurrent costs for the proposed management plans of LVSCA were estimated based on the conditions and methodologies stated in the preceding section. Results of the estimates are shown in Tables 5.2.7 to 5.2.9 and summarised below.

**Estimated Costs for Proposed Management Plans (LVSCA)**

(Unit: KSh million)

| Management Plan | Proposed Plans | Development Costs | Annual Recurrent Costs* |
|---|---|---|---|
| Water Resources Management | Monitoring | 124 | 123 |
| | Evaluation | 30 | - |
| | Permitting | 18 | - |
| | Watershed Conservation (412,000 ha) | 32,548 | - |
| | Operation of Catchment Forum | - | 1 |
| | Sub-total | 32,720 | 124 |
| Flood and Drought Disaster Management | FFWS (1 location) | 1,482 | 7 |
| | CBDM (2 locations) | 311 | 2 |
| | Flood Fighting (1 location) | 30 | 0.2 |
| | Sun-total | 1,823 | 9.2 |
| Environmental Management | Setting of Environmental Flow Rate including Survey (8 locations) | 49 | - |
| | Environmental Monitoring (13 locations) | - | 2.4 |
| | Sub-total | 49 | 2.4 |
| Total | | 34,592 | 135.6 |

Note : * Recurrent cost includes operation and maintenance costs
FFWS = Flood Forecasting and Warning System, CBDM = Community-based Disaster Management
Source: JICA Study Team (Ref. Tables 5.2.7 – 5.2.9)

# CHAPTER 6 ECONOMIC EVALUATION

## 6.1 Basic Conditions and Methodology for Economic Evaluation

The overall economic evaluation was performed for four sectors: 1) urban water supply (for 25 UCs, excluding rehabilitation works), 2) sewerage (for 19 UCs, excluding rehabilitation works), 3) large-scale irrigation (with 68,782 ha), and 4) hydropower (with one dam) in LVSCA at a master plan level. The following assumptions were made for economic analysis:

a) Price Level

Investment costs and O&M costs are estimated at the November 1, 2012 price level. Exchange rate applied is US$1.0 = KSh85.24 = ¥79.98.

b) Social Discount Rate

The social discount rate reflects the opportunity cost of capital to the national economy. In this study, 10% of the prevailing opportunity cost of capital in the water sector of Kenya is applied.

c) Economic Life of Facilities

The economic life of project facilities is set at 50 years for irrigation and hydropower projects, and 30 years for water supply and sanitation projects which are generally applied for economic evaluation. Further, economic life of dam is set at 50 years while that for water transfer facility is set at 30 years which are generally applied.

d) Cost Allocation for Multipurpose Dams

The costs of multipurpose dams are allocated to the three subsectors of urban water supply, irrigation, and hydropower according to the degree of contribution of the dams to each subsector.

e) Economic Cost

The financial cost of the project is converted to the economic cost for economic evaluation. The prices of internationally tradable goods and services are valued on the basis of the international border prices, which can often be found in the World Bank's "Commodity Prices and Price Forecast". The prices of non-traded goods and services were converted from their financial values to economic values by applying a standard conversion factor of 0.90 based on the facts that the ratio of taxation against the GDP in Kenya is about 11%, as well as on the fact that the conversion factors widely applied in the water sector of Kenya are mostly around 0.90.

f) Economic Benefit

The details of economic benefit calculations for the four subsectors are described in the sectoral reports. The economic benefit was estimated by setting the items of economic benefits.

Based on the abovementioned basic conditions for economic evaluation, economic benefits were estimated as follows:

**Estimated Economic Benefits (LVSCA)**

| Subsector | Items of Economic Benefit | Benefit at Net Present Value |
|---|---|---|
| a) Water Supply | - Cost saving for water users<br>- Increase of water supply amount | KSh 205.9 billion (30 years) |
| b) Sewerage | - Cost saving for users<br>- Affordability to pay<br>- Improvement of public health | KSh 94.6 billion (30 years) |
| c) Irrigation | - Crop production increase | KSh 90.6 billion (50 years) |
| d) Hydropower | - Capacity increase<br>- Energy increase | KSh 36.1 billion (50 years) |

Source: JICA Study Team

The details of the calculations are described in sectoral reports.

## 6.2 Economic Evaluation for Proposed Plan

The table below shows the estimated economic and financial costs, and the results of economic evaluation in LVSCA.

**Summary of Economic Evaluation Results (LVSCA)**

(Unit: KSh billion)

| Subsector | Scope | Eestimated Financial Cost | Estimated Economic Cost | Net Present Value | | B/C | EIRR |
|---|---|---|---|---|---|---|---|
| | | | | Cost | Benefit | | |
| Water Supply | 25 UCs | 150.7 | 142.3 | 163.2 | 205.9 | 1.26 | 13.30% |
| Sewerage | 19 UCs | 78.8 | 74.1 | 90.8 | 94.6 | 1.04 | 10.60% |
| Irrigation | 67,872 ha | 104.9 | 98.2 | 83.5 | 90.6 | 1.09 | 10.70% |
| Hydropower | One project | 46.0 | 44.2 | 34.8 | 36.1 | 1.04 | 10.30% |

Source: JICA Study Team

The total economic costs for water resources development is estimated at KSh 358.8 billion, of which water supply projects is the largest (KSh 142.3 billion), followed by large-scale irrigation projects (KSh 968.2 billion).

In terms of economic viability, all subsectors were found to be economically feasible with more than 10% of EIRR. The results of economic analysis for the four subsectors are summarised as follows:

a) Water supply projects in LVSCA do not require high cost of structures for water source development, such as large-scale dams or water transmission system, which resulted in high economic feasibility in this subsector.

b) All of the sewerage projects were estimated to be slightly over 10% in the evaluation. The sewerage projects should be promoted from the perspective of environmental conservation, human health, and water recycling.

c) The relative high potentiality of irrigation from water resources in this catchment increased the economic viability resulting to a higher level of EIRR. The irrigation subsector has the potential to boost the national economy by KSh 90.6 billion at the present value.

d) Although the unit construction cost was relatively high in LVSCA, the energy and power benefits in this catchment area were high, which increased the economic benefits in this subsector.

# CHAPTER 7 IMPLEMENTATION PROGRAMMES

## 7.1 General

Implementation programmes were prepared for the projects proposed in the water supply, sanitation, irrigation, hydropower, and water resources development plans and for the management plans proposed for water resources management, flood and drought disaster management, and environmental management plans. The prepared implementation programmes will be a roadmap for the smooth implementation of the projects and plans by the target year of 2030.

The implementation programmes for the projects are composed of the projects assessed to be viable technically, economically and environmentally.

## 7.2 Criteria for Prioritisation for Implementation

### 7.2.1 Criteria for Prioritisation of Development Plans

In order to prepare the implementation programmes, the proposed projects and plans were prioritised for implementation in accordance with the following criteria in terms of project status and subsector:

(1) Prioritisation by Project Status

The priority ranking was set for the proposed projects in accordance with the following criteria by project status:

Priority ranking 1: Projects with finance,
Priority ranking 2: Projects with detailed designs completed,
Priority ranking 3: Projects with feasibility studies completed, and
Priority ranking 4: Projects other than the above.

It is noted that the national flagship projects and projects proposed by the government organisations in charge were included in the ranking above.

(2) Prioritisation by Subsector

For projects having the same ranking in project status derived from the abovementioned ranking study, the following criteria were applied for further prioritisation of the respective subsectors:

1) Water supply:
- a) Rehabilitation of the existing facilities will be made prior to their expansion.
- b) Projects with large service population such as urban water supply and large-scale rural water supply projects have higher priority.
- c) Small-scale rural water supply projects will be implemented progressively by individuals and communities.

2) Sanitation:
- a) Rehabilitation of the existing facilities will be made prior to their expansion.

b) Sewerage projects in the urban area with more severe environmental impacts have higher priority.

c) On-site sanitation facilities will be installed progressively by individuals and communities.

3) Irrigation: a) Rehabilitation of the existing facilities will be made prior to their expansion.

b) Projects with higher economic viability including large- and small-scale projects proposed by the government organisations have higher priority.

c) Other small-scale and private projects will be implemented progressively under counties and by private companies, respectively.

4) Hydropower: a) Hydropower project will be implemented following the water resources development for water supply and irrigation.

5) Water resources: a) Water resources development such as dams, water transfers, small dams, water pans, and boreholes will be implemented in accordance with the requirements for water supply and irrigation development.

### 7.2.2 Criteria for Prioritisation of Management Plans

Criteria for prioritisation of the proposed management plans for implementation were set as presented below for the water resources management, flood and drought disaster management, and environmental management.

(1) Criteria for Water Resources Management Plan

Considering the magnitude of contribution to stable and sustainable management works, the following activities were prioritised among development activities in water resources management:

a) Replacement of iron posts for river gauges to concrete posts,
b) Installation of dedicated boreholes for groundwater monitoring,
c) Installation and rehabilitation of river and rainfall gauging stations, and
d) Establishment of additional water quality test laboratories.

Among the recurrent activities, items that can start immediately were prioritised.

(2) Criteria for Flood and Drought Disaster Management Plan

1) For Flood Disaster Management Plan

a) Non-structural measures are scheduled mostly in the short term because they serve as immediate measures to mitigate flood damage before the completion of structural measures.

b) The construction schedule of multipurpose dams is certainly in accordance with the water resources development subsector.

c) Urban drainage measures where studies have been completed are scheduled in the short term.

2) For Drought Disaster Management Plan

   a) Drought disaster management plans such as preparation of water use restriction for reservoirs and establishment of basin drought conciliation council should be implemented as early as possible wherever applicable.

(3) Environmental Management Plan

Prior to the implementation of development projects, environmental flow rate should be set as early as possible, because it will be rather difficult to revise the flow rate after the start of certain development projects. For this, environmental survey should start immediately to set the environmental flow rate. Therefore, the following priorities were set:

a) Environmental survey to set the environmental flow rate, which should be conducted during the short term.
b) Locations of setting environmental flow rate should be prioritised by referring to the implementation programme of development plans such as dams.

After setting the environmental flow rate, environmental monitoring should be conducted to confirm the adequacy of the flow rate. Therefore, environmental monitoring for examining the established environmental flow rate should be conducted during the medium term.

At important points where there is currently no measurement by WRMA, environmental monitoring should start immediately. Such activities should be started in the short term.

## 7.3 Implementation Programmes of Proposed Plans

The implementation schedules of proposed plans were prepared under the following conditions as well as the criteria for prioritisation as described in the preceding sections:

a) All proposed projects and plans should be realised by the target year of 2030.
b) The programmes must follow the existing implementation schedules having been prepared by the Government of Kenya.
d) The programmes should be prepared in close harmony with the requirements of other water subsectors.
e) The programmes must be prepared, of which annual disbursement costs are to be as even as possible.

The proposed implementation schedules are shown in Figures 7.3.1 to 7.3.5 for the development plans, and Figures 7.3.6 to 7.3.8 for the management plans. Prior to implementation of the development projects, environmental impact assessment (EIA) should be implemented including the issues of compensation.

# *Tables*

## Table 3.3.1 Monthly Water Demand by Sub-Basin in 2030 (LVSCA)

($m^3/s$)

| Sub-basin | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Des | Annual (MCM/year) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1GA | 0.6 | 0.6 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 | 0.4 | 0.4 | 0.6 | 11 |
| 1GB | 1.3 | 1.4 | 1.1 | 0.1 | 0.1 | 0.4 | 0.6 | 0.1 | 0.5 | 0.9 | 1.0 | 1.2 | 23 |
| 1GC | 1.8 | 1.9 | 1.6 | 0.9 | 0.9 | 1.1 | 1.2 | 0.9 | 1.3 | 1.5 | 1.6 | 1.8 | 44 |
| 1GD | 7.6 | 7.4 | 5.8 | 3.7 | 4.9 | 5.8 | 8.1 | 1.2 | 4.2 | 6.1 | 6.0 | 5.9 | 175 |
| 1GE | 2.2 | 2.2 | 1.7 | 1.0 | 1.4 | 1.7 | 2.3 | 0.1 | 1.1 | 1.8 | 1.7 | 1.7 | 49 |
| 1GF | 3.2 | 3.2 | 2.4 | 1.3 | 1.9 | 2.4 | 3.5 | 0.1 | 1.6 | 2.5 | 2.5 | 2.4 | 71 |
| 1GG | 0.7 | 0.8 | 0.6 | 0.1 | 0.1 | 0.3 | 0.4 | 0.1 | 0.3 | 0.5 | 0.6 | 0.7 | 14 |
| 1HA1 | 6.2 | 6.4 | 5.3 | 5.4 | 4.2 | 6.3 | 7.6 | 3.3 | 4.7 | 5.9 | 5.7 | 5.8 | 175 |
| 1HA2 | 3.2 | 3.3 | 2.2 | 2.3 | 1.2 | 3.3 | 4.7 | 0.1 | 1.6 | 2.9 | 2.6 | 2.7 | 79 |
| 1HB1 | 3.6 | 3.7 | 2.5 | 2.7 | 1.3 | 3.7 | 4.9 | 0.2 | 1.8 | 3.2 | 2.9 | 3.0 | 88 |
| 1HB2 | 3.5 | 3.7 | 2.4 | 2.6 | 1.2 | 3.6 | 4.7 | 0.1 | 1.7 | 3.1 | 2.8 | 2.9 | 85 |
| 1HC | 4.1 | 4.4 | 2.7 | 3.3 | 1.4 | 4.4 | 3.5 | 0.2 | 2.0 | 3.7 | 3.4 | 3.5 | 96 |
| 1HD | 5.5 | 5.8 | 4.2 | 4.2 | 2.6 | 5.5 | 7.0 | 1.1 | 3.3 | 5.0 | 4.7 | 4.8 | 141 |
| 1HE | 4.6 | 4.9 | 3.3 | 3.4 | 1.8 | 4.6 | 5.8 | 0.4 | 2.5 | 4.1 | 3.8 | 3.9 | 113 |
| 1HF | 6.4 | 6.7 | 4.4 | 4.5 | 2.3 | 6.5 | 9.4 | 0.5 | 3.4 | 5.7 | 5.1 | 5.4 | 158 |
| 1HG | 2.5 | 2.6 | 1.7 | 1.8 | 0.9 | 2.5 | 3.6 | 0.2 | 1.3 | 2.2 | 2.0 | 2.1 | 61 |
| 1JA | 2.4 | 2.2 | 1.8 | 1.4 | 1.9 | 2.5 | 1.5 | 0.3 | 1.5 | 2.6 | 2.4 | 2.2 | 60 |
| 1JB | 1.2 | 1.1 | 0.8 | 0.7 | 0.9 | 1.3 | 0.7 | 0.1 | 0.7 | 1.3 | 1.2 | 1.1 | 29 |
| 1JC | 1.3 | 1.3 | 1.2 | 1.1 | 1.2 | 1.3 | 1.1 | 0.9 | 1.1 | 1.3 | 1.3 | 1.3 | 38 |
| 1JD | 0.4 | 0.4 | 0.3 | 0.2 | 0.3 | 0.4 | 0.3 | 0.1 | 0.3 | 0.4 | 0.4 | 0.4 | 10 |
| 1JE | 2.6 | 2.4 | 1.9 | 1.5 | 2.0 | 2.7 | 1.6 | 0.3 | 1.5 | 2.8 | 2.6 | 2.4 | 64 |
| 1JF | 4.2 | 3.8 | 3.1 | 2.4 | 3.2 | 4.4 | 2.6 | 0.4 | 2.5 | 4.5 | 4.1 | 3.9 | 102 |
| 1JG1 | 0.9 | 0.9 | 0.7 | 0.6 | 0.7 | 0.9 | 0.6 | 0.2 | 0.6 | 0.9 | 0.9 | 0.8 | 23 |
| 1JG2 | 0.8 | 0.7 | 0.5 | 0.4 | 0.5 | 0.7 | 0.4 | 0.1 | 0.4 | 0.8 | 0.7 | 0.7 | 18 |
| 1KA | 5.1 | 5.0 | 3.8 | 2.9 | 3.2 | 5.2 | 4.9 | 2.2 | 3.7 | 4.6 | 4.2 | 4.4 | 129 |
| 1KB | 29.3 | 28.3 | 16.7 | 9.0 | 11.9 | 30.0 | 24.9 | 2.7 | 16.1 | 24.7 | 20.9 | 23.0 | 622 |
| 1KC | 14.1 | 13.7 | 8.1 | 4.6 | 6.0 | 14.6 | 10.6 | 1.6 | 7.9 | 12.0 | 10.2 | 11.2 | 300 |
| 1LA1 | 3.0 | 2.8 | 2.4 | 2.0 | 2.5 | 3.1 | 2.1 | 0.9 | 2.1 | 3.2 | 3.0 | 2.9 | 79 |
| 1LA2 | 0.5 | 0.4 | 0.4 | 0.3 | 0.4 | 0.5 | 0.4 | 0.2 | 0.3 | 0.5 | 0.5 | 0.4 | 13 |
| 1LA3 | 0.7 | 0.7 | 0.6 | 0.5 | 0.6 | 0.7 | 0.7 | 0.3 | 0.5 | 0.7 | 0.7 | 0.7 | 19 |
| 1LB1 | 1.9 | 1.7 | 1.4 | 1.1 | 1.5 | 2.0 | 1.4 | 0.3 | 1.2 | 2.0 | 1.9 | 1.8 | 48 |
| 1LB2 | 0.6 | 0.6 | 0.5 | 0.4 | 0.5 | 0.6 | 0.6 | 0.3 | 0.4 | 0.6 | 0.6 | 0.6 | 16 |
| Total | 126.0 | 124.7 | 86.6 | 67.0 | 64.0 | 123.2 | 122.0 | 19.9 | 72.4 | 112.5 | 102.0 | 106.1 | 2,953 |

Source: JICA Study Team

## Table 4.2.1 Water Service Providers (WSPs) (LVSCA)

| WSPs | Service Towns/Areas | Service Population in 2010 | Capacity ($m^3$/day) | NRW |
|---|---|---|---|---|
| [Urban] | | | | |
| Kisumu WSC | Kisumu | 181,512 | 22,400 | 50% |
| Kericho WSC | Kericho | 98,507 | 13,680 | 46% |
| Gusii WSC | Kisii, Nyamira, Tabaka, Ogembo, Keroka, Gesusu, Birongo, Borabu | 221,439 | 15,350 | 46% |
| Tililbei WSC | Litein, Chebang'ang', Fort Tenan, Bomet, Sotik, Londiani, Sigowet, Longisa, Chepalungu, Sosiot, Bargeywet, Kipkelion, Sigor, Kipsitet, Chesinende, Chepkemel | 79,488 | 17,800 | N.A |
| South Nyanza WSC | Mbita, Oyugis, Seme, Nyahera, Kendu Bay, West Karachuonyo, Homa Bay, Ndhiwa | 417,021 | 7,710 | 39% |
| Nyanas WSC | Sondu, Muhoroni, Koru Mnara, Kibigori, Awasi, Tamu, Nandi Hills, Kaptumo, Mosombor, Lessos, Kubujoi | 302,747 | 4,832 | 66% |
| Gulf WSC | Kombewa, Kiboswa | 6,956 | 4,520 | 59% |
| Mikutra WSC | Kilgoris, Angata Barakoi, Nkararu, Migori, Isebania, Rongo, Lolgorian, Kehancha | 11,814 | 2,846 | 60& |
| [Rural] | | | | |
| NYASARE | Migori | N.A | 300 | N.A |
| Total | | 1,319,484 | 89,438 | |

Source: Performance Report of Kenya's Water Services, No. 4, 2011, and data from WSBs

## Table 4.2.2 Proposed Water Supply Development Plan for UWSS (LVSCA)

| Urban Centre | | Service Population in 2030 | Water Demand in2030 ($m^3$/day) | Current Capacity in 2010 ($m^3$/day) | Under Construction ($m^3$/day) | Proposed Projects | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Rehabilitation Works ($m^3$/day) | Expansion Works ($m^3$/day) | New Construction ($m^3$/day) |
| Kisumu and Surrounding Area | | | | | | | | |
| 1 | Kisumu | 1,457,208 | 212,752 | 22,400 | 24,000 | 46,400 | 166,352 | 0 |
| 2 | Ahero | 255,366 | 30,389 | 0 | 0 | 0 | 0 | 30,389 |
| 3 | Awasi | 172,268 | 20,500 | 100 | 0 | 100 | 20,400 | 0 |
| 4 | Muhoroni | 173,451 | 20,641 | 720 | 0 | 720 | 19,921 | 0 |
| 5 | Kipkelion | 235,382 | 28,010 | 280 | 0 | 280 | 27,730 | 0 |
| 6 | Londiani | 217,220 | 25,849 | 0 | 0 | 0 | 0 | 25,849 |
| | Sub-total | 2,510,895 | 338,141 | 23,500 | 24,000 | 47,500 | 234,403 | 56,238 |
| Kisii and Surrounding Area | | | | | | | | |
| 1 | Rongo | 519,406 | 61,809 | 320 | 2,000 | 2,320 | 59,489 | 0 |
| 2 | Kisii | 411,773 | 49,001 | 7,500 | 12,000 | 19,500 | 29,501 | 0 |
| 3 | Suneka | 255,809 | 30,441 | 0 | 0 | 0 | 0 | 30,441 |
| 4 | Keroka | 209,679 | 24,952 | 600 | 0 | 600 | 24,352 | 0 |
| 5 | Awendo | 80,193 | 9,543 | 0 | 2,000 | 2,000 | 7,543 | 0 |
| 6 | Tabaka | 52,467 | 6,244 | 150 | 0 | 150 | 6,094 | 0 |
| 7 | Ogembo | 11,674 | 1,389 | 600 | 0 | 600 | 789 | 0 |
| | Sub-total | 1,541,001 | 183,379 | 9,170 | 16,000 | 25,170 | 127,768 | 30,441 |
| Other Area | | | | | | | | |
| 1 | Kericho | 512,485 | 60,986 | 12,960 | 0 | 12,960 | 48,026 | 0 |
| 2 | Bomet | 421,478 | 50,156 | 450 | 0 | 450 | 49,706 | 0 |
| 3 | Migori | 267,297 | 31,808 | 1,056 | 15,000 | 16,056 | 15,752 | 0 |
| 4 | Homa Bay | 218,278 | 25,975 | 3,500 | 2,000 | 5,500 | 20,475 | 0 |
| 5 | Nyamira | 209,750 | 24,960 | 3,200 | 0 | 3,200 | 21,760 | 0 |
| 6 | Oyugis | 178,454 | 21,236 | 1,920 | 0 | 1,920 | 19,316 | 0 |
| 7 | Kehancha | 151,564 | 18,036 | 320 | 0 | 320 | 17,716 | 0 |
| 8 | Kendu Bay | 74,234 | 8,834 | 720 | 0 | 720 | 8,114 | 0 |
| 9 | Mbita Point | 60,351 | 7,182 | 0 | 0 | 0 | 0 | 7,182 |
| 10 | Litein | 45,823 | 5,453 | 5,453 | 0 | 5,453 | 0 | 0 |
| 11 | Sotik | 42,113 | 5,011 | 500 | 0 | 500 | 4,511 | 0 |
| 12 | Nyansiongo | 28,376 | 3,377 | 600 | 0 | 600 | 2,777 | 0 |
| | Sub-total | 2,210,203 | 263,014 | 30,679 | 17,000 | 47,679 | 208,153 | 7,182 |
| | | | | | | | | |
| | Total | 6,262,099 | 784,534 | 63,349 | 57,000 | 120,349 | 570,324 | 93,861 |
| | | | | | | | 664,185 | |

Note: The service population of piped water supply (UWSS+LSRWSS) in 2010 was estimated at 0.88 million. The service population for each urban centre in 2010 is not clear. All urban population of urban centre in 2030 was counted as service population.

Source: JICA Study Team, based on data from WSBs and Census 2009

**Table 4.2.3 Proposed Water Supply Development Plan for LSRWSS (LVSCA)**

| Item | Service Population in 2030 | Water Demand in 2030 ($m^3$/day) | Current Capacity in 2010 ($m^3$/day) | Proposed Projects | |
|---|---|---|---|---|---|
| | | | | Rehabilitation Works ($m^3$/day) | New Construction ($m^3$/day) |
| Urban Pop. | 1.73 | 206,000 | 26,000 | 26,000 | 251,000 |
| Rural Pop. | 0.94 | 71,000 | | | |
| Total | 2.67 | 277,000 | | | |

Note: The service population of piped water supply (UWSS+LSRWSS) in 2010 is estimated at 0.88 million.

Source: JICA Study Team, based on data from WSBs and Census 2009

**Table 4.2.4 Proposed Water Supply Development Plan for SSRWSS (LVSCA)**

| Counties | Service Population in 2010 | Service Population in 2030 | Difference (2010-2030) | Required Water Supply Amount in 2030 ($m^3$/day) |
|---|---|---|---|---|
| 14 | 2,369,000 | 3,788,577 | 1,419,577 | 208,372 |

Source: JICA Study Team, based on data from Census 2009

**Table 4.3.1 Proposed Sewerage Development Plan (LVSCA)**

| Major Urban Area | | Service Population in 2030 | Required Capacity in 2030 ($m^3$/day) | Current Capacity in 2010 ($m^3$/day) | Under Construction ($m^3$/day) | Proposed Projects | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Rehabilitation Works ($m^3$/day) | Expansion Works ($m^3$/day) | New Construction ($m^3$/day) |
| 1 | Kisumu | 1,457,208 | 136,103 | 17,800 | 0 | 17,800 | 118,303 | 0 |
| 2 | Rongo | 519,406 | 39,579 | 0 | 0 | 0 | 0 | 39,579 |
| 3 | Kericho | 512,485 | 39,051 | 1,500 | 0 | 1,500 | 37,551 | 0 |
| 4 | Bomet | 421,478 | 32,117 | 0 | 0 | 0 | 0 | 32,117 |
| 5 | Kisii | 411,773 | 31,377 | 0 | 0 | 0 | 0 | 31,377 |
| 6 | Migori | 267,297 | 20,368 | 0 | 0 | 0 | 0 | 20,368 |
| 7 | Suneka | 255,809 | 19,493 | 0 | 0 | 0 | 0 | 19,493 |
| 8 | Ahero | 255,366 | 19,459 | 0 | 0 | 0 | 0 | 19,459 |
| 9 | Kipkelion | 235,382 | 17,936 | 0 | 0 | 0 | 0 | 17,936 |
| 10 | Homa Bay | 218,278 | 16,633 | 1,231 | 0 | 1,231 | 15,402 | 0 |
| 11 | Londiani | 217,220 | 16,552 | 0 | 0 | 0 | 0 | 16,552 |
| 12 | Nyamira | 209,750 | 15,983 | 0 | 0 | 0 | 0 | 15,983 |
| 13 | Keroka | 209,679 | 15,978 | 0 | 0 | 0 | 0 | 15,978 |
| 14 | Oyugis | 178,454 | 13,598 | 0 | 0 | 0 | 0 | 13,598 |
| 15 | Muhoroni | 173,451 | 13,217 | 0 | 0 | 0 | 0 | 13,217 |
| 16 | Awasi | 172,268 | 13,127 | 0 | 0 | 0 | 0 | 13,127 |
| 17 | Kehancha | 151,564 | 11,549 | 0 | 0 | 0 | 0 | 11,549 |
| 18 | Awengo | 80,193 | 6,111 | 0 | 0 | 0 | 0 | 6,111 |
| 19 | Kendu Bay | 74,234 | 5,657 | 0 | 0 | 0 | 0 | 5,657 |
| | Total | 6,021,294 | 483,887 | 20,531 | 0 | 20,531 | 171,256 | 292,101 |

Note: Data of the service population for each urban centre in 2010 is not available. All urban population of urban centre in 2030 is counted as service population.

Source: JICA Study Team, based on data from WSBs and Census 2009

**Table 4.3.2 Users and Required Units of On-Site Sanitation Facilities (LVSCA)**

| Counties | Users in 2010 | Users in 2030 | Difference (2010-2030) | Required Units of On-site Facilities* |
|---|---|---|---|---|
| 14 | 6,040,000 | 6,700,000 | 660,000 | 1,340,000 |

Note: * 5 users/facilities

Source: JICA Study Team, based on data from Census 2009

## Table 4.4.1 Large Scale Irrigation Projects Selected for Implementation by 2030 (LVSCA)

| No | Name of Project | County | Sub-basin Code | Irrigation Area (ha) | Project Type*1 | Water Source Facilities*2 | | Present Status*3 | Estimated Cost*4 (KSh mil.) | Executing Agency |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Type | Name of Dam | | | |
| 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/Kericho | 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 | 2KB | 32,700 | New | Multi-dam | Katieno | Proposed | 17,160 | NIB |
| 7. | Nandi Forest Irrigation | Vihiga/Nandi | 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 |

Note: *1: Reh = Rehabilitation, Ext = Extension; *2: Multi = Multipurpose, E = Existing; *3: F/S = Feasibility study, D/D = Detailed design,
*4: Estimated Cost = Construction cost for irrigation sytem (excluding cost allocation of multipurpose dam)

Source: JICA Study Team, based on information from government authorities.

### Table 4.6.1 Available Surface Water and Groundwater Resources for 2030 by Sub-basin (LVSCA)

| | Surface Water ($m^3/s$) | | | | | | | | | | | | | Groundwater |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sub-basin | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Average | (MCM/year) |
| 1GA | 2.5 | 1.9 | 2.4 | 8.0 | 9.0 | 6.1 | 6.6 | 7.8 | 5.9 | 5.5 | 5.8 | 3.8 | 5.4 | 1.7 |
| 1GB | 2.3 | 1.4 | 2.4 | 9.4 | 9.4 | 5.6 | 4.8 | 5.5 | 5.2 | 5.5 | 6.1 | 3.9 | 5.1 | 3.7 |
| 1GC | 5.3 | 4.7 | 5.2 | 12.3 | 14.6 | 9.8 | 10.3 | 13.3 | 10.8 | 9.6 | 9.8 | 7.3 | 9.4 | 4.1 |
| 1GD | 1.4 | 0.5 | 1.1 | 7.1 | 6.2 | 2.7 | 1.0 | 1.7 | 1.7 | 2.4 | 3.1 | 2.3 | 2.6 | 10.4 |
| 1GE | 1.3 | 0.7 | 1.1 | 5.7 | 5.1 | 2.4 | 0.8 | 1.4 | 1.3 | 2.3 | 3.0 | 2.2 | 2.3 | 6.3 |
| 1GF | 1.0 | 0.3 | 0.8 | 4.9 | 4.3 | 1.6 | 0.3 | 0.5 | 0.3 | 1.3 | 2.2 | 2.1 | 1.6 | 8.7 |
| 1GG | 1.9 | 1.6 | 2.2 | 6.9 | 7.3 | 4.5 | 4.5 | 5.5 | 4.4 | 4.1 | 4.5 | 2.9 | 4.2 | 1.7 |
| 1HA1 | 1.9 | 1.2 | 2.1 | 5.9 | 5.9 | 3.5 | 2.3 | 2.4 | 2.3 | 2.8 | 3.7 | 3.5 | 3.1 | 2.2 |
| 1HA2 | 0.6 | 0.1 | 0.3 | 2.8 | 1.2 | 0.5 | 0.1 | 0.1 | 0.1 | 0.3 | 0.8 | 1.7 | 0.7 | 9.1 |
| 1HB1 | 1.1 | 0.3 | 0.6 | 2.8 | 4.0 | 2.1 | 0.8 | 0.5 | 0.6 | 1.2 | 1.9 | 2.5 | 1.5 | 2.3 |
| 1HB2 | 0.9 | 0.3 | 0.8 | 2.8 | 3.1 | 1.7 | 0.8 | 0.6 | 0.5 | 0.9 | 1.4 | 1.7 | 1.3 | 1.2 |
| 1HC | 1.2 | 0.2 | 0.5 | 1.8 | 3.3 | 1.9 | 0.5 | 0.1 | 0.1 | 0.5 | 1.1 | 2.4 | 1.1 | 3.1 |
| 1HD | 3.2 | 1.8 | 3.0 | 9.5 | 11.2 | 7.1 | 3.6 | 2.4 | 2.9 | 4.4 | 6.2 | 6.4 | 5.1 | 6.3 |
| 1HE | 2.3 | 1.1 | 2.2 | 7.3 | 9.9 | 5.2 | 2.3 | 1.1 | 1.7 | 3.4 | 5.6 | 5.2 | 4.0 | 7.6 |
| 1HF | 2.2 | 0.6 | 1.1 | 4.8 | 7.6 | 4.3 | 1.0 | 0.1 | 0.1 | 0.4 | 1.3 | 3.1 | 2.2 | 4.1 |
| 1HG | 1.0 | 0.3 | 0.7 | 3.5 | 5.2 | 1.4 | 0.3 | 0.1 | 0.1 | 0.5 | 1.8 | 2.3 | 1.4 | 0.7 |
| 1JA | 6.8 | 6.3 | 7.4 | 15.3 | 15.9 | 11.3 | 10.0 | 10.9 | 10.7 | 10.2 | 11.5 | 9.4 | 10.5 | 6.8 |
| 1JB | 1.4 | 1.3 | 1.8 | 3.9 | 4.0 | 2.7 | 2.2 | 2.2 | 2.3 | 2.4 | 2.8 | 2.1 | 2.4 | 2.2 |
| 1JC | 3.3 | 3.1 | 3.7 | 7.3 | 7.8 | 5.4 | 4.9 | 5.3 | 5.2 | 5.2 | 5.5 | 4.3 | 5.1 | 1.2 |
| 1JD | 2.7 | 2.5 | 3.0 | 5.4 | 5.7 | 4.4 | 3.6 | 3.4 | 3.6 | 3.9 | 4.3 | 3.7 | 3.8 | 0.7 |
| 1JE | 3.3 | 3.1 | 4.3 | 8.8 | 7.6 | 5.0 | 3.5 | 3.0 | 3.7 | 4.2 | 5.9 | 5.4 | 4.8 | 9.2 |
| 1JF | 8.8 | 7.7 | 9.9 | 20.4 | 20.4 | 14.8 | 11.3 | 10.4 | 11.4 | 11.9 | 14.8 | 13.3 | 12.9 | 4.5 |
| 1JG1 | 1.6 | 1.1 | 1.5 | 4.5 | 5.3 | 3.5 | 2.1 | 1.7 | 2.0 | 2.5 | 3.1 | 2.9 | 2.6 | 0.6 |
| 1JG2 | 0.6 | 0.3 | 0.4 | 1.3 | 1.8 | 1.0 | 0.4 | 0.3 | 0.4 | 0.6 | 0.8 | 1.1 | 0.8 | 1.1 |
| 1KA | 2.1 | 1.4 | 2.3 | 6.1 | 7.5 | 3.9 | 1.9 | 1.3 | 1.9 | 2.9 | 4.3 | 3.9 | 3.3 | 6.2 |
| 1KB | 14.7 | 10.1 | 15.3 | 40.1 | 48.9 | 22.7 | 10.7 | 7.2 | 9.4 | 14.4 | 22.5 | 25.3 | 20.1 | 30.5 |
| 1KC | 15.0 | 12.9 | 17.6 | 38.0 | 38.1 | 18.6 | 9.0 | 5.3 | 6.3 | 10.8 | 17.5 | 22.9 | 17.7 | 22.7 |
| 1LA1 | 6.1 | 5.4 | 6.5 | 16.5 | 14.9 | 9.7 | 7.4 | 7.3 | 7.6 | 7.6 | 10.2 | 9.9 | 9.1 | 7.2 |
| 1LA2 | 6.6 | 6.4 | 6.8 | 14.4 | 14.4 | 8.2 | 4.6 | 3.0 | 3.7 | 4.4 | 5.8 | 9.1 | 7.3 | 1.2 |
| 1LA3 | 11.5 | 12.1 | 12.3 | 30.6 | 27.1 | 11.3 | 4.9 | 2.3 | 2.6 | 3.3 | 6.0 | 13.1 | 11.4 | 5.7 |
| 1LB1 | 10.1 | 9.0 | 10.3 | 25.9 | 23.1 | 13.9 | 8.9 | 7.9 | 8.4 | 8.7 | 12.7 | 16.0 | 12.9 | 3.3 |
| 1LB2 | 7.9 | 8.7 | 9.5 | 25.7 | 23.3 | 9.3 | 3.0 | 0.6 | 1.1 | 2.1 | 3.3 | 9.5 | 8.7 | 12.1 |

Source: JICA Study Team

## Table 4.6.2 Water Demands for 2030 by Sub-sector and Sub-basin (LVSCA)

($m^3/s$)

| Sub-basin | Domestic | | Industrial | | Irrigation | | Livestock | | Wildlife | | Fisheries | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2010 | 2030 | 2010 | 2030 | 2010 | 2030 | 2010 | 2030 | 2010 | 2030 | 2010 | 2030 |
| 1GA | 0.08 | 0.06 | 0.00 | 0.00 | 0.06 | 0.19 | 0.02 | 0.04 | 0.00 | 0.00 | 0.01 | 0.01 |
| 1GB | 0.08 | 0.07 | 0.00 | 0.00 | 0.02 | 0.32 | 0.02 | 0.05 | 0.00 | 0.00 | 0.00 | 0.02 |
| 1GC | 0.16 | 0.79 | 0.01 | 0.04 | 0.05 | 0.08 | 0.03 | 0.08 | 0.00 | 0.00 | 0.01 | 0.02 |
| 1GD | 0.15 | 0.93 | 0.02 | 0.19 | 0.02 | 1.39 | 0.03 | 0.08 | 0.00 | 0.00 | 0.01 | 0.01 |
| 1GE | 0.10 | 0.08 | 0.01 | 0.00 | 0.25 | 0.48 | 0.02 | 0.05 | 0.00 | 0.00 | 0.01 | 0.01 |
| 1GF | 0.08 | 0.04 | 0.01 | 0.00 | 0.18 | 0.45 | 0.02 | 0.04 | 0.00 | 0.00 | 0.00 | 0.01 |
| 1GG | 0.06 | 0.06 | 0.00 | 0.00 | 0.30 | 0.06 | 0.01 | 0.03 | 0.00 | 0.00 | 0.00 | 0.03 |
| 1HA1 | 0.18 | 2.54 | 0.03 | 0.62 | 0.02 | 0.30 | 0.02 | 0.05 | 0.00 | 0.00 | 0.01 | 0.04 |
| 1HA2 | 0.42 | 0.06 | 0.09 | 0.00 | 0.29 | 2.77 | 0.03 | 0.07 | 0.00 | 0.00 | 0.01 | 0.01 |
| 1HB1 | 0.11 | 0.12 | 0.01 | 0.00 | 0.31 | 0.31 | 0.03 | 0.07 | 0.00 | 0.00 | 0.01 | 0.02 |
| 1HB2 | 0.20 | 0.04 | 0.04 | 0.00 | 0.29 | 0.30 | 0.02 | 0.04 | 0.00 | 0.00 | 0.01 | 0.03 |
| 1HC | 0.10 | 0.10 | 0.00 | 0.00 | 0.28 | 0.18 | 0.03 | 0.08 | 0.00 | 0.00 | 0.00 | 0.01 |
| 1HD | 0.27 | 0.95 | 0.01 | 0.04 | 0.40 | 0.51 | 0.05 | 0.13 | 0.00 | 0.00 | 0.01 | 0.01 |
| 1HE | 0.28 | 0.30 | 0.01 | 0.01 | 0.36 | 0.41 | 0.05 | 0.11 | 0.00 | 0.00 | 0.02 | 0.00 |
| 1HF | 0.11 | 0.43 | 0.00 | 0.02 | 0.59 | 0.63 | 0.03 | 0.08 | 0.00 | 0.00 | 0.01 | 0.01 |
| 1HG | 0.05 | 0.14 | 0.00 | 0.01 | 0.22 | 0.24 | 0.01 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1JA | 0.13 | 0.25 | 0.00 | 0.01 | 0.04 | 0.93 | 0.03 | 0.07 | 0.00 | 0.00 | 0.01 | 0.01 |
| 1JB | 0.03 | 0.04 | 0.00 | 0.00 | 0.01 | 0.06 | 0.01 | 0.02 | 0.00 | 0.00 | 0.00 | 0.01 |
| 1JC | 0.08 | 0.78 | 0.01 | 0.11 | 0.01 | 0.34 | 0.01 | 0.03 | 0.00 | 0.00 | 0.00 | 0.01 |
| 1JD | 0.06 | 0.06 | 0.01 | 0.00 | 0.01 | 0.38 | 0.01 | 0.02 | 0.00 | 0.00 | 0.00 | 0.02 |
| 1JE | 0.12 | 0.18 | 0.00 | 0.00 | 0.03 | 0.81 | 0.04 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1JF | 0.16 | 0.29 | 0.00 | 0.01 | 0.04 | 0.67 | 0.05 | 0.11 | 0.00 | 0.00 | 0.01 | 0.03 |
| 1JG1 | 0.09 | 0.11 | 0.00 | 0.00 | 0.07 | 4.57 | 0.02 | 0.04 | 0.00 | 0.00 | 0.00 | 0.09 |
| 1JG2 | 0.02 | 0.02 | 0.00 | 0.00 | 0.08 | 0.20 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.04 |
| 1KA | 0.20 | 2.02 | 0.01 | 0.10 | 0.07 | 0.62 | 0.03 | 0.08 | 0.00 | 0.00 | 0.02 | 0.01 |
| 1KB | 1.11 | 2.08 | 0.03 | 0.07 | 0.43 | 11.89 | 0.22 | 0.52 | 0.01 | 0.01 | 0.05 | 0.00 |
| 1KC | 0.40 | 1.09 | 0.01 | 0.04 | 0.03 | 1.82 | 0.20 | 0.49 | 0.01 | 0.01 | 0.02 | 0.00 |
| 1LA1 | 0.15 | 0.74 | 0.00 | 0.03 | 0.04 | 0.47 | 0.05 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1LA2 | 0.04 | 0.06 | 0.00 | 0.00 | 0.01 | 0.10 | 0.05 | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1LA3 | 0.06 | 0.08 | 0.00 | 0.00 | 0.02 | 1.00 | 0.11 | 0.25 | 0.01 | 0.01 | 0.00 | 0.00 |
| 1LB1 | 0.14 | 0.15 | 0.00 | 0.00 | 0.03 | 2.28 | 0.06 | 0.15 | 0.01 | 0.01 | 0.00 | 0.00 |
| 1LB2 | 0.04 | 0.05 | 0.00 | 0.00 | 0.02 | 0.83 | 0.08 | 0.20 | 0.01 | 0.01 | 0.00 | 0.00 |
| 1GA | 0.08 | 0.06 | 0.00 | 0.00 | 0.06 | 0.19 | 0.02 | 0.04 | 0.00 | 0.00 | 0.01 | 0.01 |
| 1GB | 0.08 | 0.07 | 0.00 | 0.00 | 0.02 | 0.32 | 0.02 | 0.05 | 0.00 | 0.00 | 0.00 | 0.02 |
| 1GC | 0.16 | 0.79 | 0.01 | 0.04 | 0.05 | 0.08 | 0.03 | 0.08 | 0.00 | 0.00 | 0.01 | 0.02 |
| 1GD | 0.15 | 0.93 | 0.02 | 0.19 | 0.02 | 1.39 | 0.03 | 0.08 | 0.00 | 0.00 | 0.01 | 0.01 |
| 1GE | 0.10 | 0.08 | 0.01 | 0.00 | 0.25 | 0.48 | 0.02 | 0.05 | 0.00 | 0.00 | 0.01 | 0.01 |

Source: JICA Study Team

### Table 4.6.3 Reserve Quantity by Sub-basin for Water Balance Study

| Sub-basin | Catchment Area ($km^2$) | Accumulated Catchment Area ($km^2$) | River Name | Reserve *1 ($m^3/s$) | Node *2 |
|---|---|---|---|---|---|
| 1GA | 454 | | Nyando River | 0.6 | 2 |
| 1GB | 522 | 976 | | 0.8 | 6 |
| 1GC | 902 | | | 2.0 | 12 |
| 1GG | 385 | | | 0.3 | 14 |
| 1GD | 652 | 2,915 | | 1.3 | 29 |
| 1GE | 371 | | | 0.0 | 31 |
| 1GF | 317 | 3,604 | | 0.0 | 38 |
| | | | | | |
| 1HA1 | 350 | | | 0.4 | 45 |
| | | | | | |
| 1HA2 | 543 | | | 0.0 | 48 |
| | | | | | |
| 1HB1 | 487 | | | 0.0 | 50 |
| | | | | | |
| 1HB2 | 267 | | | 0.0 | 53 |
| | | | | | |
| 1HD | 779 | | | 0.0 | 55 |
| | | | | | |
| 1HE | 737 | | | 0.0 | 57 |
| | | | | | |
| 1HF | 861 | | | 0.0 | 59 |
| | | | | | |
| 1HG | 336 | | | 0.0 | 61 |
| | | | | | |
| 1JB | 178 | | Sondu River | 0.5 | 69 |
| 1JA | 849 | 1,028 | | 3.2 | 74 |
| 1JC | 340 | | | 1.7 | 76 |
| 1JD | 217 | 1,585 | | 6.6 | 82 |
| 1JE | 581 | | | 0.7 | 85 |
| 1JF | 990 | 1,570 | | 3.9 | 92 |
| 1JG1 | 230 | 3,385 | | 10.2 | 101 |
| 1JG2 | 89 | 3,474 | | 10.5 | 109 |
| | | | | | |
| 1KA | 469 | | Gucha/Migori River | 0.0 | 112 |
| 1KC | 2,921 | | | 1.7 | 129 |
| 1KB | 3,453 | 6,843 | | 2.3 | 134 |
| | | | | | |
| 1LB1 | 1,475 | | Mara River | 1.6 | 140 |
| 1LA1 | 924 | | | 1.2 | 142 |
| 1LA2 | 1,008 | 3,406 | | 4.8 | 147 |
| 1LB2 | 2,677 | | | 0.0 | 149 |
| 1LA3 | 2,455 | 8,538 | | 5.7 | 162 |

Note: *1 = Reserve was set at 95% value of the naturalized present daily flow duration curve with a probability of once in 10 years.
*2 = Node numbers in Figure 4.6.3.
Source: JICA Study Team

# Table 4.6.4 Dam Candidates (LVSCA)

(1) Priority Dams proposed in NWMP (1992)

| Catchment Area | | Proposed Dams | Sub-basin | Stage | Purpose | Related Agency/ Owner | Status/ Construction Year | Source of Information | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| 2. | LVS | 3. Londiani | 1GC | M/P | W | NWCPC/ LVSWSB | Pre-F/S done (2012) | NWCPC/ LVSWSB | 2008-12 Flagship Projects under Vision 2030 |
| | | 4. Kibos | 1HA | M/P | W | LBDA/ LVSWSB | (No.51 site) At M/P level. | NWCPC | Integrated Flood Management for Nyando River Basin Study (2009). |
| | | 5. Itare | 1JA | M/P | W | RVWSB | A study is done (1998). | NWCPC/ RVWSB | 2008-12 Flagship Projects under Vision 2030, Nakuru Water Supply and Sanitation Study (1998) |
| | | 6. Sondu/Miriu | 1JG | D/D | P, I | KenGen/ LBDA | Completed (2007) | KenGen, WRMA | |
| | | 7. Magwagwa | 1JG | F/S | P, I | LBDA/ MORDA | F/S, D/D, T/D completed (2012) | MORDA | MORDA 18 Projects, Construction will start soon. |
| | | 8. Bunyunyu | 1KB | M/P | W | NWCPC | D/D done (2011) | NWCPC | 2008-12 Flagship Projects under Vision 2030 |

(2) Future Development Potential Dams at the time of NWMP (1992)

| | | **NWMP (1992)** | | | | **Current Status** | | | |
|---|---|---|---|---|---|---|---|---|---|
| Catchment Area | | Future Development Potential Dams | | Sub-basin | Purpose | Related Agency/ Owner | Status/ Construction Year | Source of Information | Remarks |
| 2. | LVS | 09 | Nyando | 1GD1 | W, I, F | MORDA | (No.11 site) At M/P level | WRMA | Integrated Flood Management for Nyando River Basin Study (2009) |
| | | | | | | NWCPC | (Koru at No.8A site) F/S done (2009), Preliminary design ongoing | NWCPC | 2008-12 Flagship Projects under Vision 2030 |
| | | 10 | Timbilil | 1JC | W | LVSWSB | Pre-F/S done | LVSWSB, WRMA | Kericho Water Supply |
| | | 11 | Sisei | 1JF | W | | | | No information is found. |
| | | 12 | Katieno | 1KB | W | NIB/ LBDA | Pre-F/S done (2010) | NIB | Pre-F/S to compare Katieno with Gogo Falls |
| | | 13 | Namba Kodero | 1KC | W, P | | | | No information is found. |
| | | 14 | Amala | 1LB1 | W | - | No further study is done. | WRMA | |

(3) Dam Schemes Studied by Government

| | | **Identified Dams** | | | | **Current Status** | | | |
|---|---|---|---|---|---|---|---|---|---|
| Catchment Area | | Dams not in NWMP (1992) | | Sub-basin | Purpose | Related Agency/ Owner | Status/ Construction Year | Source of Information | Remarks |
| 2. | LVS | 4 | Awasi | 1GD1 | I, P, F | NWCPC | No study is started. | NWCPC | 2008-12 Flagship Projects under Vision 2030 |
| | | 5 | Ilooiterre | 1KC | W, I, P | ENSDA | Pre-F/S done. | ENSDA | |
| | | 6 | Sand River (Naikara) | 1LA3 | I, F, P | ENSDA/ MORDA | No study is started. | MORDA | MORDA Strategic Plan 2008-12 |

Note:
Purpose: W=water supply, I=irrigation, P=hydropower, F=flood control
Project Stage: M/P=master plan, Pre-F/S=prefeasibility study, F/S=feasibility study, D/D=detailed design, T/D=tender documents, U/C=under construction

Source: JICA Study Team based on NWMP (1992) and information from the government agencies mentioned in the above tables.

# Table 4.6.5 Water Transfer Candidates (LVSCA)

(1) Priority Water Transfer Schemes proposed in NWMP (1992)

a) Intra-basin Bulk Water Transfer Schemes

| Catchment Area | | | NWMP (1992) Intra- basin Water Transfer | | | | Current Status | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | No. | Sub-basin | Water Source | Sub-basin | Notes | Related Agency / Owner | Status/ Construction Year | Source of Information | Remarks |
| 2. | LVS | R4 | 1GC | Londiani Dam | 1GC | | NWCPC/ LVSWSB | Pre-F/S done. | NWCPC, LVSWSB | |
| | | R5 | 1HA | Kibos Dam | 1HA | | LBDA/ LVSWSB | at M/P level | LVSWSB | |
| | | R6 | 1KB | Bunyunyu Dam | 1KA | | NWCPC | D/D done. | NWCPC | |
| | | | | | 1KB | | NWCPC | D/D done. | NWCPC | |

b) Inter-basin Bulk Water Transfer Schemes

| Catchment Area | | | NWMP (1992) Inter- basin Water Transfer | | | | Current Status | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | No. | Sub-basin | Water Source | Sub-basin | Notes | Related Agency / Owner | Status/ Construction Year | Source of Information | Remarks |
| 2. | LVS | E3 | 1JA | Itare Dam | 2EC | | RVWSB | A study was done. | RVWSB | Nakuru Water Supply and Sanitation Study (1998) |
| | | | | | 2EG1 | | RVWSB | A study was done. | RVWSB | Nakuru Water Supply and Sanitation Study (1998) |
| | | | | | 2FC | | RVWSB | A study was done. | RVWSB | Nakuru Water Supply and Sanitation Study (1998) |
| | | | | | 2FC | | RVWSB | A study was done. | RVWSB | Nakuru Water Supply and Sanitation Study (1998) |

(2) Water Transfer Schemes Studied by Government

a) Intra-basin Bulk Water Transfer Schemes
None

b) Inter-basin Bulk Water Transfer Schemes

| Catchment Area | | No. | Sub-basin | Water Source | Sub-basin | Related Agency / Owner | Status/ Construction Year | Source of Information | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| 2. | LVS | | 1GC | Koru Dam (at No.8A site) | 1HA | NWCPC | Preliminary design ongoing | NWCPC | |
| | | | 1JG | Magwagwa Dam | 1GF | LBDA/ MORDA | F/S, D/D completed | MORDA | |
| | | | 1LB1 | Amala Transfer | 2KA | ENSDA/ MORDA | F/S, D/D ongoing | ENSDA | |

Note:
Project Stage: M/P=master plan, Pre-F/S=prefeasibility study, F/S=feasibility study, D/D=detailed design, T/D=tender documents, U/C=under construction
* = Listed by NWCPC as "Inter-basin Transfer Schemes."

Source: JICA Study Team based on NWMP (1992) and information from the government agencies mentioned in the above tables.

## Table 4.6.6 Proposed of Dams and Water Transfer (LVSCA)

(1) Proposed Dams

| No. | Name of Dam | Sub-basin | Relevant County | Purpose 1) | Effective Storage Volume (MCM) | Storage Volume Allocation (MCM) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Domestic and Industrial | Irrigation | Hydro-power | Flood Control |
| 8 | Londiani | 1GC | Kericho | W (Londiani, Kipkerion and RVCA) | 25.0 | 25.0 | 0.0 | | |
| 9 | Nyando (Koru) | 1GD1 | Kisumu, Kericho | W (Muhoroni, Awasi, Ahero, Kisumu), I (3,000 ha), F | 2) *86.6* | 4) 14.0 | 19.0 | | 53.6 |
| 10 | Kibos | 1HA | Nandi | W (Kisumu), F | 26.0 | 26.0 | 0.0 | | |
| 11 | Itare | 1JA | Nakuru | W (Litein and RVCA) | 20.0 | 20.0 | 0.0 | | |
| 12 | Magwagwa | 1JG | Bomet, Nyamira | W, I (15,000 ha), P (115 MW), F | *445.0* | 4) 3.0 | 5) (442.0) | 442.0 | |
| 13 | Bunyunyu | 1KB | Kisii | W (Rongo, Tabaka, Suneka, Kisii, Awendo, Ogembo, Keroko) | *6.3* | 6.3 | 0.0 | | |
| 14 | Katieno | 1KB | Migori | I (40,500ha) | 201.0 | 0.0 | 201.0 | | |
| 15 | Ilooiterre | 1KC | Narok | W, I (3,000 ha) | *13.6* | 4) 4.0 | 9.6 | | |
| 16 | Sand River (Naikara) | 1LA3 | Narok | W | 1.0 | 1.0 | 0.0 | | |
| 17 | Amala | 1LB1 | Bomet, Narok | W, I (5,000 ha and RVCA) | 175.0 | 1.0 | 174.0 | | |
| | Total | | | | 999.5 | 100.3 | 403.6 | 442.0 | 53.6 |

Note:
1) W=Domestic and industrial water supply, I=Irrigation, P=Hydropower, F=Flood control
2) Figures in Italic Font are those proposed by the Kenyan Government.
3) An adjustment is made to the effective storage volume by deducting dead storage volume from the reservoir storage volume indicated in the existing reports.
4) Allocated storage volumes are estimated by the JICA Study Team, since these are not available in the existing design reports.
5) Storage volumes in parentheses mean that the volumes are to be used first for hydropower generation and then used for irrigation and/ or domestic water purpose.
Source: JICA Study Team

(2) Proposed Water Transfer

| Wter Transfer Scheme | | Relevant County | Purpose | Capacity, Dimensions |
|---|---|---|---|---|
| 3 | Itare and Londiani Dams to Nakuru (RVCA) | Nakuru | W | Capacity of 41 MCM/year, Tunnel of 14.5 km long, Pipeline of 120 km long |
| 4 | Amala Transfer from Amala Dam to RVCA | Narok | W, I, P | Capacity of 82 MCM/year, Tunnel of 3.8 km long |

Source: JICA Study Team based on NWMP (1992) and data from NWCPC, MORDA, RDAs, and WSBs

# Table 4.6.7 Balance between Water Resources and Water Demands in 2030 (LVSCA)

(Unit: MCM/year)

| No. | Sub basin | CA ($km^2$) | Major Domestic Demand Centre | Domestic and Industrial | | | | | | | | | | Irrigation | | | | | | | | Livestock | | | Wildlife | | | Fisheries | | | Summary | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Surface Water | | | | | | | | Surface Water | | | | | | | SW | | | SW | | | SW | | | Surface Water | | | | | |
| | | | | Demand | Demand (Domestic ) | Demand( Industrial) | Deficit | River Water | Dam | Transfer | Small Dam/ Water Pans | Groundwater | Balance | Demand | Deficit | River Water | Dam | Transfer | Small Dam/ Water Pans | Groundwater | Balance | Demand | Small Dam/ Water Pans | Balance | Demand | Small Dam/ Water Pans | Balance | Demand | Small Dam/ Water Pans | Balance | Demand | River Water | Dam | Transfer | Small Dam/ Water Pans | Groundwater | Balance |
| 1 | 1GA | 454 | Yala, Siaya | 1.9 | 1.8 | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 | 0.0 | 1.3 | 0.0 | 6.9 | 0.0 | 5.9 | 0.0 | 0.0 | 0.7 | 0.3 | 0.0 | 1.2 | 1.2 | 0.0 | 0.1 | 0.1 | 0.0 | 0.3 | 0.3 | 0.0 | 10.3 | 6.5 | 0.0 | 0.0 | 2.2 | 1.6 | 0.0 |
| 2 | 1GB | 522 | | 2.2 | 2.2 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 1.9 | 0.0 | 16.9 | 0.0 | 14.7 | 0.0 | 0.0 | 0.8 | 1.5 | 0.0 | 1.6 | 1.6 | 0.0 | 0.1 | 0.1 | 0.0 | 0.6 | 0.6 | 0.0 | 21.3 | 15.0 | 0.0 | 0.0 | 3.0 | 3.3 | 0.0 |
| 3 | 1GC | 902 | Kipkelion, Londiani | 26.2 | 25.0 | 1.2 | -2.1 | 20.4 | 2.1 | 0.0 | 0.0 | 3.7 | 0.0 | 3.1 | 0.0 | 1.5 | 0.0 | 0.0 | 1.3 | 0.3 | 0.0 | 2.5 | 2.5 | 0.0 | 0.1 | 0.1 | 0.0 | 0.5 | 0.5 | 0.0 | 32.4 | 21.8 | 2.1 | 0.0 | 4.5 | 4.0 | 0.0 |
| 4 | 1GD | 652 | Ahero, Awasi, Muhoroni | 35.3 | 29.4 | 5.9 | -4.6 | 24.3 | 4.6 | 0.0 | 0.0 | 6.4 | 0.0 | 45.9 | -13.0 | 8.6 | 34.0 | 0.0 | 1.0 | 2.3 | 0.0 | 2.5 | 2.5 | 0.0 | 0.1 | 0.1 | 0.0 | 0.3 | 0.3 | 0.0 | 84.0 | 32.8 | 38.6 | 0.0 | 3.8 | 8.7 | 0.0 |
| | Reference Point (1GD03) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | 1GE | 371 | | 2.7 | 2.5 | 0.2 | -0.5 | 0.8 | 0.5 | 0.0 | 0.0 | 1.4 | 0.0 | 15.7 | -33.5 | 12.4 | 0.0 | 0.0 | 0.5 | 2.8 | 0.0 | 1.4 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.3 | 0.0 | 20.1 | 13.2 | 0.5 | 0.0 | 2.3 | 4.2 | 0.0 |
| 6 | 1GF | 317 | | 1.3 | 1.3 | 0.0 | -0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 1.2 | 0.0 | 14.4 | 0.0 | 9.6 | 0.0 | 0.0 | 0.5 | 4.3 | 0.0 | 1.3 | 1.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.3 | 0.0 | 17.3 | 9.7 | 0.0 | 0.0 | 2.0 | 5.5 | 0.0 |
| 7 | 1GG | 385 | | 1.9 | 1.8 | 0.0 | 0.0 | 1.1 | 0.0 | 0.0 | 0.0 | 0.8 | 0.0 | 2.3 | 0.0 | 1.0 | 0.0 | 0.0 | 0.6 | 0.7 | | 1.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.9 | 0.9 | 0.0 | 6.2 | 2.1 | 0.0 | 0.0 | 2.6 | 1.5 | 0.0 |
| 8 | 1JA | 849 | Litein | 8.1 | 7.9 | 0.2 | 0.0 | 5.0 | 0.0 | 0.0 | 0.0 | 3.1 | 0.0 | 29.1 | 0.0 | 24.6 | 0.0 | 0.0 | 1.7 | 2.8 | 0.0 | 2.2 | 2.2 | 0.0 | 0.1 | 0.1 | 0.0 | 0.2 | 0.2 | 0.0 | 39.8 | 29.6 | 0.0 | 0.0 | 4.2 | 6.0 | 0.0 |
| 9 | 1JB | 178 | | 1.3 | 1.3 | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 | 0.0 | 0.7 | 0.0 | 1.8 | 0.0 | 0.3 | 0.0 | 0.0 | 0.4 | 1.2 | 0.0 | 0.5 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.3 | 0.0 | 3.9 | 0.9 | 0.0 | 0.0 | 1.2 | 1.9 | 0.0 |
| 10 | 1JC | 340 | Kericho | 28.2 | 24.7 | 3.5 | -3.0 | 21.2 | 0.0 | 0.0 | 5.7 | 1.2 | 0.0 | 10.5 | 0.0 | 9.9 | 0.0 | 0.0 | 0.7 | 0.0 | | 1.1 | 1.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.3 | 0.0 | 40.2 | 31.1 | 0.0 | 0.0 | 7.9 | 1.2 | 0.0 |
| 11 | 1JD | 217 | | 1.8 | 1.7 | 0.1 | -0.1 | 0.9 | 0.0 | 0.0 | 0.2 | 0.7 | 0.0 | 12.0 | 0.0 | 11.5 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.8 | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.5 | 0.0 | 15.2 | 12.4 | 0.0 | 0.0 | 2.0 | 0.7 | 0.0 |
| 12 | 1JE | 581 | Nyansiongo | 5.8 | 5.7 | 0.1 | 0.0 | 2.8 | 0.0 | 0.0 | 0.0 | 3.0 | 0.0 | 25.3 | 0.0 | 19.4 | 0.0 | 0.0 | 1.2 | 4.8 | 0.0 | 3.0 | 3.0 | 0.0 | 0.1 | 0.1 | 0.0 | 0.2 | 0.2 | 0.0 | 34.3 | 22.1 | 0.0 | 0.0 | 4.4 | 7.8 | 0.0 |
| 13 | 1JF | 990 | Sotik | 9.2 | 9.0 | 0.2 | 0.0 | 4.8 | 0.0 | 0.0 | 0.0 | 4.4 | 0.0 | 20.8 | 0.0 | 18.8 | 0.0 | 0.0 | 2.0 | 0.1 | 0.0 | 3.6 | 3.6 | 0.0 | 0.1 | 0.1 | 0.0 | 1.0 | 1.0 | 0.0 | 34.8 | 23.6 | 0.0 | 0.0 | 6.7 | 4.4 | 0.0 |
| 14 | 1JG1 | 230 | | 3.5 | 3.4 | 0.1 | -1.2 | 1.7 | 0.0 | 0.0 | 1.2 | 0.6 | 0.0 | 143.4 | -33.8 | 7.0 | 136.0 | 0.0 | 0.5 | 0.0 | 0.0 | 1.1 | 1.1 | 0.0 | 0.0 | 0.0 | 0.0 | 2.9 | 2.9 | 0.0 | 151.0 | 8.7 | 136.0 | 0.0 | 5.8 | 0.6 | 0.0 |
| | Reference Point (1JG05) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 15 | 1JG2 | 89 | | 0.6 | 0.6 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 6.3 | 0.0 | 5.6 | 0.0 | 0.0 | 0.2 | 0.5 | 0.0 | 0.4 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 1.2 | 1.2 | 0.0 | 8.5 | 5.8 | 0.0 | 0.0 | 1.8 | 0.9 | 0.0 |
| 16 | 1KA | 469 | | 66.7 | 63.6 | 3.0 | -17.7 | 41.3 | 17.7 | 0.0 | 1.4 | 6.2 | 0.0 | 14.0 | 0.0 | 13.4 | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 | 2.4 | 2.4 | 0.0 | 0.1 | 0.1 | 0.0 | 0.3 | 0.3 | 0.0 | 83.4 | 54.6 | 17.7 | 0.0 | 4.8 | 6.2 | 0.0 |
| 17 | 1KB | 3,453 | Keroko, , Awendo, Ogembo | 67.7 | 65.5 | 2.2 | -2.3 | 42.9 | 2.3 | 0.0 | 0.0 | 22.6 | 0.0 | 441.0 | -156.4 | 18.2 | 413.0 | 0.0 | 4.9 | 4.9 | 0.0 | 16.6 | 16.6 | 0.0 | 0.4 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 525.7 | 61.1 | 415.3 | 0.0 | 21.9 | 27.5 | 0.0 |
| | Reference Point (1KB03) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 18 | 1KC | 2,921 | Migori, Kehancha | 35.7 | 34.5 | 1.3 | -0.6 | 25.1 | 0.6 | 0.0 | 0.0 | 10.0 | 0.0 | 55.5 | -6.1 | 12.6 | 31.0 | 0.0 | 4.1 | 7.8 | 0.0 | 15.3 | 15.3 | 0.0 | 0.4 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 106.9 | 37.8 | 31.6 | 0.0 | 19.7 | 17.8 | 0.0 |
| | Reference Point (1FG01) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 19 | 1LA1 | 924 | Bomet | 24.5 | 23.5 | 1.0 | -0.9 | 18.4 | 0.0 | 0.0 | 0.0 | 6.1 | 0.0 | 9.1 | 0.0 | 7.5 | 0.0 | 0.0 | 0.8 | 0.9 | 0.0 | 3.6 | 3.6 | 0.0 | 0.1 | 0.1 | 0.0 | 0.1 | 0.1 | 0.0 | 37.4 | 25.9 | 0.0 | 0.0 | 4.6 | 6.9 | 0.0 |
| 20 | 1LA2 | 1,008 | | 2.0 | 2.0 | 0.0 | 0.0 | 0.8 | 0.0 | 0.0 | 0.0 | 1.2 | 0.0 | 2.1 | 0.0 | 1.3 | 0.0 | 0.0 | 0.8 | 0.0 | 0.0 | 4.0 | 4.0 | 0.0 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 8.2 | 2.1 | 0.0 | 0.0 | 5.0 | 1.2 | 0.0 |
| | Reference Point (1LA04) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 21 | 1LA3 | 3,024 | | 2.4 | 2.4 | 0.0 | -0.2 | 0.5 | 0.2 | 0.0 | 0.0 | 1.8 | 0.0 | 19.3 | 0.0 | 15.7 | 0.0 | 0.0 | 2.0 | 1.5 | 0.0 | 8.0 | 8.0 | 0.0 | 0.3 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 29.9 | 16.2 | 0.2 | 0.0 | 10.3 | 3.3 | 0.0 |
| 22 | 1LB1 | 1,475 | | 4.9 | 4.8 | 0.1 | 0.0 | 2.1 | 0.0 | 0.0 | 0.0 | 2.8 | 0.0 | 60.8 | -8.1 | 14.2 | 45.0 | 0.0 | 1.2 | 0.4 | 0.0 | 4.7 | 4.7 | 0.0 | 0.2 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 70.5 | 16.2 | 45.0 | 0.0 | 6.1 | 3.2 | 0.0 |
| 23 | 1LB2 | 2,677 | | 1.4 | 1.4 | 0.0 | -0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 1.4 | 0.0 | 19.2 | 0.0 | 8.6 | 0.0 | 0.0 | 2.2 | 8.3 | 0.0 | 6.2 | 6.2 | 0.0 | 0.3 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 27.2 | 8.7 | 0.0 | 0.0 | 8.8 | 9.7 | 0.0 |
| 24 | 1HA1 | 350 | Kisumu | 99.4 | 80.0 | 19.4 | -55.9 | 41.3 | 26.7 | 15.7 | 13.5 | 2.2 | 0.0 | 9.9 | 0.0 | 9.4 | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 | 1.7 | 1.7 | 0.0 | 0.0 | 0.0 | 0.0 | 1.4 | 1.4 | 0.0 | 112.5 | 50.6 | 26.7 | 15.7 | 17.2 | 2.2 | 0.0 |
| 25 | 1HA2 | 543 | | 1.8 | 1.8 | 0.0 | -1.0 | 0.2 | 0.0 | 0.0 | 0.0 | 1.6 | 0.0 | 89.9 | -77.5 | 10.9 | 0.0 | 73.0 | 0.9 | 5.1 | 0.0 | 2.3 | 2.3 | 0.0 | 0.1 | 0.1 | 0.0 | 0.3 | 0.3 | 0.0 | 94.3 | 11.1 | 0.0 | 73.0 | 3.5 | 6.7 | 0.0 |
| 26 | 1HB1 | 487 | | 3.7 | 3.6 | 0.0 | -0.1 | 0.7 | 0.0 | 0.0 | 0.7 | 2.3 | 0.0 | 10.1 | 0.0 | 9.4 | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 | 2.2 | 2.2 | 0.0 | 0.1 | 0.1 | 0.0 | 0.7 | 0.7 | 0.0 | 16.8 | 10.1 | 0.0 | 0.0 | 4.4 | 2.3 | 0.0 |
| 27 | 1HB2 | 267 | | 1.4 | 1.4 | 0.0 | -0.5 | 0.2 | 0.0 | 0.0 | 0.0 | 1.2 | 0.0 | 9.8 | 0.0 | 9.3 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 1.3 | 1.3 | 0.0 | 0.0 | 0.0 | 0.0 | 1.1 | 1.1 | 0.0 | 13.6 | 9.5 | 0.0 | 0.0 | 2.8 | 1.2 | 0.0 |
| 28 | 1HC | 336 | | 3.3 | 3.2 | 0.0 | -0.7 | 1.0 | 0.0 | 0.0 | 0.0 | 2.3 | 0.0 | 5.6 | 0.0 | 4.2 | 0.0 | 0.0 | 0.9 | 0.6 | 0.0 | 2.4 | 2.4 | 0.0 | 0.1 | 0.1 | 0.0 | 0.4 | 0.4 | 0.0 | 11.8 | 5.1 | 0.0 | 0.0 | 3.8 | 2.8 | 0.0 |
| 28 | 1HD | 779 | Oyugis, Nyamira, Kendu Bay | 31.3 | 30.1 | 1.2 | -4.5 | 19.5 | 0.0 | 0.0 | 5.5 | 6.3 | 0.0 | 16.6 | 0.0 | 15.3 | 0.0 | 0.0 | 1.3 | 0.0 | 0.0 | 3.9 | 3.9 | 0.0 | 0.1 | 0.1 | 0.0 | 0.4 | 0.4 | 0.0 | 52.3 | 34.8 | 0.0 | 0.0 | 11.2 | 6.3 | 0.0 |
| 29 | 1HE | 737 | | 9.5 | 9.3 | 0.2 | -0.9 | 2.5 | 0.0 | 0.0 | 0.0 | 7.0 | 0.0 | 13.4 | 0.0 | 11.9 | 0.0 | 0.0 | 1.2 | 0.4 | 0.0 | 3.6 | 3.6 | 0.0 | 0.1 | 0.1 | 0.0 | 0.1 | 0.1 | 0.0 | 26.8 | 14.4 | 0.0 | 0.0 | 5.0 | 7.4 | 0.0 |
| 30 | 1HF | 861 | Homa Bay | 14.1 | 13.6 | 0.5 | -7.7 | 2.8 | 0.0 | 0.0 | 7.2 | 4.1 | 0.0 | 20.4 | 0.0 | 19.0 | 0.0 | 0.0 | 1.4 | 0.0 | 0.0 | 2.6 | 2.6 | 0.0 | 0.1 | 0.1 | 0.0 | 0.4 | 0.4 | 0.0 | 37.6 | 21.7 | 0.0 | 0.0 | 11.7 | 4.1 | 0.0 |
| 31 | 1HG | 336 | Mbita point | 4.7 | 4.5 | 0.2 | -1.3 | 2.0 | 0.0 | 0.0 | 2.0 | 0.7 | 0.0 | 7.3 | 0.0 | 6.8 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 1.1 | 1.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.0 | 13.2 | 8.8 | 0.0 | 0.0 | 3.7 | 0.7 | 0.0 |
| | | | | 504.3 | 463.6 | 40.7 | -106.0 | 248.1 | 93.6 | 15.7 | 37.6 | 110.4 | 0.0 | 1158.4 | -328.4 | 338.2 | 659.0 | 73.0 | 36.7 | 51.4 | 0.0 | 106.3 | 106.3 | 0.0 | 3.3 | 3.3 | 0.0 | 15.0 | 15.0 | 0.0 | 1787.4 | 624.0 | 713.7 | 88.7 | 199.0 | 161.9 | 0.0 |

Note: 1GC: Londiani Dam, 1GD,1GE : Nyando (Koru) Dam, 1HA1: Kibos Dam and Nyando (Koru) Dam, 1JG1: Magwagwa Dam, 1KA: Bynyunyu Dam, 1KB: Katieno Dam, 1KC: Ilooiterre Dam 1LA03: Sand River Dam, 1LB1: Amala Dam

Source: JICA Study Team

## Table 4.6.8 Naturalised River Flow, Reserve, Water Demands, and Yields and Supply Reliability at Reference Points (LVSCA)

| Catch-ment Area | Reference Point | River Name | Catchment Area at Reference Point ($km^2$) | Naturalised River Flow (1/10 Drought Discharge) *3 | Reserve ($m^3/s$) *1 | Present (2010) Water Demand ($m^3/s$) *2 | | Future (2030) Water Demand ($m^3/s$) *2 | | Yield of Water Resources Development ($m^3/s$) | Present (2010) Water Supply Reliability | Future (2030) Water Supply Reliability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Upstream of Reference Point | Downstream of Reference Point | Upstream of Reference Point | Downstream of Reference Point | | | |
| LVSCA | 1GD03 | Nyando | 2,625 | 1.5 | 1.6 | 0.9 | 0.7 | 3.3 | 2.1 | 3.8 | 1/2 | 1/5 |
| | 1JG05 | Sondu | 3,318 | 10.1 | 10.5 | 0.7 | 0.1 | 7.2 | 4.3 | 10.7 | 1/5 | 1/20 |
| | 1KB03 | Gucha | 1,114 | 0.3 | 0.4 | 0.6 | 0.2 | 6.0 | 1.9 | 7.1 | 1/2 | 1/10 |
| | 1KC03 | Migori | 3,046 | 1.4 | 1.5 | 0.3 | 0.5 | 2.2 | 3.6 | 5.0 | 1/3 | 1/20 |
| | 1LA04 | Mara | 1,475 | 4.1 | 4.3 | 0.3 | 0.1 | 3.4 | 0.1 | 3.1 | 1/20 | 1/10 |

Note: *1 = Reserve was set at 95% value of the naturalized present daily flow duration curve with a probability of once in 10 years.
*2 = Water demand was estimated by averaging the monthly demands of all water users during active irrigation period.
*3 = 1/10 drought discharge is the 355-day (97.3%) value of the naturalized daily flow duration curve with a probability of once in 10 years.

Source: JICA Study Team

## Table 5.2.1 Cost Estimate for Proposed Urban Water Supply Development (LVSCA)

| | Urban Centre | Service Population in 2030 | Water Demand in 2030 ($m^3$/day) | Rehabilitation Works ($m^3$/day) | Development Capacity ($m^3$/day) | Project Cost (KSh million) | | | | | O&M Cost (KSh million/year) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Total | Rehabilitation Works | Major Dam/ Major Transmission | Intake/ Minor Transmission | Distribution | |
| Kisumu and Surrounding Area | | | | | | | | | | | |
| 1 | Kisumu | 1,457,208 | 212,752 | 46,400 | 166,352 | 34,574 | 2,670 | | 5,317 | 26,587 | 1,553 |
| 2 | Ahero | 255,366 | 30,389 | 0 | 50,789 | 9,747 | 0 | | 1,623 | 8,117 | 474 |
| 3 | Awasi | 172,268 | 20,500 | 100 | | | | | | | |
| 4 | Muhoroni | 173,451 | 20,641 | 720 | 19,921 | 3,862 | 41 | | 637 | 3,184 | 186 |
| 5 | Kipkelion | 235,382 | 28,010 | 280 | 53,579 | 10,292 | 16 | | 1,713 | 8,563 | 500 |
| 6 | Londiani | 217,220 | 25,849 | 0 | | | | | | | |
| | Major Water Sourece Works | | | | | | | | | | |
| | Nandi Forest | | | | | 7,126 | | 7,126 | | | 36 |
| | Nyando (Koru) | | | | | 8,175 | | 8,175 | | | 41 |
| | Kibos | | | | | 9,044 | | 9,044 | | | 45 |
| | Sub-total | 2,510,895 | 338,141 | 47,500 | 290,641 | 82,820 | 2,733 | 24,345 | 9,290 | 46,452 | 2,835 |
| Kisii and Surrounding Area | | | | | | | | | | | |
| 1 | Rongo | 519,406 | 61,809 | 2,320 | 59,489 | 11,543 | 133 | | 1,902 | 9,508 | 555 |
| 2 | Kisii | 411,773 | 49,001 | 19,500 | 29,501 | 6,780 | 1,122 | | 943 | 4,715 | 275 |
| 3 | Suneka | 255,809 | 30,441 | 0 | 30,441 | 5,838 | 0 | | 973 | 4,865 | 284 |
| 4 | Keroka | 209,679 | 24,952 | 600 | 24,352 | 4,705 | 35 | | 778 | 3,892 | 227 |
| 5 | Awendo | 80,193 | 9,543 | 2,000 | 7,543 | 1,562 | 115 | | 241 | 1,206 | 70 |
| 6 | Tabaka | 52,467 | 6,244 | 150 | 6,094 | 1,177 | 9 | | 195 | 974 | 57 |
| 7 | Ogembo | 11,674 | 1,389 | 600 | 789 | 186 | 35 | | 25 | 126 | 7 |
| | Major Water Sourece Works | | | | | | | | | | |
| | Bunyunyu Dam | | | | | 2,080 | | 2,080 | | | 10 |
| | Sub-total | 1,541,001 | 183,379 | 25,170 | 158,209 | 33,871 | 1,448 | 2,080 | 5,057 | 25,286 | 1,487 |
| Other Area | | | | | | | | | | | |
| 1 | Kericho | 512,485 | 60,986 | 12,960 | 48,026 | 9,957 | 746 | | 1,535 | 7,676 | 448 |
| 2 | Bomet | 421,478 | 50,156 | 450 | 49,706 | 9,559 | 26 | | 1,589 | 7,944 | 464 |
| 3 | Migori | 267,297 | 31,808 | 16,056 | 15,752 | 3,945 | 924 | | 504 | 2,518 | 147 |
| 4 | Homa Bay | 218,278 | 25,975 | 5,500 | 20,475 | 4,243 | 316 | | 654 | 3,272 | 191 |
| 5 | Nyamira | 209,750 | 24,960 | 3,200 | 41,076 | 8,173 | 184 | | 1,313 | 6,565 | 383 |
| 6 | Oyugis | 178,454 | 21,236 | 1,920 | | | 110 | | | | |
| 7 | Kehancha | 151,564 | 18,036 | 320 | 17,716 | 3,416 | 18 | | 566 | 2,831 | 165 |
| 8 | Kendu Bay | 74,234 | 8,834 | 720 | 8,114 | 1,598 | 41 | | 259 | 1,297 | 76 |
| 9 | Mbita Point | 60,351 | 7,182 | 0 | 7,182 | 1,377 | 0 | | 230 | 1,148 | 67 |
| 10 | Litein | 45,823 | 5,453 | 5,453 | 0 | 343 | 314 | | 0 | 0 | 0 |
| 11 | Sotik | 42,113 | 5,011 | 500 | | | 29 | | | | |
| 12 | Nyansiongo | 28,376 | 3,377 | 600 | 2,777 | 567 | 35 | | 89 | 444 | 26 |
| | Sub-total | 2,210,203 | 263,014 | 47,679 | 210,824 | 43,177 | 2,743 | | 6,739 | 33,695 | 1,968 |
| | | | | | | | | | | | |
| Total | | 6,262,099 | 784,534 | 120,349 | 659,674 | 159,868 | 6,921 | 26,424 | 21,086 | 105,437 | 6,289 |

Source: JICA Study Team

## Table 5.2.2 Cost Estimate for Proposed Large Scale Rural Water Supply Development (LVSCA)

| | Item | Service Population in 2030 | Water Demand in 2030 ($m^3$/day) | Rehabilitation Works ($m^3$/day) | Development Capacity ($m^3$/day) | Project Cost (KSh million) | | | | | O&M Cost (KSh million/year) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Total | Rehabilitation Works | Major Dam/ Major Transmission | Intake/ Minor Transmission | Distribution | |
| 1 | Other Urban Pop. | 1,731,843 | 206,089 | 26,089 | 180,000 | 36,025 | 1,500 | 0 | 5,754 | 28,772 | 1,680 |
| 2 | Rural Pop. | 935,056 | 71,064 | 10,150 | 60,914 | 11,684 | 0 | 0 | 1,947 | 9,737 | 569 |
| | Major Water Sourece Works | | | | | | | | | | |
| | Magwagwa | | | | | 68 | | 68 | | | 0 |
| | Katieno | | | | | 0 | | 0 | | | 0 |
| | Ilooiterre | | | | | 426 | | 426 | | | 2 |
| | Sand River (Naikara) | | | | | 1,466 | | 1,466 | | | 7 |
| | Amala | | | | | 111 | | 111 | | | 1 |
| Total | | 2,666,899 | 277,154 | 36,239 | 240,915 | 49,780 | 1,500 | 2,071 | 7,701 | 38,508 | 2,259 |

Source: JICA Study Team

## Table 5.2.3 Cost Estimate for Proposed Sewerage Development (LVSCA)

| Major Urban Area | | Service Population in 2030 | Required Capacity in 2030 ($m^3$/day) | Current Capacity in 2010 ($m^3$/day) | Capacity to be developed ($m^3$/day) | Project Cost (KSh million) | | | O&M Cost (KSh million/year) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Total | Rehabilitation Works | Expansion/ New Construct. | |
| 1 | Kisumu | 1,457,208 | 136,103 | 17,800 | 118,303 | 21,081 | 910 | 20,171 | 1,104 |
| 2 | Rongo | 519,406 | 39,579 | 0 | 39,579 | 6,747 | 0 | 6,747 | 369 |
| 3 | Kericho | 512,485 | 39,051 | 1,500 | 37,551 | 6,478 | 77 | 6,402 | 350 |
| 4 | Bomet | 421,478 | 32,117 | 0 | 32,117 | 5,475 | 0 | 5,475 | 300 |
| 5 | Kisii | 411,773 | 31,377 | 1,260 | 30,117 | 5,199 | 64 | 5,134 | 281 |
| 6 | Migori | 267,297 | 20,368 | 0 | 20,368 | 3,472 | 0 | 3,472 | 190 |
| 7 | Suneka | 255,809 | 19,493 | 0 | 19,493 | 3,323 | 0 | 3,323 | 182 |
| 8 | Ahero | 255,366 | 19,459 | 0 | 19,459 | 3,317 | 0 | 3,317 | 182 |
| 9 | Kipkelion | 235,382 | 17,936 | 0 | 17,936 | 3,058 | 0 | 3,058 | 167 |
| 10 | Homa Bay | 218,278 | 16,633 | 1,231 | 15,402 | 2,689 | 63 | 2,626 | 144 |
| 11 | Londiani | 217,220 | 16,552 | 0 | 16,552 | 2,822 | 0 | 2,822 | 154 |
| 12 | Nyamira | 209,750 | 15,983 | 0 | 15,983 | 2,725 | 0 | 2,725 | 149 |
| 13 | Keroka | 209,679 | 15,978 | 0 | 15,978 | 2,724 | 0 | 2,724 | 149 |
| 14 | Oyugis | 178,454 | 13,598 | 0 | 13,598 | 2,318 | 0 | 2,318 | 127 |
| 15 | Muhoroni | 173,451 | 13,217 | 0 | 13,217 | 2,253 | 0 | 2,253 | 123 |
| 16 | Awasi | 172,268 | 13,127 | 0 | 13,127 | 2,238 | 0 | 2,238 | 123 |
| 17 | Kehancha | 151,564 | 11,549 | 0 | 11,549 | 1,969 | 0 | 1,969 | 108 |
| 18 | Awendo | 80,193 | 6,111 | 0 | 6,111 | 1,042 | 0 | 1,042 | 57 |
| 19 | Kendu Bay | 74,234 | 5,657 | 0 | 5,657 | 964 | 0 | 964 | 53 |
| Total | | 6,021,294 | 483,887 | 21,791 | 462,096 | 79,895 | 1,114 | 78,781 | 4,313 |

Source: JICA Study Team

## Table 5.2.4 Cost Estimate for Proposed Irrigation Development (LVSCA)

| Category | Irrigation Area in 2030 (ha) | Project Cost* (KSh million) | | | Annual O&M Cost (KSh million) |
|---|---|---|---|---|---|
| | | Irrigation System | Multipurpose Dam Cost Allocation** | Total Project Cost | |
| Large Scale Irrigation | 75,572 | 78,869 | 49,388 | 128,257 | 385 |
| Small Scale Irrigation | 22,501 | 14,540 | - | 14,540 | 73 |
| Private Irrigation | 15,133 | 29,338 | - | 29,338 | 293 |
| Total | 113,206 | 122,747 | 49,388 | 172,135 | 751 |

Note: *: Project cost includes direct construction cost, physical contingency, engineering services and indirect costs.
**: Refer to Sectoral Report (G)

Source: JICA Study Team, based on data from relevant government authorities

**Table 5.2.5 Cost Estimate for Proposed Hydropower Projects (LVSCA)**

| Catchment Area | No. | Name of Plan | Installed Capacity | Estimated Cost | | | | Purpose |
|---|---|---|---|---|---|---|---|---|
| | | | | Dam Allocation Cost (KSh million) | Hydropower Component cost (KSh million) | Total Project Cost (KSh million) | Annual O&M Cost (KSh million) | |
| LVSCA | 4 | Magwagwa Multipurpose Dam Development Plan | 115 MW | 14,269 | 31,786 | 46,055 | 230 | Water Supply, Irrigation, Hydropower |
| | Total | | 115 MW | 14,269 | 31,786 | 46,055 | 230 | |

Source: JICA Study Team based on information from MORDA, KenGen and Regional Development Authorities

**Table 5.2.6 Cost Estimate for Proposed Dams and Water Transfer (LVSCA)**

Dams

| | Name of Dam | Sub-basin | Purpose 1) | Effective Storage (MCM) | Study Stage 2) | Cost (KSh million) |
|---|---|---|---|---|---|---|
| 8 | Londiani | 1GC | W | 25.0 | Pre-F/S done in 2012 | 6,137 |
| 9 | Nyando (Koru) | 1GD1 | W, I, F | 86.6 | Preliminary Design ongoing | 19,179 |
| 10 | Kibos | 1HA | W, F | 26.0 | NWMP 2030 | 8,950 |
| 11 | Itare | 1JA | W | 20.0 | NWMP 2030 | 5,114 |
| 12 | Magwagwa | 1JG | W, I, P, F | 445.0 | D/D completed | 20,202 |
| 13 | Bunyunyu | 1KB | W | 6.3 | Final Design completed | 2,046 |
| 14 | Katieno | 1KB | I | 201.0 | Pre-F/S done | 5,455 |
| 15 | Ilooiterre | 1KC | W, I | 13.6 | Pre-F/S done | 1,449 |
| 16 | Sand River (Naikara) | 1LA3 | W, F | 20.0 | Proposed by MORDA | 5,711 |
| 17 | Amala | 1LB1 | W, I | 175.0 | NWMP 2030 | 20,031 |
| Total | | | | 1,018.5 | | 94,274 |

Note: 1) W=Domestic and industrial water supply, I=Irrigation, P=Hydropower, F=Flood control
2) D/D=Detailed Design, F/S=Feasibility Study, Pre-F/S=Pre-Feasibility Study, M/P=Master Plan

Water Transfer

| | Wter Transfer Scheme | Purpose | Capacity, Dimensions | Cost (KSh million) |
|---|---|---|---|---|
| 3 | Itare and Londiani Dams to Nakuru (RVCA) | W | Capacity of 41 MCM/year, Tunnel of 14.5 km long, Pipeline of 120 km long | 25,742 |
| 4 | Amala Transfer from Amala Dam to RVCA | W, I, P | Capacity of 82 MCM/year, Tunnel of 3.8 km long | 2,301 |
| Total | | | | 28,043 |

Source: JICA Study Team based on NWMP (1992) and data from NWCPC, MORDA, RDAs, and WSBs

## Table 5.2.7 Cost Estimate for Proposed Water Resources Management Plan (LVSCA)

**Development Cost** (Unit: KSh thousand)

| No. | Item | LVSCA | | | |
|---|---|---|---|---|---|
| | | Unit cost | Q'ty | Unit of Q'ty | Cost |
| **1) Monitoring** | | | | | **124,260** |
| | Installation/Rehabilitation of River Gauging Stations | 240 | 9 | nos. | 2,160 |
| | Installation/Rehabilitation of Rainfall Gauging Stations | 100 | 20 | nos. | 2,000 |
| | Installation of Dedicated Boreholes for Groundwater Monitoring | 2,000 | 19 | nos. | 38,000 |
| | Replacement of iron post for river gauge to concrete post | 100 | 23 | nos. | 2,300 |
| | Upgrade manual gauge to automatic (surface water level) | 1,000 | 23 | nos. | 23,000 |
| | Upgrade manual gauge to automatic (groundwater level) | 200 | 19 | nos. | 3,800 |
| | Upgrade manual gauge to automatic (rainfall) | 1,000 | 50 | nos. | 50,000 |
| | Flood Discharge Measurement Equipment (each sub-region) | 1,000 | 3 | nos. | 3,000 |
| | | | | | |
| **2) Evaluation** | | | | | **30,000** |
| | Hydromet DB Upgrade (Software + Hardware) including training | 2,500 | 12 | nos. | 30,000 |
| | Establishment of additional Water Quality Test Laboratory (Lodwar, Kapenguria, Mombasa, Garissa, Marsabit, Wajir) - Building and Utility | 6,750 | 0 | nos. | 0 |
| | Laboratory Equipment and Reagents | 2,105 | 0 | nos. | 0 |
| | | | | | |
| **3) Permitting** | | | | | |
| | PDB Upgrade (Software + Hardware) including training | 1,500 | 12 | nos. | 18,000 |
| | | | | | |
| **4) Watershed Conservation** | | | | | |
| | Forestation to achieve 10% of Forest Cover | 79 | 412,000 | ha | 32,548,000 |
| | | | | | |
| | **Total** | | | | **32,720,260** |

**Recurrent Cost (Annual)** (Unit: KSh thousand)

| No. | Item | LVSCA | | | |
|---|---|---|---|---|---|
| | | Unit cost | Q'ty | Unit of Q'ty | Cost* |
| **1) Monintoring and Analysis** | | | | | **123,228** |
| | Surface Water Monitoring (Daily) | 12 | 276 | nos. | 3,312 |
| | River Discharge Measurement (Monthly) | 80 | 276 | nos. | 22,080 |
| | Groundwater Monitoring (Monthly) | 12 | 228 | nos. | 2,736 |
| | Rainfall Monitoring (Daily) | 12 | 600 | nos. | 7,200 |
| | Flood Discharge Measurement (Three times a year) | 100 | 828 | nos. | 82,800 |
| | Surface Water Quality Monitoring (Monthly) | 30 | 60 | nos. | 1,800 |
| | Surface Water Quality Monitoring (Quarterly) | 30 | 72 | nos. | 2,160 |
| | Gruondwater Quality Monitoring (Twice a year) | 30 | 38 | nos. | 1,140 |
| | | | | | |
| **2) Others** | | | | | |
| | Catchment Forum Operation (Venue and Allowances to WRUAs) | 500 | 2 | times | 1,000 |
| | | | | | |
| | **Total** | | | | **124,228** |

Note: Recurrent cost includes operation and maintenance costs
Source: JICA Study Team, based on data from relevant government authorities

## Table 5.2.8 Cost Estimate for Proposed Flood Disaster Management Plan (LVSCA)

| CA | No. | Description | | Project Cost for Structure (KSh million) | Project Cost for Non-Structure (KSh million) | Recurrent Cost* (KSh million /year) | Source | Remarks |
|---|---|---|---|---|---|---|---|---|
| LVS | S1 | **Kano Plain (Nyando River Basin)** | | **0.00** | **1,511.58** | **7.56** | | |
| | A | S1.1 | Construction of Multipurpose Dam | - | | - | | Nyando Dam |
| | B | S1.2 | River Training Works | (8,252.97) | | - | Nyando MP | |
| | C | S1.3 | Establishment of Flood Forecasting and Warning System | | 1,481.58 | 7.41 | Nyando MP | |
| | G | S1.4 | Formulation of Flood Fighting Plan | | 30.00 | 0.15 | | 10M/M |
| | S2 | **Sondu Rivermouth** | | **42.16** | **19.83** | **0.31** | | |
| | A | S2.1 | Construction of Multipurpose Dam | - | | - | | Magwagwa Dam |
| | F | S2.2 | Establishment of Community-based Flood Management System | 42.16 | 19.83 | 0.31 | Nyando MP | |
| | S3 | **Kuja Rivermouth** | | **169.41** | **79.69** | **1.25** | | |
| | F | S3.1 | Establishment of Community-based Flood Management System | 169.41 | 79.69 | 1.25 | Nyando MP | |
| | S4 | **Kisumu** | | **0.00** | **0.00** | **0.00** | | |
| | A | S4.1 | Construction of Multipurpose Dam | - | | - | | Kibos Dam |
| | H | S4.2 | Implementation of Urban Drainage Measures | (3,559.18) | | - | NWMP (1992) | US$33.48 million in 1992 |

Note: 1. US$1.0 = KSh 85.24 (as of November 1, 2012)
2. Cost for non-structural measures was estimated by multiplying Nyando MP (2006)'s cost by 1.95.
3. Cost for urban drainage implementation was estimated by multiplying NWMP (1992)'s cost by 1.25 (MUV Index) as pro forma amount.
4. Cost for river training works except for Yala Swamp and Kano Plain is estimated as cost for F/S including necessary surveys. (Table 6.2.2 of Sectoral Report (J))
5. Cost for Community-based Disaster Management is estimated by multiplying Nyando MP (2006)'s cost by the percentage of Nyando inundation area and sub-locations (15/55).

* Recurrent cost includes operation and maintenance costs

Source: JICA Study Team, based on existing master plan studies

**Table 5.2.9 Cost Estimate for Proposed Environmental Management Plan (LVSCA)**

| Description | | Development Cost | | Recurrent Cost* (KSh million /year) |
|---|---|---|---|---|
| | | River and Lake Environment Survey (KSh million) | Setting of Environmental Flow Rate (KSh million) | |
| 1.Environmental River Flow | | | | |
| 1.1 | Nyando River | 11.0 | 1.6 | - |
| 1.2 | Sondu River | 6.3 | 1.6 | - |
| 1.3 | Kuja-Migori River | 25.3 | 2.7 | - |
| 1.4 | Mara River | - | 0.2 | - |
| 2.Environmental Monitoring | | | | |
| 2.1 | Nyando River | - | - | 0.0 |
| 2.2 | Sondu River | - | - | 0.0 |
| 2.3 | Kuja-Migori River | - | - | 0.0 |
| 2.4 | Mara River | - | - | 0.0 |
| 2.5 | Lake Victoria | - | - | 1.2 |
| 2.6 | Kisumu City | | | 0.6 |
| 2.7 | Homa bay Town | | | 0.6 |

Note: Basic conditions for cost estimate are supposed as follows;

1. Unit cost of environmental experts based on hearing of environmental experts in Kenya,
2. Unit cost of field survey team, consisting of environmental experts, survey assistants, and others, for setting of environmental flow rate is assumed at KSh 130,000 / day,
3. Necessary days for field survey are assumed at one day / 10 km of river length, 10 days/lake (Lake Turkana is assumed to be 20 days),
4. Personnel costs for data analysis of field survey is assumed at KSh 2,000,000 for one water bodies (Tana River and Athi River is KSh 4,000,000),
5. Overhead cost of field survey, including transportation, accommodation, survey tool and others, is assumed at 30% of direct personnel costs,
6. Cost for stakeholder meeting for setting of environmental flow rate is assumed at KSh 200,000 / time (3 times for one setting point), and
7. Cost for latest data collection and analysis for setting of environmental flow rate is assumed at KSh 200,000 / setting point
8. Environmental monitoring cost is assumed at KSh 150,000 / time / one point
9. Environmental monitoring points of the Nyando, Sondu, Kuja-Migori and Mara rivers are same as river gauging station of Water Resource Management Plan to monitor water quality and quantity. Thus, the monitoring cost is included in Cost of Water Resource Management Plan.

* Recurrent cost includes operation and maintenance costs

Source: JICA Study Team, based on information from environmental experts

# *Figures*

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Source: JICA Study Team

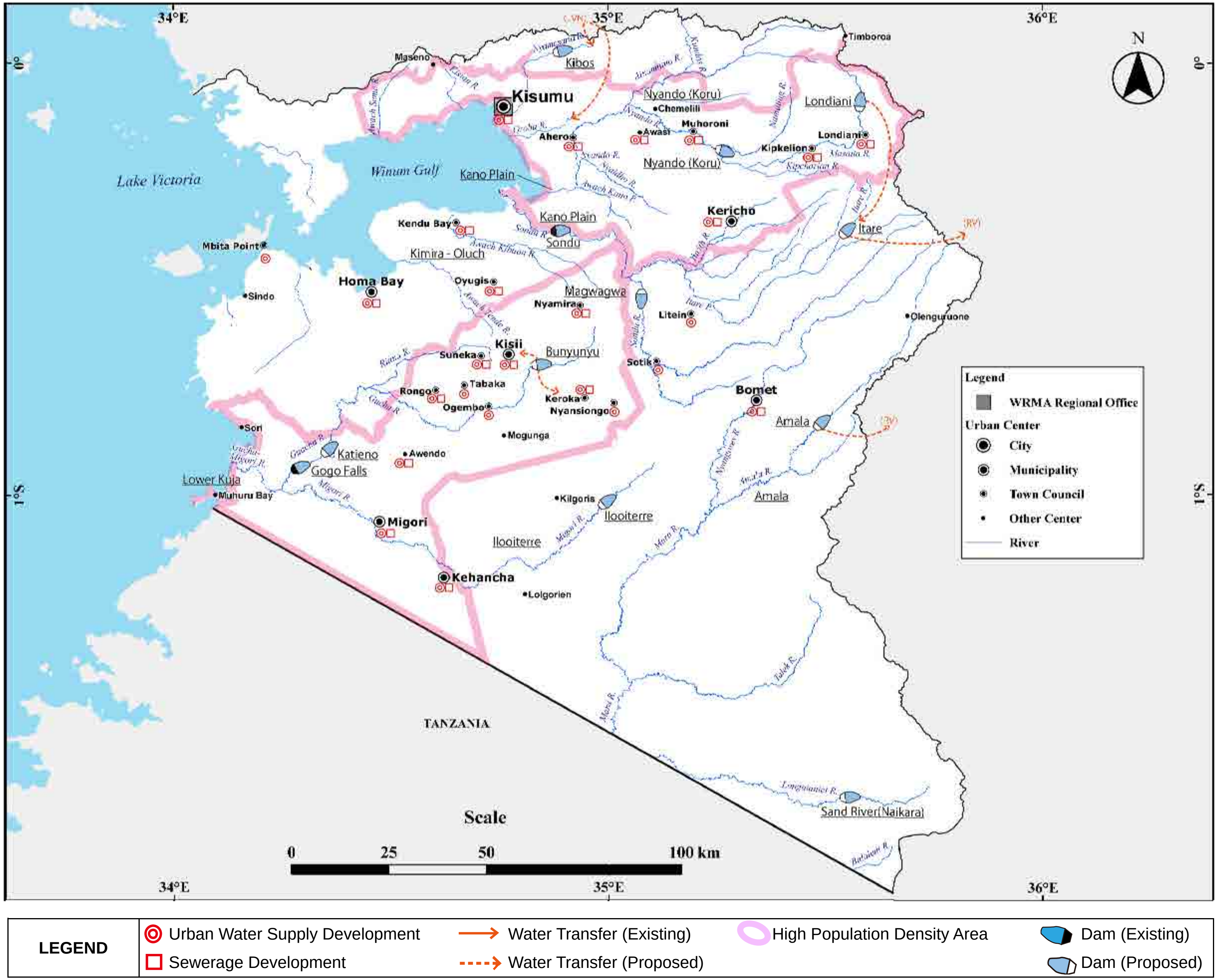


Figure 4.2.1
Proposed Urban Water Supply and
Sewerage Development Plans (LVSCA)

Source: JICA Study Team

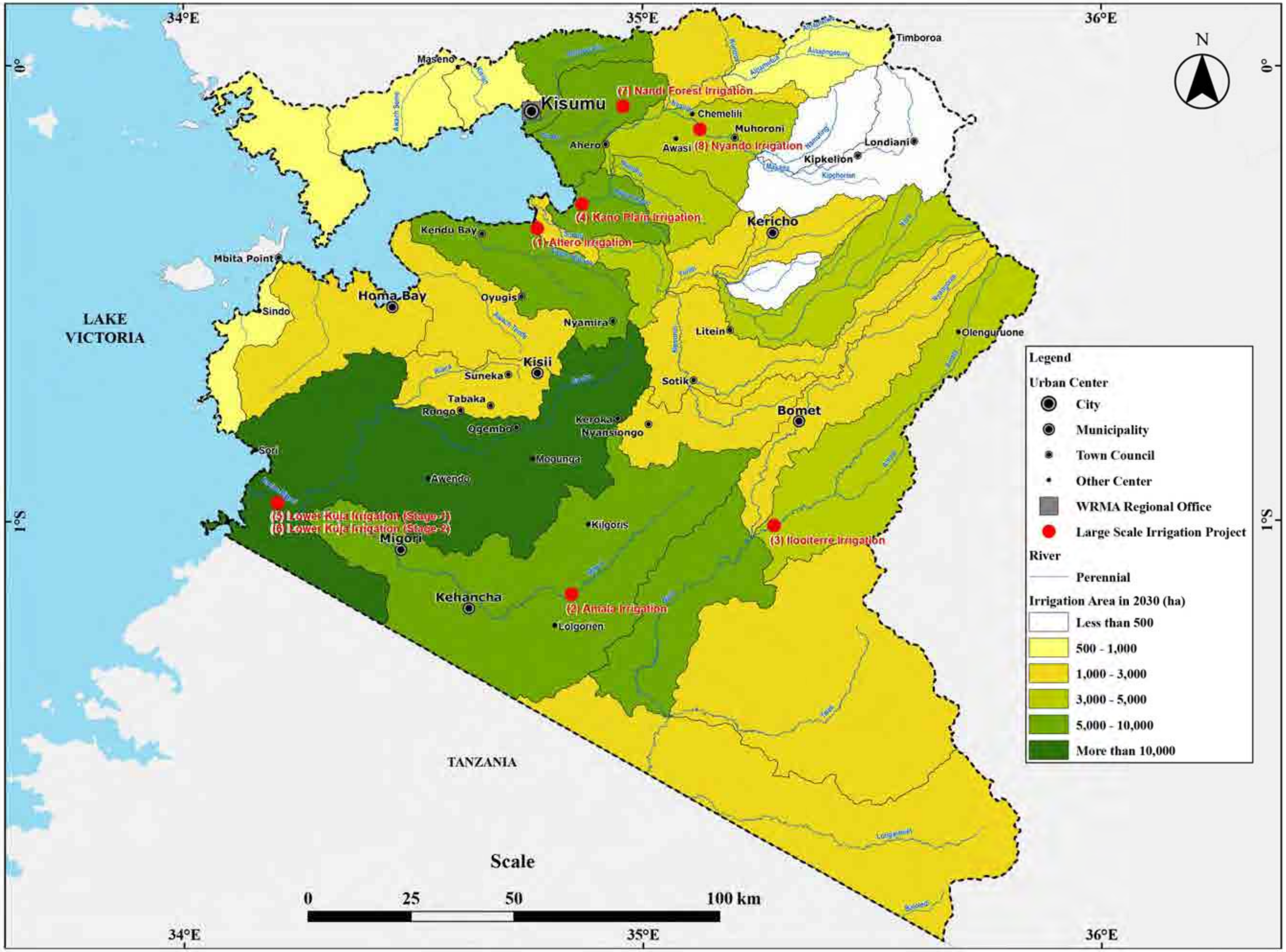


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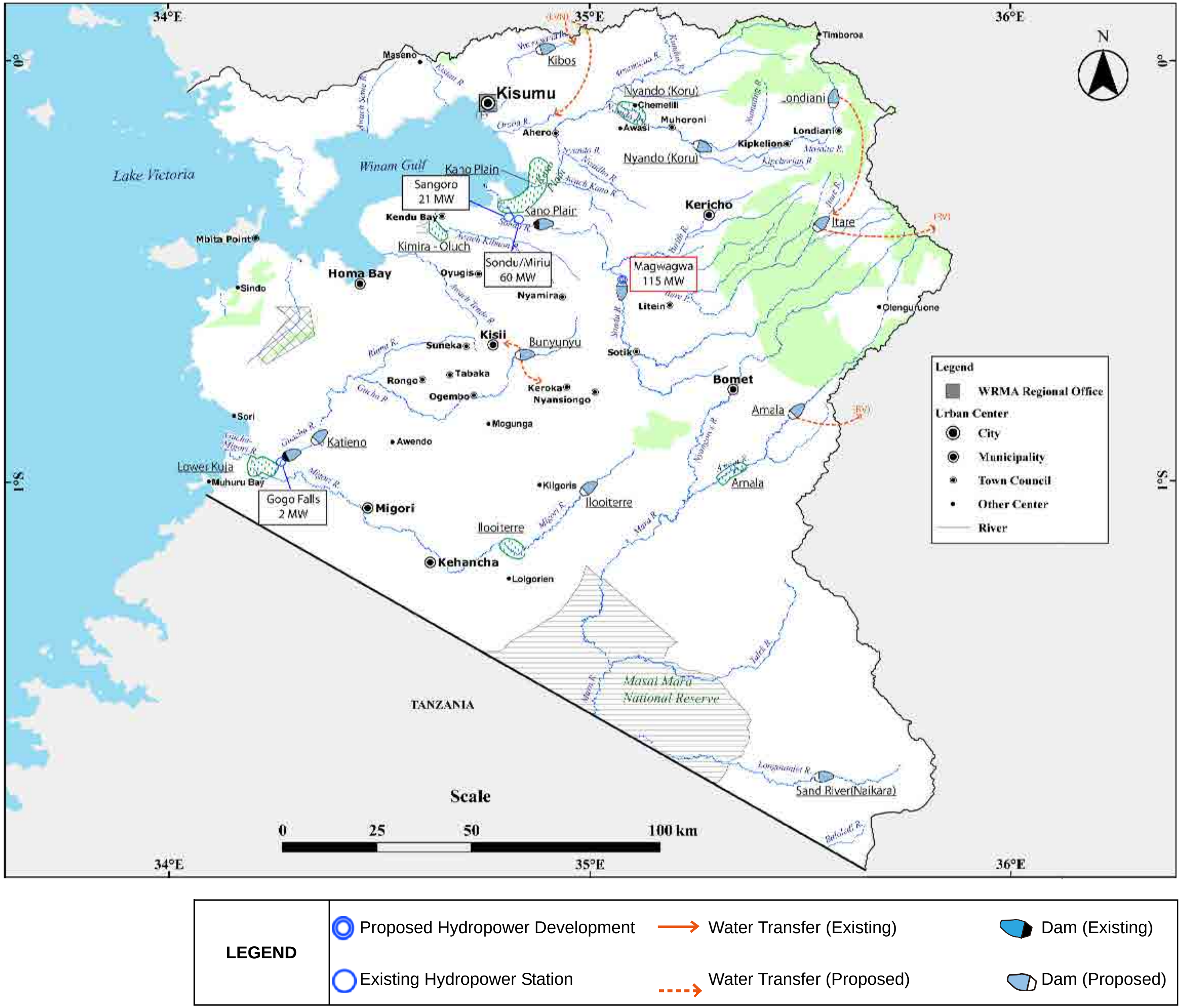
Figure 4.4.1
Proposed Irrigation Development Plan
(LVSCA)




Source: JICA Study Team

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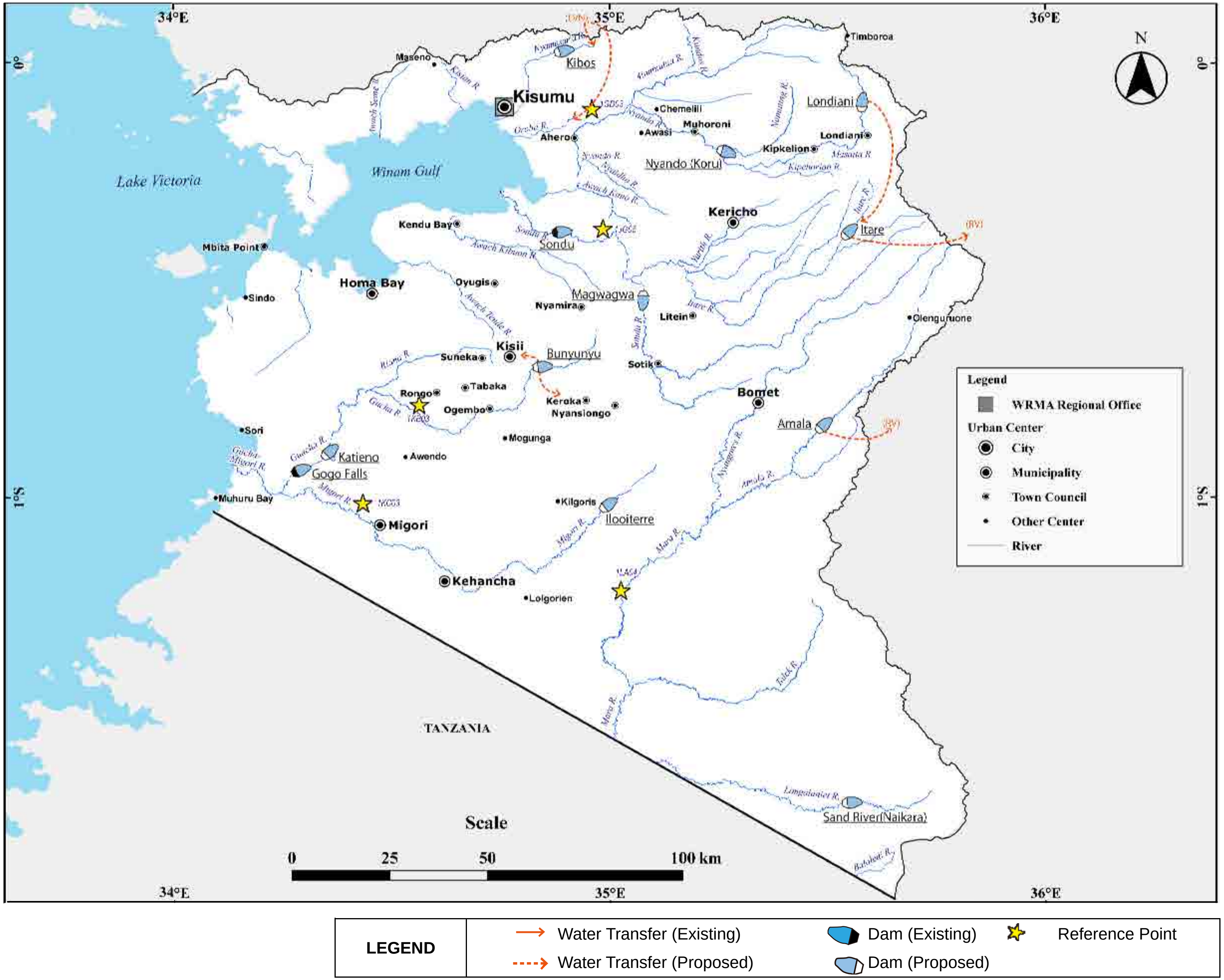
**Figure 4.5.1**
**Existing Hydropower Station and Proposed Hydropower Development Plan (LVSCA)**




Source: JICA Study Team

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**Figure 4.6.1**
**Existing and Proposed Dams and Water Transfer Facilities (LVSCA)**

Source: JICA Study Team

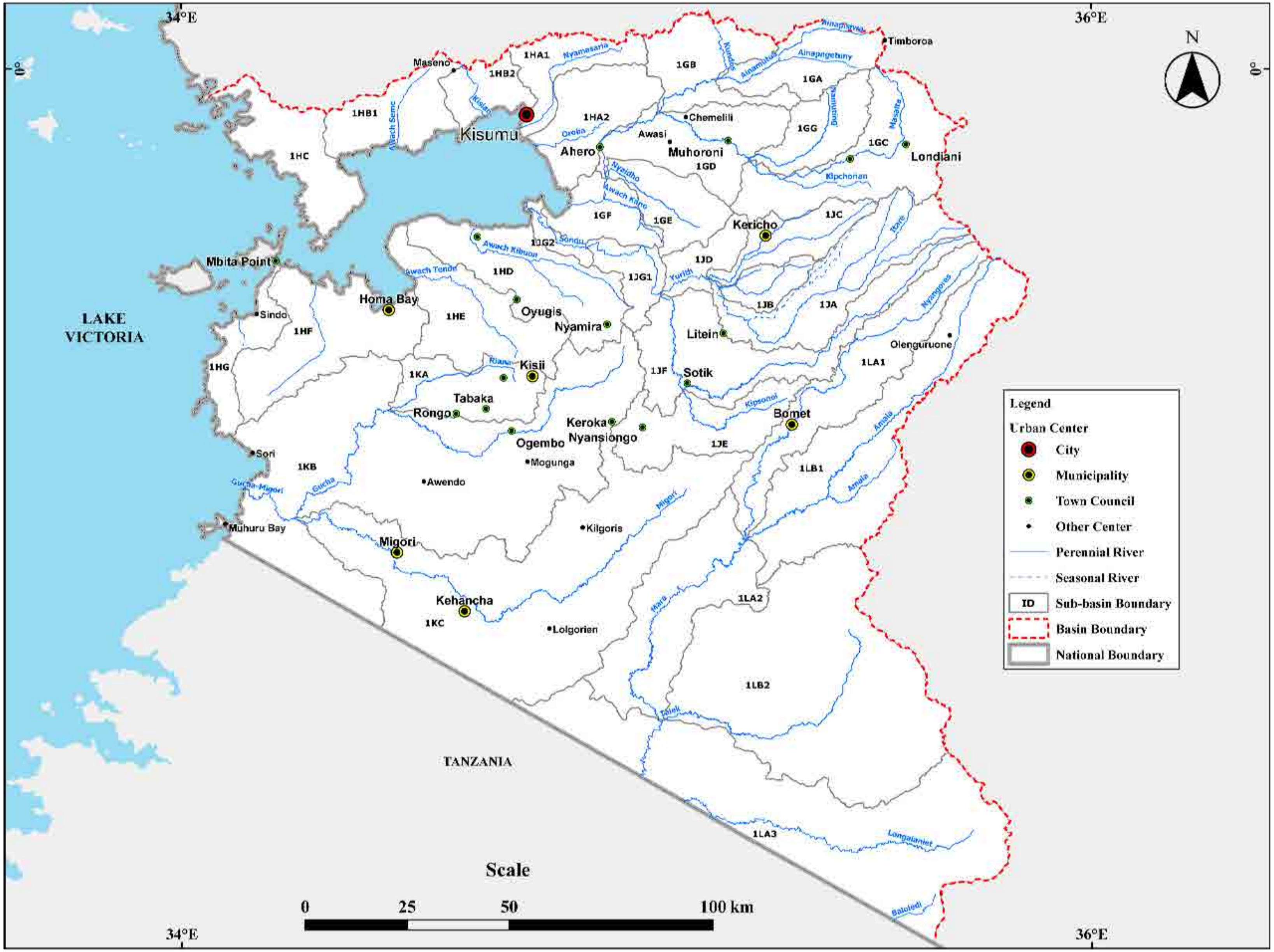


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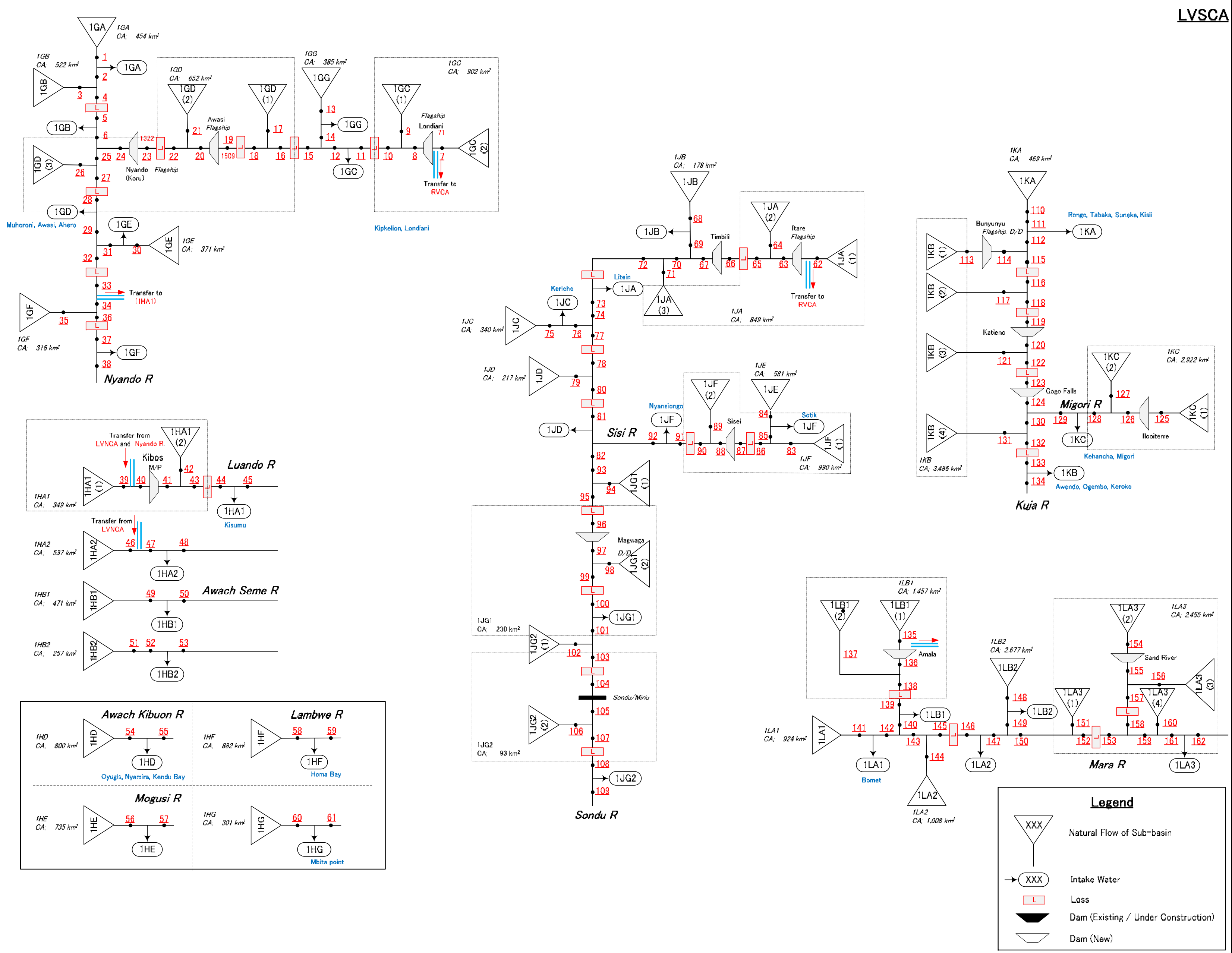
Figure 4.6.2
Sub-basin Division Map
(LVSCA)

LVSCA




Source: JICA Study Team

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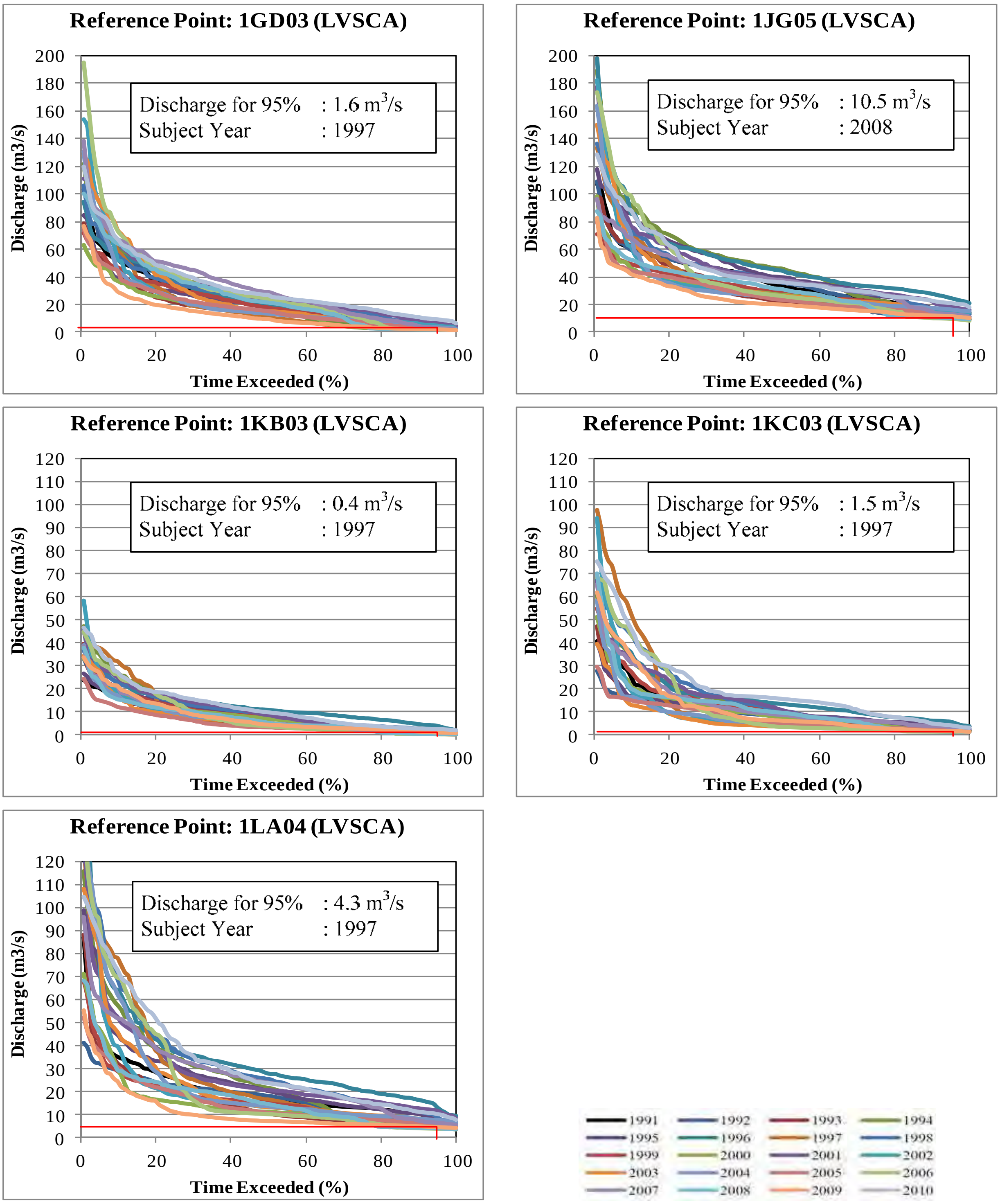
Figure 4.6.3 Surface Water Balance Calculation Model (LVSCA)




Source: JICA Study Team

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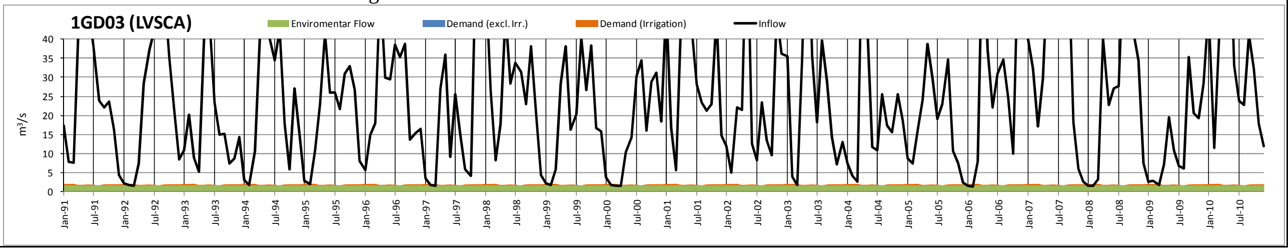
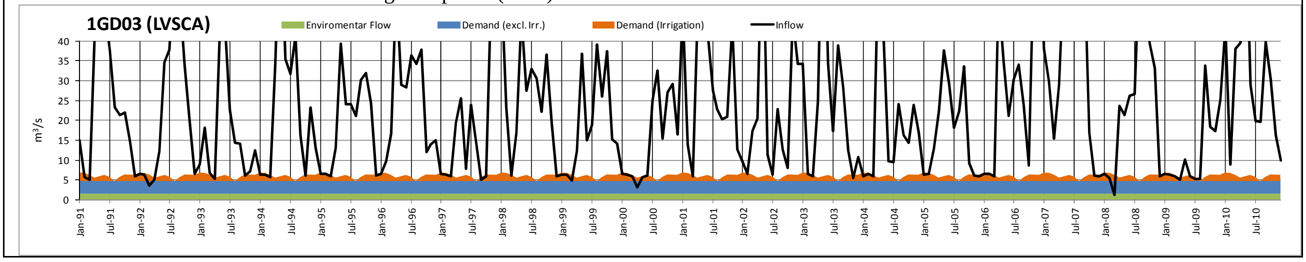
**Figure 4.6.4**
**Simulated Flow Duration Curves for Estimate of Reserve at Reference Points (LVSCA)**

River Name: Nyando River (LVSCA)
Reference Point: 1GD03

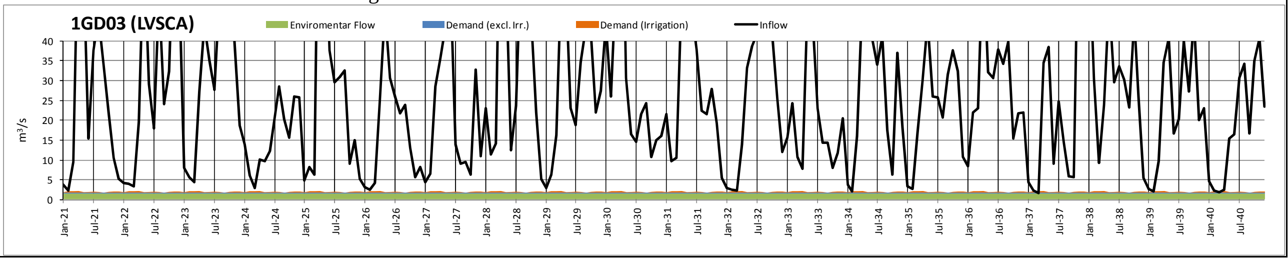
| | | | | |
|---|---|---|---|---|
| River Flow | : Present (1991-2010) | Reserve: | 1.6 | ($m^3$/s) |
| Water Demand | : 2010 | Required Discharge to be maintained | 0.4 | ($m^3$/s) |
| Facilities | : Existing | for Downstream Demand*: | | |



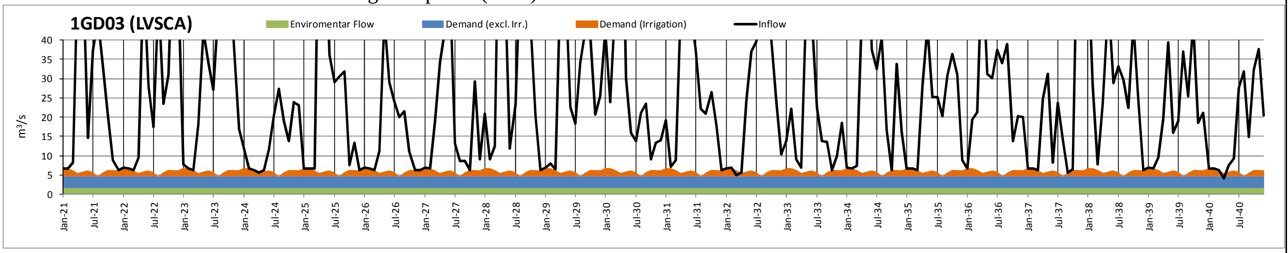

| | | | | |
|---|---|---|---|---|
| River Flow | : Present (1991-2010) | Reserve: | 1.6 | ($m^3$/s) |
| Water Demand | : 2030 | Required Discharge to be maintained | 4.5 | ($m^3$/s) |
| Facilities | : Existing +Proposed (2030) | for Downstream Demand*: | | |




| | | | | |
|---|---|---|---|---|
| River Flow | : Future (2021-2040) | Reserve: | 1.6 | ($m^3$/s) |
| Water Demand | : 2010 | Required Discharge to be maintained | 0.4 | ($m^3$/s) |
| Facilities | : Existing | for Downstream Demand*: | | |




| | | | | |
|---|---|---|---|---|
| River Flow | : Future (2021-2040) | Reserve: | 1.6 | ($m^3$/s) |
| Water Demand | : 2030 | Required Discharge to be maintained | 4.5 | ($m^3$/s) |
| Facilities | : Existing +Proposed (2030) | for Downstream Demand*: | | |



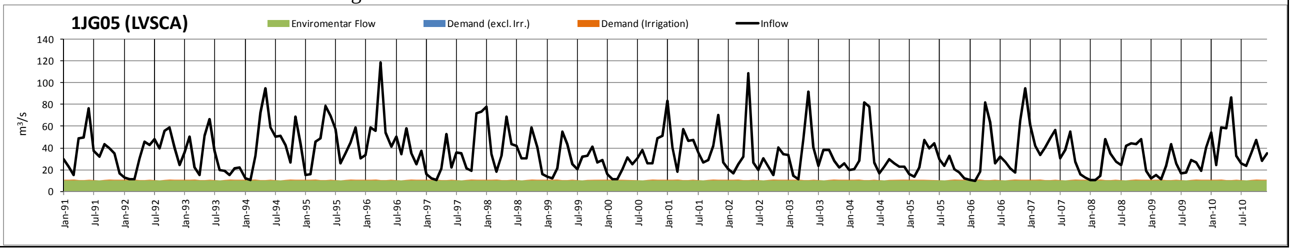

Note: * Irrigation water demand is the average irrigation water demand during March, April, May and June.

Source: JICA Study Team

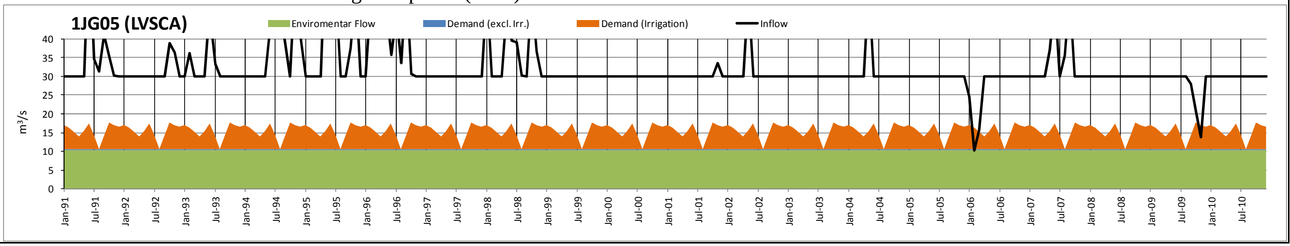
| | |
|---|---|
| **THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030** | **Figure 4.6.5** **River Flow at Reference Point 1GD3 under Present and Future Water Demands and Facilities Conditions (LVSCA) (1/5)** |
| **JAPAN INTERNATIONAL COOPERATION AGENCY** | |

River Name: Sondu River (LVSCA)
Reference Point: 1JG05

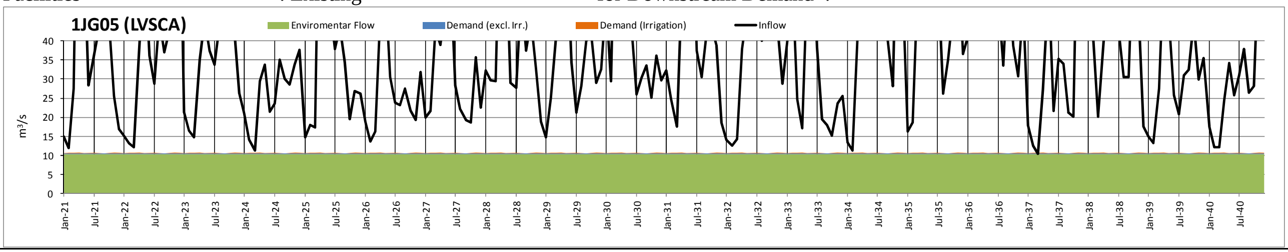
| | | | | |
|---|---|---|---|---|
| River Flow | : Present (1991-2010) | Reserve: | 10.4 | ($m^3/s$) |
| Water Demand | : 2010 | Required Discharge to be maintained | 0.2 | ($m^3/s$) |
| Facilities | : Existing | for Downstream Demand*: | | |



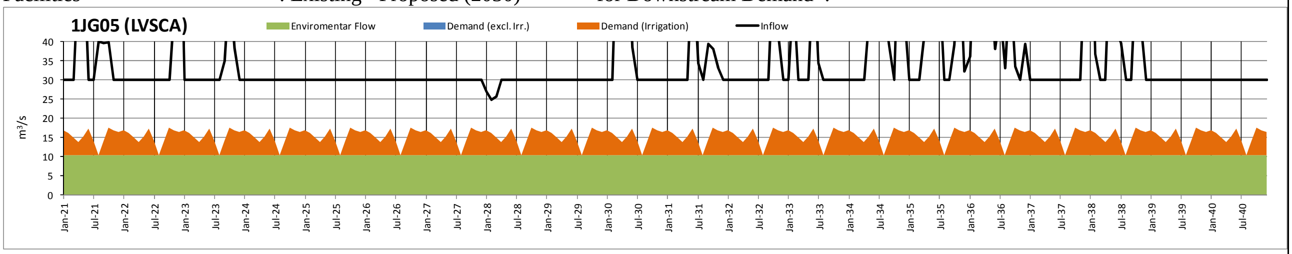

| | | | | |
|---|---|---|---|---|
| River Flow | : Present (1991-2010) | Reserve: | 10.4 | ($m^3/s$) |
| Water Demand | : 2030 | Required Discharge to be maintained | 5.4 | ($m^3/s$) |
| Facilities | : Existing +Proposed (2030) | for Downstream Demand*: | | |




| | | | | |
|---|---|---|---|---|
| River Flow | : Future (2021-2040) | Reserve: | 10.4 | ($m^3/s$) |
| Water Demand | : 2010 | Required Discharge to be maintained | 0.2 | ($m^3/s$) |
| Facilities | : Existing | for Downstream Demand*: | | |




| | | | | |
|---|---|---|---|---|
| River Flow | : Future (2021-2040) | Reserve: | 10.4 | ($m^3/s$) |
| Water Demand | : 2030 | Required Discharge to be maintained | 5.4 | ($m^3/s$) |
| Facilities | : Existing +Proposed (2030) | for Downstream Demand*: | | |



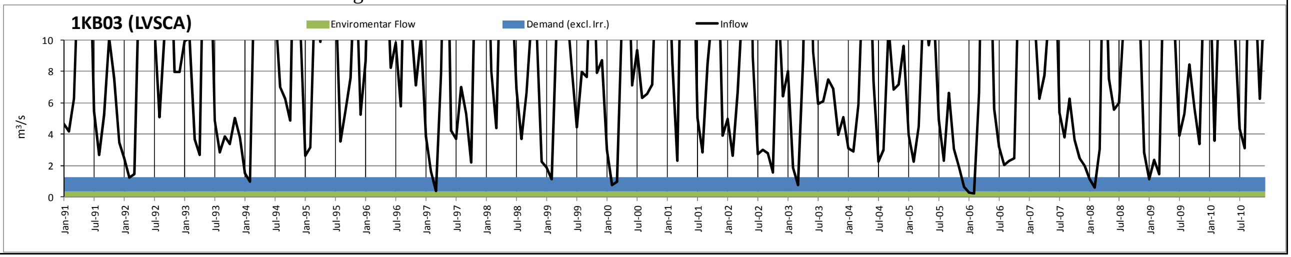

Note: * Irrigation water demand is the average irrigation water demand during March, April, May and June.
Hydropower discharge is constant from the proposed Magwagwa Dam.

Source: JICA Study Team

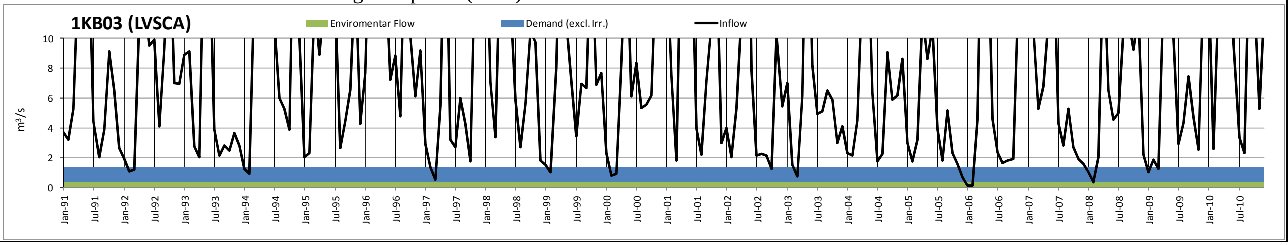
| THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030 | **Figure 4.6.5** **River Flow at Reference Point 1JG03 under Present and Future Water Demands and Facilities Conditions (LVSCA) (2/5)** |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | |

River Name: Gucha River (LVSCA)
Reference Point: 1KB03

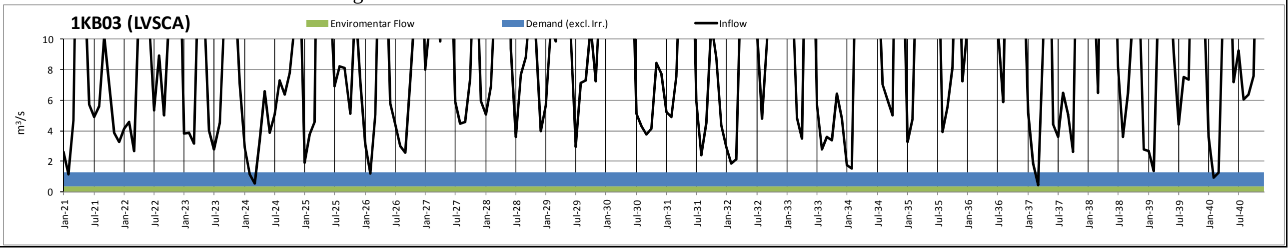
| | | | | |
|---|---|---|---|---|
| River Flow | : Present (1991-2010) | Reserve: | 0.4 | ($m^3/s$) |
| Water Demand | : 2010 | Required Discharge to be maintained | 0.9 | ($m^3/s$) |
| Facilities | : Existing | for Downstream Demand: | | |



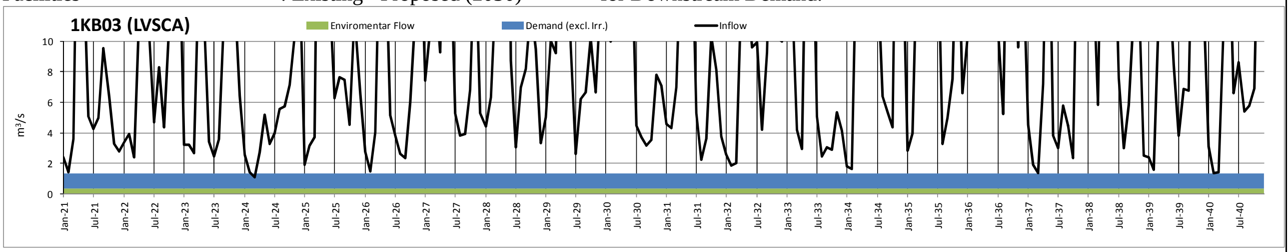

| | | | | |
|---|---|---|---|---|
| River Flow | : Present (1991-2010) | Reserve: | 0.4 | ($m^3/s$) |
| Water Demand | : 2030 | Required Discharge to be maintained | 1.0 | ($m^3/s$) |
| Facilities | : Existing +Proposed (2030) | for Downstream Demand: | | |




| | | | | |
|---|---|---|---|---|
| River Flow | : Future (2021-2040) | Reserve: | 0.4 | ($m^3/s$) |
| Water Demand | : 2010 | Required Discharge to be maintained | 0.9 | ($m^3/s$) |
| Facilities | : Existing | for Downstream Demand: | | |




| | | | | |
|---|---|---|---|---|
| River Flow | : Future (2021-2040) | Reserve: | 0.4 | ($m^3/s$) |
| Water Demand | : 2030 | Required Discharge to be maintained | 1.0 | ($m^3/s$) |
| Facilities | : Existing +Proposed (2030) | for Downstream Demand: | | |




Source: JICA Study Team

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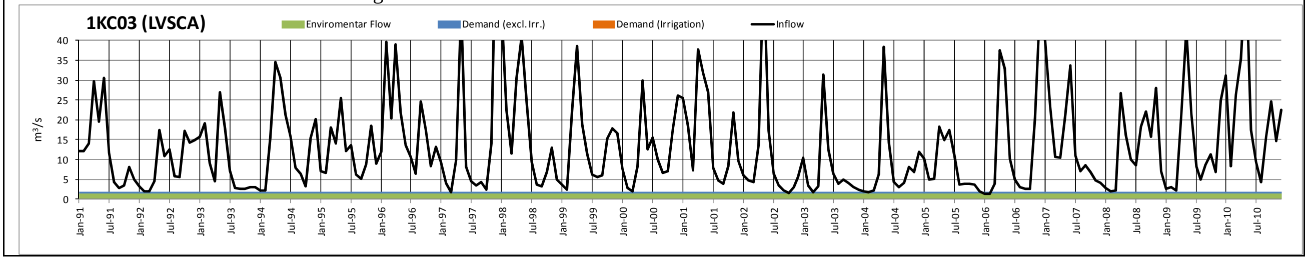
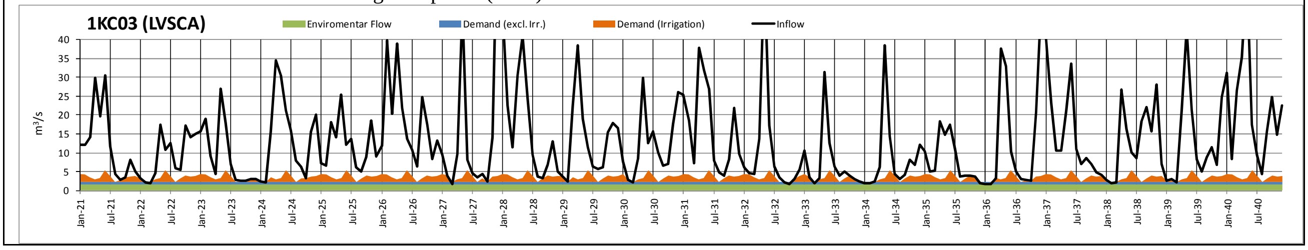
**Figure 4.6.5**
**River Flow at Reference Point 1KB03 under Present and Future Water Demands and Facilities Conditions (LVSCA) (3/5)**

River Name: Migori River (LVSCA)
Reference Point: 1KC03

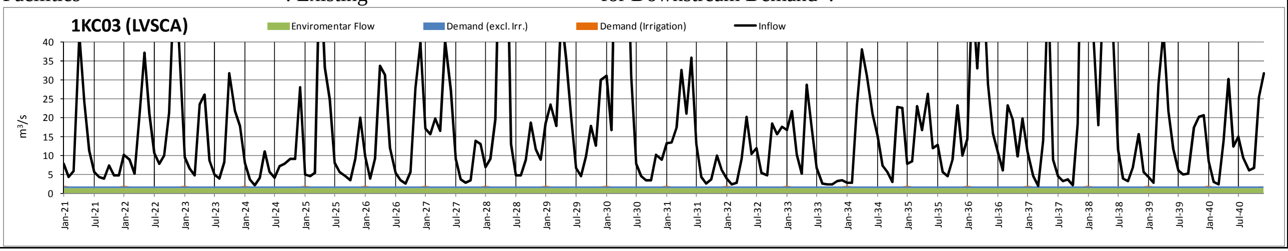
| | | | | |
|---|---|---|---|---|
| River Flow | : Present (1991-2010) | Reserve: | 1.5 | ($m^3$/s) |
| Water Demand | : 2010 | Required Discharge to be maintained | 0.4 | ($m^3$/s) |
| Facilities | : Existing | for Downstream Demand*: | | |



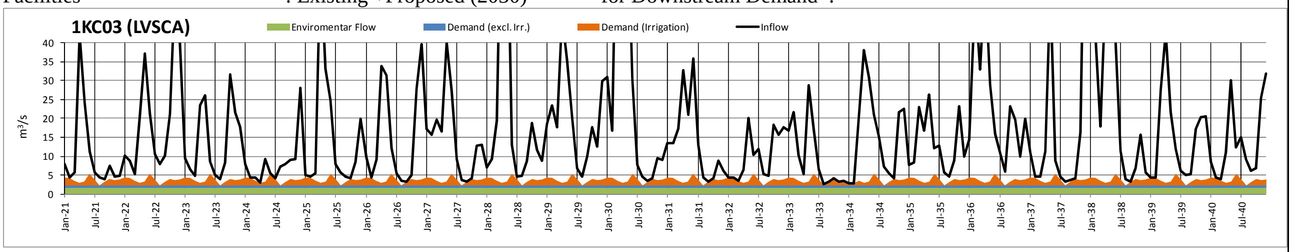

| | | | | |
|---|---|---|---|---|
| River Flow | : Present (1991-2010) | Reserve: | 1.5 | ($m^3$/s) |
| Water Demand | : 2030 | Required Discharge to be maintained | 2.3 | ($m^3$/s) |
| Facilities | : Existing +Proposed (2030) | for Downstream Demand*: | | |




| | | | | |
|---|---|---|---|---|
| River Flow | : Future (2021-2040) | Reserve: | 1.5 | ($m^3$/s) |
| Water Demand | : 2010 | Required Discharge to be maintained | 0.4 | ($m^3$/s) |
| Facilities | : Existing | for Downstream Demand*: | | |




| | | | | |
|---|---|---|---|---|
| River Flow | : Future (2021-2040) | Reserve: | 1.5 | ($m^3$/s) |
| Water Demand | : 2030 | Required Discharge to be maintained | 2.3 | ($m^3$/s) |
| Facilities | : Existing +Proposed (2030) | for Downstream Demand*: | | |




Note:* Irrigation water demand is the average irrigation water demand during March, April, May and June.

Source: JICA Study Team

| THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030 | **Figure 4.6.5 River Flow at Reference Point 1KC03 under Present and Future Water Demands and Facilities Conditions (LVSCA) (4/5)** |
|---|---|
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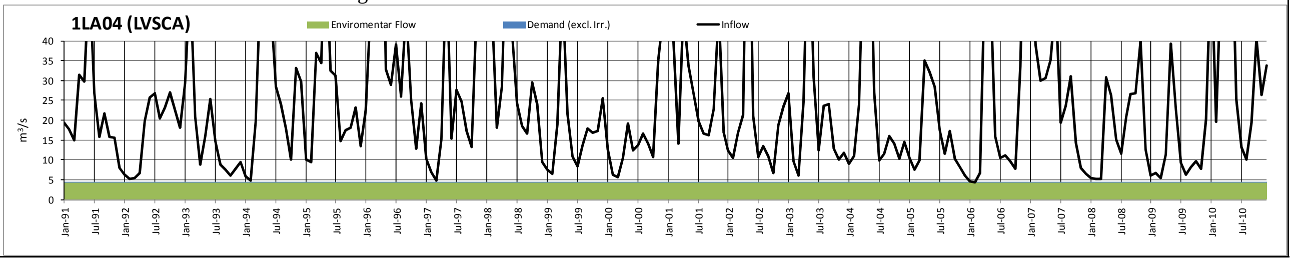
River Name: Mara River (LVSCA)
Reference Point: 1LA04

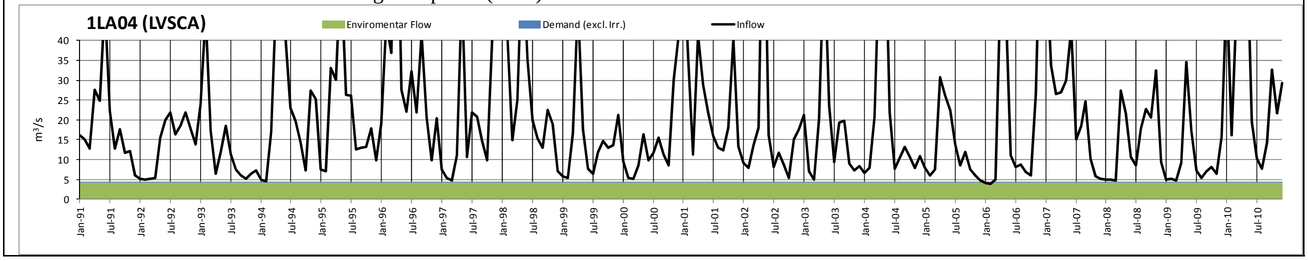
River Flow : Present (1991-2010)
Water Demand : 2010
Facilities : Existing

Reserve: 4.3 ($m^3/s$)
Required Discharge to be maintained for Downstream Demand: 0.1 ($m^3/s$)



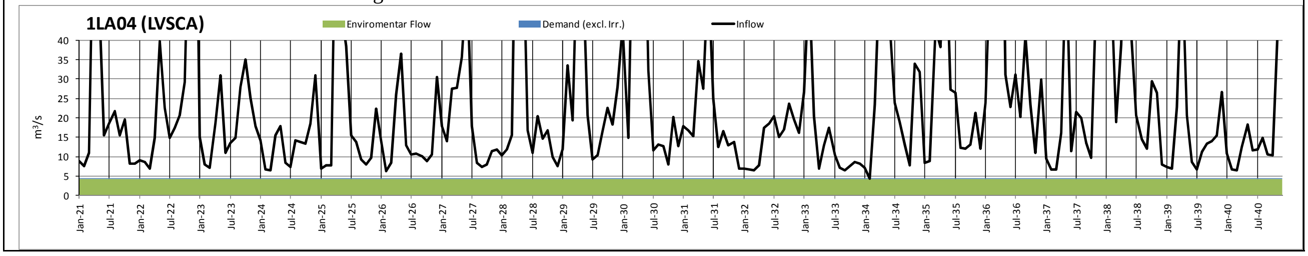

River Flow : Present (1991-2010)
Water Demand : 2030
Facilities : Existing +Proposed (2030)

Reserve: 4.3 ($m^3/s$)
Required Discharge to be maintained for Downstream Demand: 0.1 ($m^3/s$)



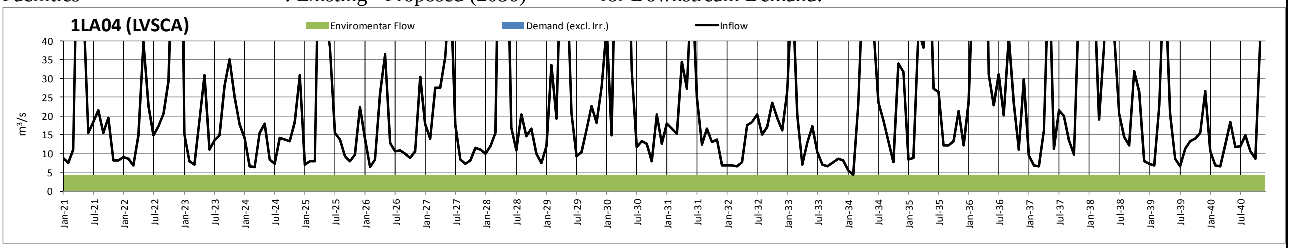

River Flow : Future (2021-2040)
Water Demand : 2010
Facilities : Existing

Reserve: 4.3 ($m^3/s$)
Required Discharge to be maintained for Downstream Demand: 0.1 ($m^3/s$)




River Flow : Future (2021-2040)
Water Demand : 2030
Facilities : Existing +Proposed (2030)

Reserve: 4.3 ($m^3/s$)
Required Discharge to be maintained for Downstream Demand: 0.1 ($m^3/s$)




Source: JICA Study Team

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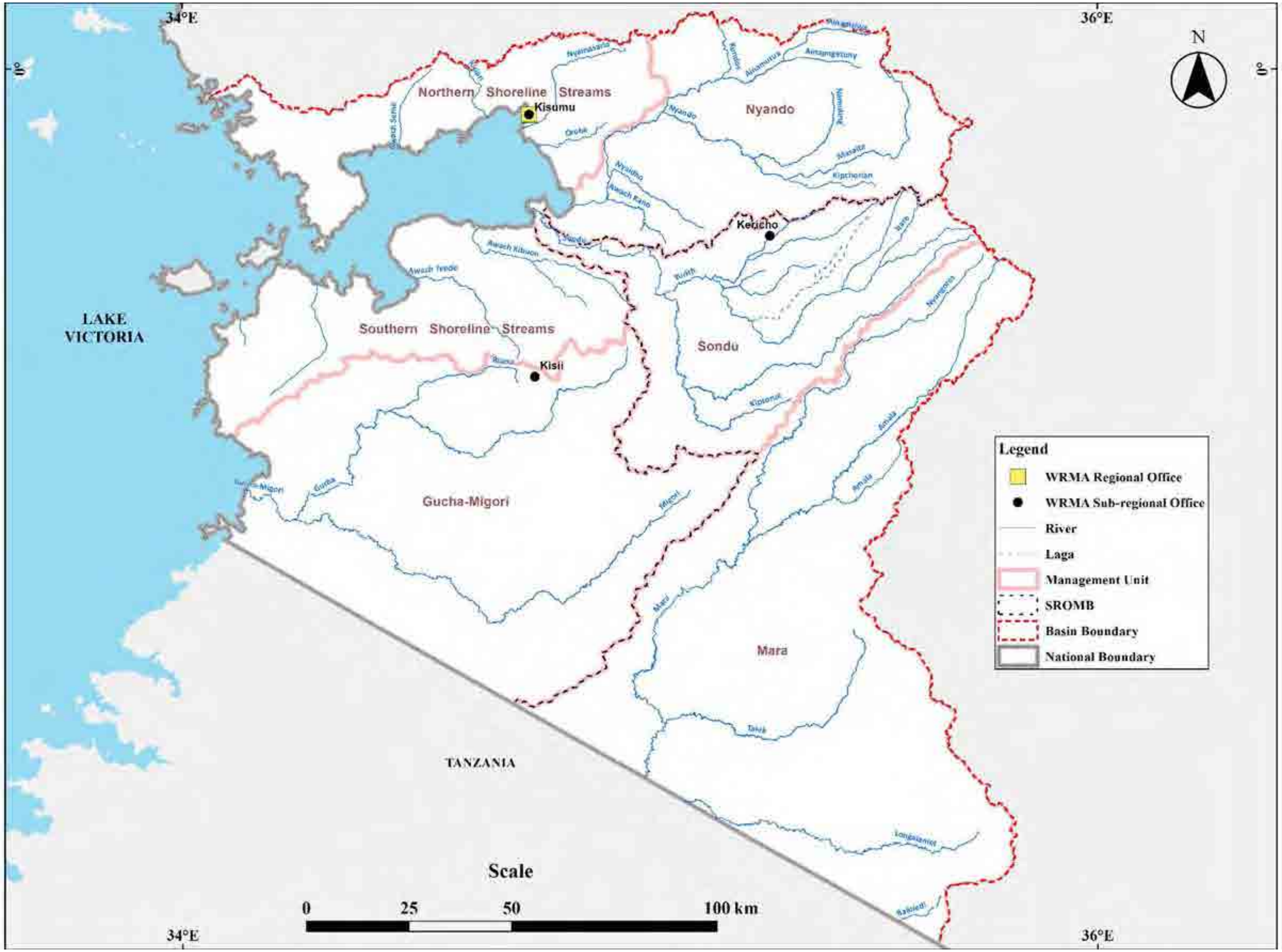
**Figure 4.6.5**
**River Flow at Reference Point 1LA04 under Present and Future Water Demands and Facilities Conditions (LVSCA) (5/5)**




Source: JICA Study Team

Figure 4.7.1
Rivers and Boundaries for Administration (LVSCA)

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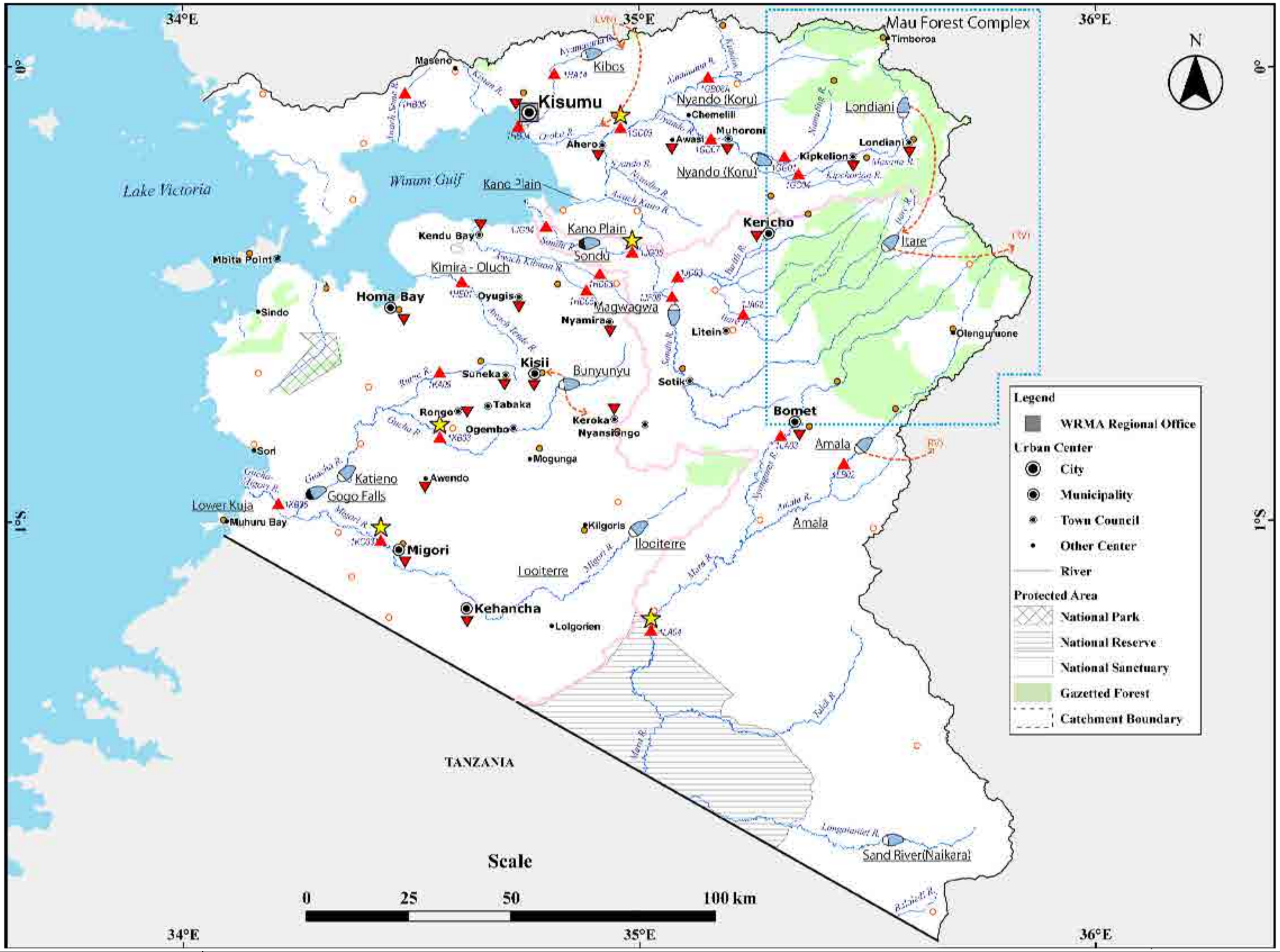
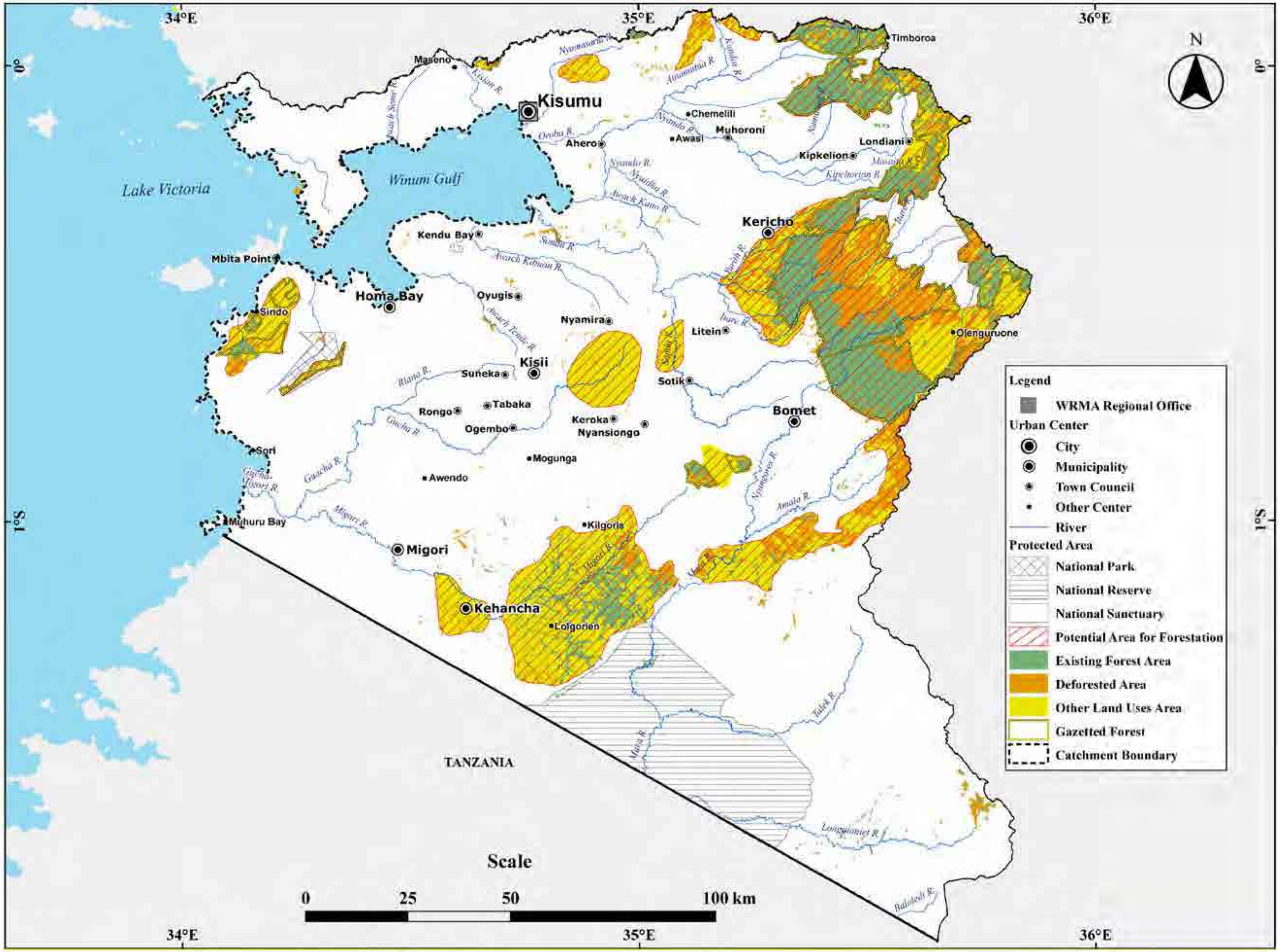
**Figure 4.7.2**
**Proposed Monitoring Stations for Water Resources Management (LVSCA)**

Source: JICA Study Team




| LEGEND | Surface Water Monitoring Station | 23 locations | Groundwater Monitoring Station | 19 locations |
|---|---|---|---|---|
| | Existing / Newly Proposed | | Proposed Monitoring Station | |
| | Rainfall Monitoring Station | 50 locations | Reference Point | 5 locations |
| | Existing / Newly Proposed | | Proposed Reference Point | |




Source: JICA Study Team, on satellite images

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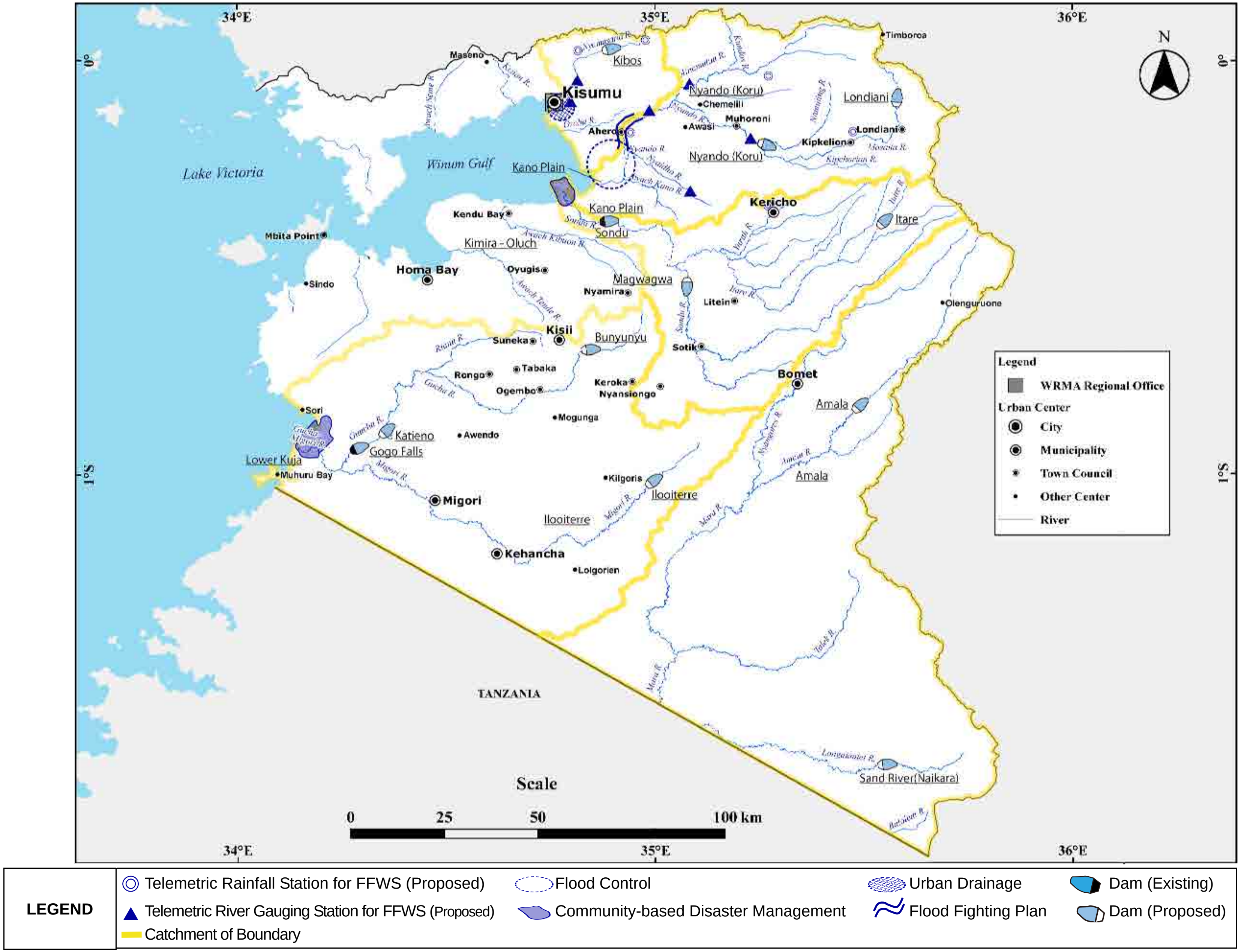
**Figure 4.7.3**
**Current Situation of Forest Areas and Potential Forestation Areas (LVSCA)**




Source: JICA Study Team

Note: The yellow line shows the boundaries of river basin unit for establishment of Basin Drought Conciliation Council in drought disaster management plan.

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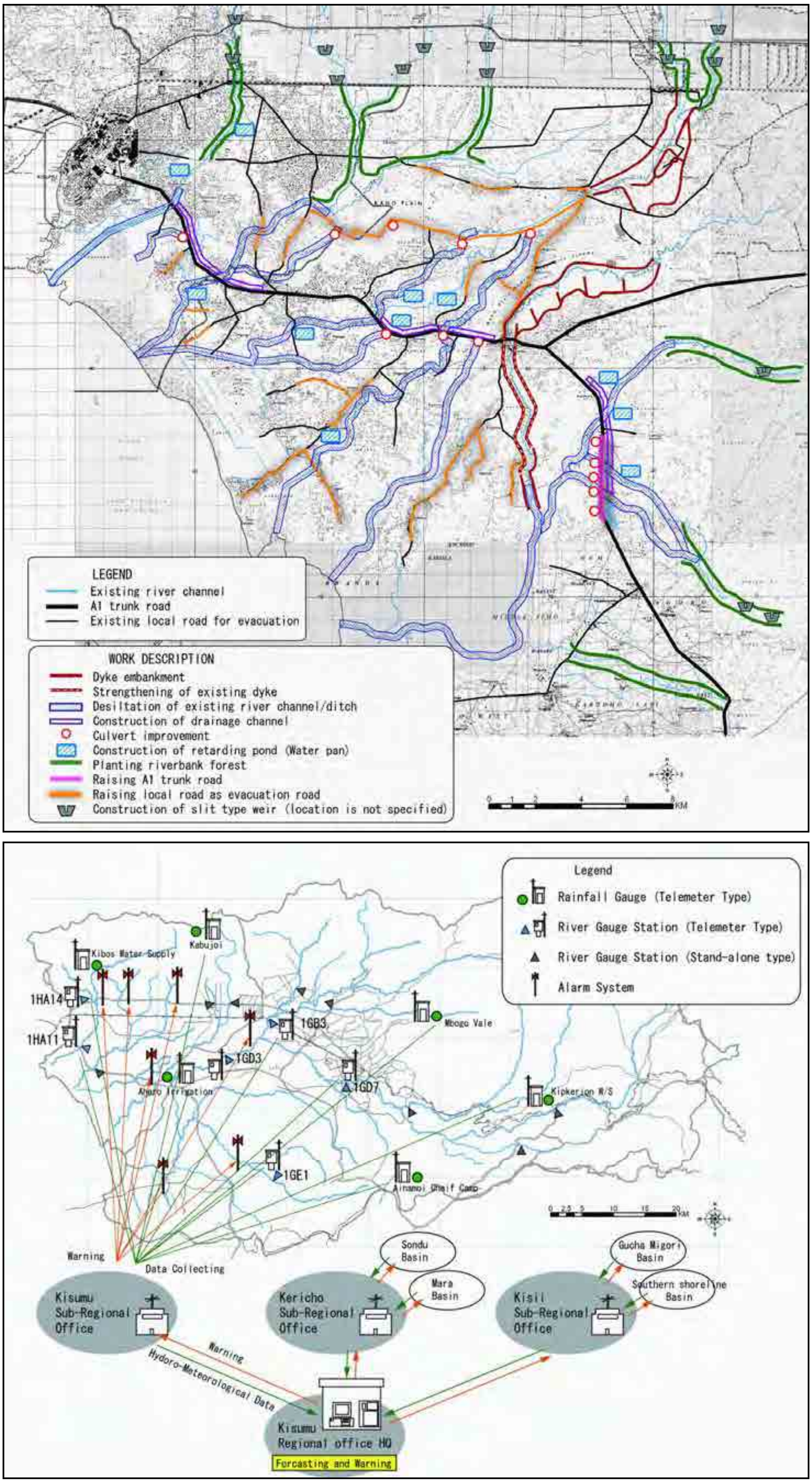
**Figure 4.8.1 Proposed Flood and Drought Disaster Management Plan (LVSCA)**




Source: Study on Integrated Flood Management for Nyando River Basin, 2009

| THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030 | **Figure 4.8.2** **Structural Measures (upper) and Network System for FFWS (lower) Proposed in Nyando Master Plan** |
|---|---|
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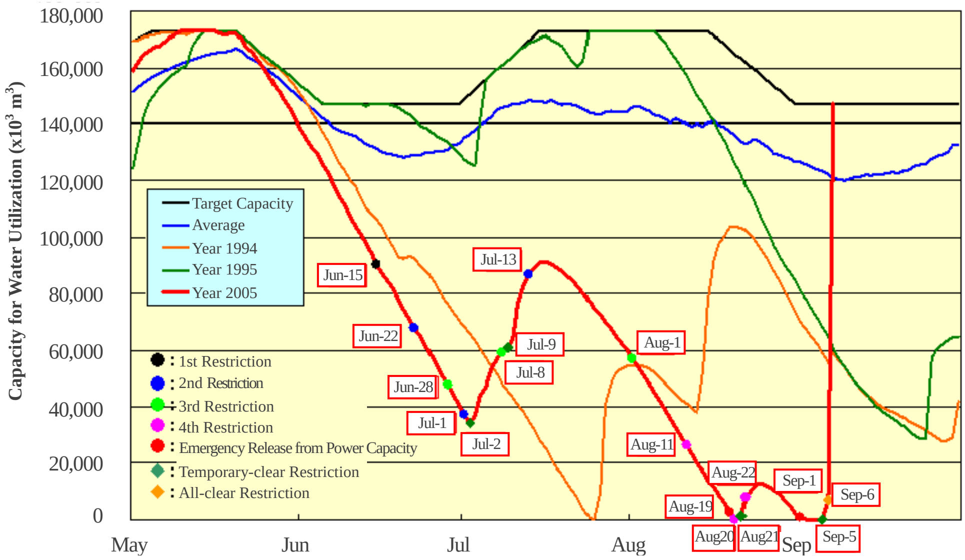
### Flow of Water Use Restriction of the Sameura Dam in 2005 Drought

| 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)<br>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<br>[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<br>[Tokushima 15.9% (new 35%), Kagawa 35%] | |
| Jun 28 | 32.40% | 9:00 The third water restriction<br>[Tokushima 17.6% (new 50%), Kagawa 50%] | |
| Jul 1 | 25.10% | 22:00 Ease the second water restriction<br>[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<br>[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<br>[Tokushima 17.2% (new 35%), Kagawa 35%] | |
| Aug 1 | 32.90% | 9:00 The third water restriction<br>[Tokushima 19.0% (new 50%), Kagawa 50%] | |
| Aug 11 | 15.10% | 9:00 The forth water restriction<br>[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<br>[Tokushima 1.85 $m^3/s$, Kagawa 1.81 $m^3/s$] | |
| Aug 20 | 0.00% | 22:00 Temporary ease the forth water restriction<br>[Tokushima 22.0% (new 75%), Kagawa 75%]<br>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<br>[Tokushima 22.4% (new 75%), Kagawa 75%] | |
| Sep 1 (8:00) | 0.5% (0.0%) | 8:00 Start emergency release from power generation capacity<br>[Tokushima 1.85$m^3/s$, Kagawa 1.81$m^3/s$] | |
| Sep 5 | 0.00% | 5:00 Stop emergency release from power generation capacity<br>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)<br>18:00 Breaking up the office (d)<br>18:00 Breaking up the office (c)<br>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 4.8.3 Example for Water Use Restriction of Sameura Dam in 2005 Drought** |
|---|---|
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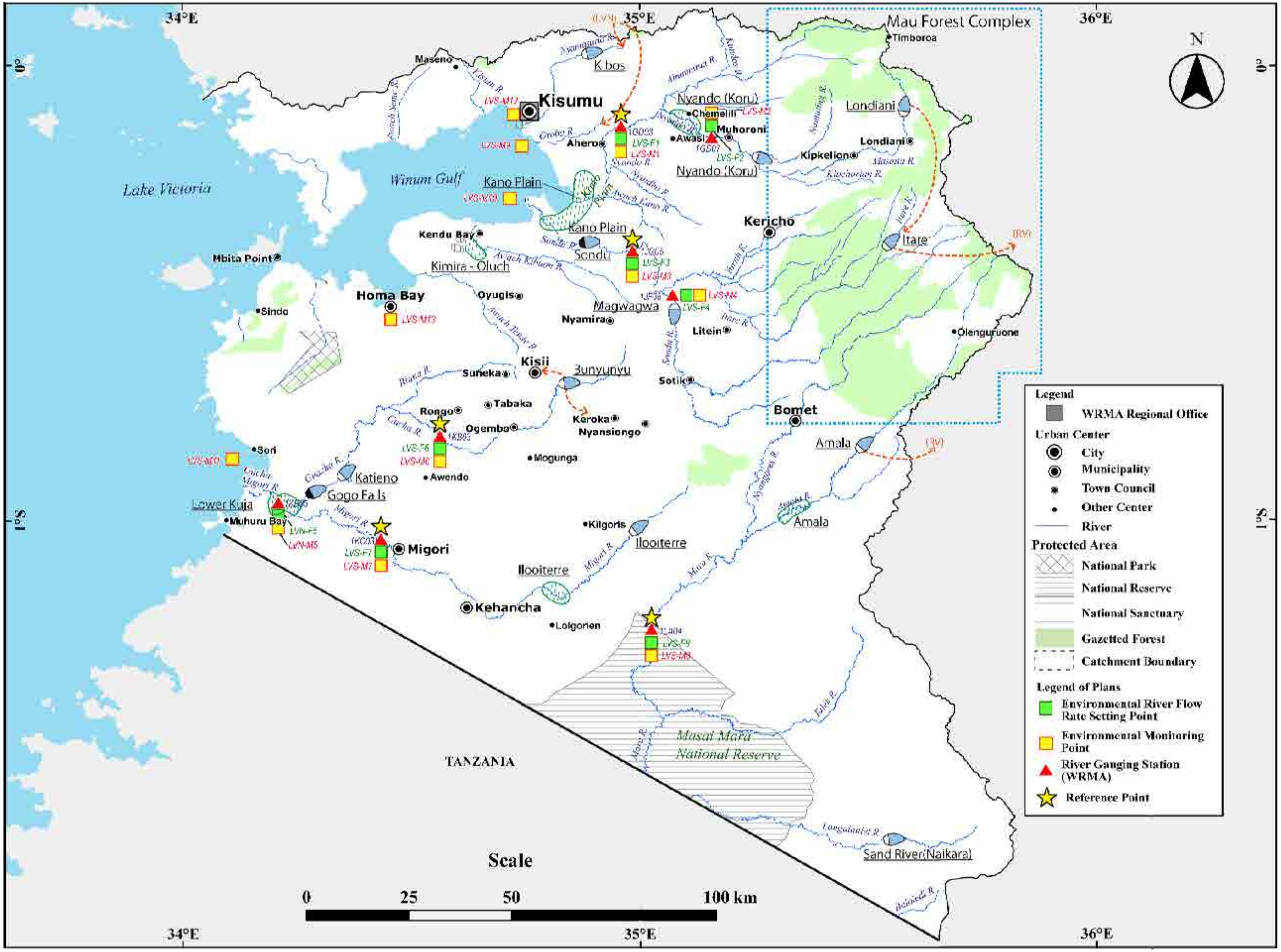
**Figure 4.9.1**
**Proposed Environmental Management Plan (LVSCA)**

Source: JICA Study Team



| WRMA Catchment | No. | Name of Project | Project Status | Capacity to be developed (m3/day) Total | Initial Develop. | Ratio | 2013 13/14 | 2014 14/15 | 2015 15/16 | 2016 16/17 | 2017 17/18 | 2018 18/19 | 2019 19/20 | 2020 20/21 | 2021 21/22 | 2022 22/23 | 2023 23/24 | 2024 24/25 | 2025 25/26 | 2026 26/27 | 2027 27/28 | 2028 28/29 | 2029 29/30 | 2030 30/31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Short Term | | | | | | | | Medium Term | | | | | Long Term | | | | | | | |
| LVS | 1 | Kisumu and Surrounding Area | | | | | | | | | | | | | | | | | | | | | | |
| | | Nandi Forest Dam | | | | | | | ■ | ■ | ■ | ■ | | | | | | | | | | | | |
| | | Kibos Dam | | | | | | | | ■ | ■ | ■ | ■ | | | | | | | | | | | |
| | | Koru Dam | | | | | | | | | | ■ | ■ | ■ | ■ | | | | | | | | | |
| | | Lake Victoria | | | | | | | | | | | | | | | | | | ■ | ■ | ■ | | |
| | | Kisumu | WSB, MTP, F/S* | 166,352 | 60,000 | 36% | | | | ■ | ■ | ■ | | | | | | ■ | ■ | ■ | | | | |
| | | Ahero, Awasi, Kipkelion, Londiani, Muhoroni (6 UC) | WSB, F/S* | 124,289 | 37,287 | 30% | | | | ■ | ■ | ■ | ■ | | | ■ | ■ | ■ | | | ■ | ■ | ■ | |
| | 2 | Kisii and Surrounding Area | | | | | | | | | | | | | | | | | | | | | | |
| | | Bunyunyu Dam | | | | | | | | | ■ | ■ | ■ | ■ | | | | | | | | | | |
| | | Kisii | WSB, MTP, F/S | 29,501 | 24,000 | 81% | | ■ | ■ | ■ | | | | | | | ■ | ■ | ■ | | | | | |
| | | Rongo, Suneka, Keroka, Awendo, Tabaka, Ogembo (6 Uc) | WSB, F/S | 128,708 | 2,000 | 2% | | | | ■ | ■ | ■ | ■ | | | ■ | ■ | ■ | ■ | | | ■ | ■ | ■ |
| | 3 | Kericho | WSB, F/S | 48,026 | 14,000 | 29% | | ■ | ■ | ■ | | | | | | | | | ■ | ■ | ■ | | | |
| | 4 | Bomet | WSB, F/S | 49,706 | 8,000 | 16% | | | | | ■ | ■ | ■ | | | | | | ■ | ■ | ■ | | | |
| | 5 | Homabay | WSB, F/S* | 20,475 | 2,000 | 10% | | ■ | ■ | ■ | | | | | | ■ | ■ | ■ | | | | | | |
| | 6 | Nyamira, Oyugis (2 UC) | WSB, D/D | 41,076 | 36,000 | 88% | | ■ | ■ | ■ | | | | | | | | ■ | ■ | ■ | | | | |
| | 7 | Mbita Point | WSB, F/S | 7,182 | 4,000 | 56% | | | | | ■ | ■ | ■ | | | | | | ■ | ■ | ■ | | | |
| | 8 | Litein, Sotik (2 UC) | WSB, F/S | 8,000 | 8,000 | 100% | | | | | ■ | ■ | ■ | | | | | | | | | | | |
| | 9 | Migori | WSB,D/D | 15,752 | 4,726 | 30% | ■ | ■ | ■ | | | | | | | | | | | | ■ | ■ | ■ | |
| | 10 | Kehancha | - | 17,716 | 5,315 | 30% | | | | | | | ■ | ■ | ■ | | | | | | ■ | ■ | ■ | |
| | 11 | Kendu Bay | - | 8,114 | 2,434 | 30% | | | | | | | | ■ | ■ | ■ | | | | | | ■ | ■ | ■ |
| | 12 | Nyansiongo | - | 2,777 | 833 | 30% | | | | | | | | ■ | ■ | ■ | | | | | | ■ | ■ | ■ |
| | Rehabilitation for 22 Urban Centres | | | | | | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | | |
| | Total Urban Water Supply Projects | | | 667,674 | 208,594 | 31% | | | | | | | | | | | | | | | | | | |
| | Water Resources Development for Rural Water Supply | | | | | | | | | | | | | | | | | | | | | | | |
| | | Magwagwa Dam | | | | | ■ | ■ | ■ | ■ | | | | | | | | | | | | | | |
| | | Amala Dam | | | | | | | | | | | | | | | | | ■ | ■ | ■ | ■ | | |
| | | Sande Dam | | | | | | | | | | | | | | | | | | ■ | ■ | ■ | ■ | |
| | | Ilooiterre Dam | | | | | | | | | | | | | | | | | | | ■ | ■ | ■ | ■ |
| | Rural Water Supply Projects | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |

Note: As for "Project Status", "WSB" means a project proposed by WSB, "MTP" means a flagship project proposed in the First Medium Term Plan (2008 – 2019) of Kenya Vision 2030, and "F/S" means a project proposed in completed F/S.

Source: JICA Study Team



**Figure 7.3.1**
**Implementation Schedule of Proposed Water Supply System Development Plan (LVSCA)**

| WRMA Catchment | No. | Urban Centre | F/S Status | Capacity to be developed ($m^3$/day) | | | Implementation Schedule | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Short Term | | | | | Medium Term | | | | | Long Term | | | | | | | |
| | | | | Total | Initial Develop. | Ratio | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
| | | | | | | | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 | 19/20 | 20/21 | 21/22 | 22/23 | 23/24 | 24/25 | 25/26 | 26/27 | 27/28 | 28/29 | 29/30 | 30/31 |
| LVS | 1 | Kisumu | WSB, F/S*, MTP | 118,303 | 27,972 | 30% | | | ■ | ■ | ■ | | | | | | | ■ | ■ | ■ | | | | |
| | 2 | Bomet | WSB, F/S | 32,117 | 1,750 | 5% | | | ■ | ■ | ■ | | | | | | | | ■ | ■ | ■ | | | |
| | 5 | Homa Bay | WSB | 15,402 | 4,500 | 29% | | | ■ | ■ | ■ | | | | | | | | | ■ | ■ | ■ | | |
| | 3 | Migori | WSB, F/S | 20,368 | 6,000 | 29% | | | | | ■ | ■ | ■ | | | | | | ■ | ■ | ■ | | | |
| | 4 | Muhoroni | WSB, F/S | 13,217 | 2,000 | 15% | | | | | ■ | ■ | ■ | | | | | | | | ■ | ■ | ■ | |
| | 6 | Kisii | WSB, MTP | 30,117 | 6,000 | 19% | | | | ■ | ■ | ■ | | | | | | | | | ■ | ■ | ■ | |
| | 8 | Kericho | WSB | 37,551 | 4,500 | 12% | | | | ■ | ■ | ■ | | | | | | | | ■ | ■ | ■ | | |
| | 7 | Rongo | _ | 39,579 | 11,874 | 30% | | | | | | | | ■ | ■ | ■ | | | | | | ■ | ■ | ■ |
| | 9 | Suneka | _ | 19,493 | 5,848 | 30% | | | | | | | | ■ | ■ | ■ | | | | | | ■ | ■ | ■ |
| | 10 | Ahero | _ | 19,459 | 19,459 | 100% | | | | | | | | | | | ■ | ■ | ■ | | | | | |
| | 11 | Kipkelion | _ | 17,936 | 17,936 | 100% | | | | | | | | | | | ■ | ■ | ■ | | | | | |
| | 12 | Londiani | _ | 16,552 | 16,552 | 100% | | | | | | | | | | | | | ■ | ■ | ■ | | | |
| | 13 | Nyamira | _ | 15,983 | 15,983 | 100% | | | | | | | | | | | | | ■ | ■ | ■ | | | |
| | 14 | Keroka | _ | 15,978 | 15,978 | 100% | | | | | | | | | | | | | ■ | ■ | ■ | | | |
| | 15 | Oyugis | _ | 13,598 | 13,598 | 100% | | | | | | | | | | | | | ■ | ■ | ■ | | | |
| | 16 | Awasi | _ | 13,127 | 13,127 | 100% | | | | | | | | | | | | | | | | ■ | ■ | ■ |
| | 17 | Kehancha | _ | 11,549 | 11,549 | 100% | | | | | | | | | | | | | | | | ■ | ■ | ■ |
| | 18 | Awendo | _ | 6,111 | 6,111 | 100% | | | | | | | | | | | | | | | | ■ | ■ | ■ |
| | 19 | Kendu Bay | _ | 5,657 | 5,657 | 100% | | | | | | | | | | | | | | | | ■ | ■ | ■ |
| | | Maseno | WSB, F/S (additional) | | | | | | | ■ | ■ | ■ | | | | | | | | | | | | |
| | | Chemelil | WSB, F/S (additional) | | | | | | | | | | | | | | | | | | | | | |
| | Rehabilitation Works for 4 Urban Centres | | | | | | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | | |
| | Total | | | 462,096 | 206,392 | 45% | | | | | | | | | | | | | | | | | | |

Note: As for "Project Status", "WSB" means a project proposed by WSB, "MTP" means a flagship project proposed in the First Medium Term Plan (2008 – 2019) of Kenya Vision 2030, and "F/S" means a project proposed in completed F/S.

Source: JICA Study Team

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**Figure 7.3.2**
**Implementation Schedule of Proposed Sewerage System Development Plan (LVSCA)**

| No | Name of Project | County | Irrigation Area (ha) | Multi-purpose Dam | Short Term | | | | | Medium Term | | | | | Long Term | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
| | | | | | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 | 19/20 | 20/21 | 21/22 | 22/23 | 23/24 | 24/25 | 25/26 | 26/27 | 27/28 | 28/29 | 29/30 | 30/31 |
| **A. Large Scale Irrigation Project (New)** | | | | | | | | | | | | | | | | | | | | | | |
| 1 | Kano Plain Irrigation | Nyamira/ Kericho | 15,000 | Magwa gwa | | | P | | | Dam | | | | | | | | | | | | |
| 2a | Lower Kuja Irrigation (Stage-1) | Migori | 7,800 | - | | | | | | | | | | | | | | | | | | |
| 2b | Lower Kuja Irrigation (Stage-2) | Migori | 32,700 | Katieno | | | | | P | | | | | Dam | | | | | | | | |
| 3 | Ahero and West Kano Irrigation | Kisumu | 1,800 | - | | | | P | | | | | | | | | | | | | | |
| 4 | Nandi Forest Irrigation | Nyando, Kisumu | 7,272 | Nandi Forest | | | | | | P | Dam | | | | | | | | | | | |
| 5 | Nyando Irrigation | Kericho | 3,000 | Nyando (Koru) | | | | | | | | P | | Dam | | | | | | | | |
| 6 | Amala Irrigation | Bomet | 5,000 | Amala | | | | | | | | | | | P | | | | | | Dam | |
| 7 | Ilooiterre Irrigation | Narok | 3,000 | Illoiterre | | | | | | | | | | | | | | Dam P | | | | |
| | Total | | 75,572 | | 7,800 | | | | | 16,800 | | | | | 50,972 | | | | | | | |
| **B. Small Scale Irrigation Project (New)** | | | | | | | | | | | | | | | | | | | | | | |
| 1 | Weir Irrigation | | 14,477 | | 2,895 | | | | | 4,343 | | | | | 7,239 | | | | | | | |
| 2 | Dam Irrigation | | 0 | | 0 | | | | | 0 | | | | | 0 | | | | | | | |
| 3 | Small Dam/Pond/Water Pan Irrigation | | 4,590 | | 918 | | | | | 1,377 | | | | | 2,295 | | | | | | | |
| 4 | Groundwater Irrigation | | 3,434 | | 687 | | | | | 1,030 | | | | | 1,717 | | | | | | | |
| | **Total for B** | | 22,501 | | 4,500 | | | | | 6,750 | | | | | 11,251 | | | | | | | |
| **C. Private Irrigation Project (New)** | | | | | | | | | | | | | | | | | | | | | | |
| 1 | Weir Irrigation | | 11,700 | | 2,340 | | | | | 3,510 | | | | | 5,850 | | | | | | | |
| 2 | Groundwater Irrigation | | 3,433 | | 687 | | | | | 1,030 | | | | | 1,716 | | | | | | | |
| | **Total for C** | | 15,133 | | 3,027 | | | | | 4,540 | | | | | 7,566 | | | | | | | |
| | **Total for LVSCA** | | 113,206 | | 15,327 | | | | | 28,090 | | | | | 69,789 | | | | | | | |

Note:
- F/S and/or D/D
- P Procurement
- Construction of Irrigation System
- Construction of Multipurpose Dam

Source: JICA Study Team



**Figure 7.3.3**
**Implementation Schedule of Proposed Irrigation Development Plan (LVSCA)**

| WRMA Catchment | No | Name of Project | Purpose | Installed Capacity (MW) | Project Status | Implementation Schedule | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Short Term | | | | | Medium Term | | | | | Long Term | | | | | | | |
| | | | | | | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
| | | | | | | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 | 19/20 | 20/21 | 21/22 | 22/23 | 23/24 | 24/25 | 25/26 | 26/27 | 27/28 | 28/29 | 29/30 | 30/31 |
| LVS | 4 | Magwagwa Dam | W, I, P, F | 115 | D/D done | | | | | | | | | | | | | | | | | | |

| Legend | |
|---|---|
| | F/S and/or D/D |
| P | Procurement |
| | Construction |

W=Domestic and industrial water supply, I=Irrigation, P=Hydropower, F-Flood control

D/D=Detailed Design, F/S=Feasibility Study, Pre-F/S=Pre-Feasibility Study

Source: JICA Study Team

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**Figure 7.3.4**
**Implementation Schedule of Proposed Hydropower Development Plan (LVSCA)**

| WRMA Catchment | No. | Name of Project | Purpose | Effective Storage Volume (MCM) | Project Status | Implementation Schedule | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Short Term | | | | | Medium Term | | | | | Long Term | | | | | | | |
| | | | | | | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
| | | | | | | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 | 19/20 | 20/21 | 21/22 | 22/23 | 23/24 | 24/25 | 25/26 | 26/27 | 27/28 | 28/29 | 29/30 | 30/31 |
| LVS | 1 | Magwagwa Dam | W, I, P, F | 445 | D/D done | | | | | | | | | | | | | | | | | | |
| | 2 | Itare Dam | W | 20 | Flagship | | | P | | | | | | | | | | | | | | | |
| | 3 | Nyando (Koru) Dam | W, I, F | 87 | Flagship<br>P/D ongoing | | | | | P | | | | | | | | | | | | | |
| | 4 | Bunyunyu Dam | W | 6 | Flagship<br>D/D done | | | | P | | | | | | | | | | | | | | |
| | 5 | Katieno Dam | I | 201 | Pre-F/S done | | | | | P | | | | | | | | | | | | | |
| | 6 | Londiani Dam | W | 25 | Flagship<br>Pre-F/S done | | | | | | | | P | | | | | | | | | | |
| | 7 | Kibos Dam | W, F | 26 | | | | | | | | | | | P | | | | | | | | |
| | 8 | Amala Dam | W, I | 175 | | | | | | | | | | | | | P | | | | | | |
| | 9 | Sand River (Naikara) Dam | W | 1 | | | | | | | | | | | | | | P | | | | | |
| | 10 | Ilooiterre Dam | W, I | 14 | Pre-F/S done | | | | | | | | | | | | | | P | | | | |

F/S and/or D/D
P Procurement
Construction
W=Domestic and industrial water supply, I=Irrigation, P=Hydropower, F-Flood control
D/D=Detailed Design, F/S=Feasibility Study, Pre-F/S=Pre-Feasibility Study

Source: JICA Study Team

| THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030 | **Figure 7.3.5 Implementation Schedule of Proposed Water Resources Development Plan (LVSCA)** |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | |

| No. | Description | Implementation Schedule | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Short Term | | | | | Medium Term | | | | | Long Term | | | | | | | |
| | | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
| | | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 | 19/20 | 20/21 | 21/22 | 22/23 | 23/24 | 24/25 | 25/26 | 26/27 | 27/28 | 28/29 | 29/30 | 30/31 |
| *Development Activities* | | | | | | | | | | | | | | | | | | | |
| (1) | Monitoring | | | | | | | | | | | | | | | | | | |
| M1 | Replacement of iron post for river gauge to concrete post | | | | | | | | | | | | | | | | | | |
| M2 | Upgrade manual gauge to automatic (surface water level) | | | | | | | | | | | | | | | | | | |
| M3 | Upgrade manual gauge to automatic (groundwater level) | | | | | | | | | | | | | | | | | | |
| M4 | Upgrade manual gauge to automatic (rainfall) | | | | | | | | | | | | | | | | | | |
| M5 | Installation of Dedicated Boreholes for Groundwater Monitoring | | | | | | | | | | | | | | | | | | |
| M6 | Installation/Rehabilitation of River Gauging Stations | | | | | | | | | | | | | | | | | | |
| M7 | Installation/Rehabilitation of Rainfall Gauging Stations | | | | | | | | | | | | | | | | | | |
| M8 | Flood Discharge Measurement Equipment (Each SRO) | | | | | | | | | | | | | | | | | | |
| (2) | Evaluation | | | | | | | | | | | | | | | | | | |
| E1 | Hydromet DB Upgrade (Software + Hardware) | | | | | | | | | | | | | | | | | | |
| (3) | Permitting | | | | | | | | | | | | | | | | | | |
| P1 | PDB Upgrade (Software + Hardware) | | | | | | | | | | | | | | | | | | |
| (4) | Watershed Conservation | | | | | | | | | | | | | | | | | | |
| W1 | Forestation (Gazetted Forest Area) | | | | | | | | | | | | | | | | | | |
| W2 | Forestation (Non-gazetted Forest Area) | | | | | | | | | | | | | | | | | | |
| *Recurrent Activities* | | | | | | | | | | | | | | | | | | | |
| (1) | Monitoring | | | | | | | | | | | | | | | | | | |
| M1 | Surface Water Level Monitoring | | | | | | | | | | | | | | | | | | |
| M2 | River Discharge Measurement | | | | | | | | | | | | | | | | | | |
| M3 | Groundwaer Level Monitoring | | | | | | | | | | | | | | | | | | |
| M4 | Rainfall Monitoring | | | | | | | | | | | | | | | | | | |
| M5 | Flood Discharge Measurement | | | | | | | | | | | | | | | | | | |
| M6 | Surface Water Quality Monitoring | | | | | | | | | | | | | | | | | | |
| M7 | Groundwater Quality Monitoring | | | | | | | | | | | | | | | | | | |
| (2) | Others | | | | | | | | | | | | | | | | | | |
| O1 | Catchment Forum Operation (Venue and Allownce to WURAs) | | | | | | | | | | | | | | | | | | |

Source: JICA Study Team

| THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030 | **Figure 7.3.6 Implementation Schedule of Proposed Water Resources Management Plan (LVSCA)** |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | |

*Flood Disaster Management Plan*

| WRMA Catchment | No. | Description | Implementation Schedule | | | | | | | | | | | | | | | | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Short Term | | | | | Medium Term | | | | | Long Term | | | | | | | | |
| | | | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | |
| | | | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 | 19/20 | 20/21 | 21/22 | 22/23 | 23/24 | 24/25 | 25/26 | 26/27 | 27/28 | 28/29 | 29/30 | 30/31 | |
| LVS | S1 | Kano Plain (Nyando River Basin) | | | | | | | | | | | | | | | | | | | |
| | | S1.1 Construction of Multipurpose Dam | | | | | | | | | | | | | | | | | | | Nyando Dam |
| | | S1.2 River Training Works | | | | | | | | | | | | | | | | | | | |
| | | S1.3 Establishment of Flood Forecasting and Warning System | | | | | | | | | | | | | | | | | | | |
| | | S1.4 Formulation of Flood Fighting Plan | | | | | | | | | | | | | | | | | | | |
| | S2 | Sondu Rivermouth | | | | | | | | | | | | | | | | | | | |
| | | S2.1 Construction of Multipurpose Dam | | | | | | | | | | | | | | | | | | | Magwagwa Dam |
| | | S2.2 Establishment of Community-based Flood Management System | | | | | | | | | | | | | | | | | | | |
| | S3 | Kuja Rivermouth | | | | | | | | | | | | | | | | | | | |
| | | S3.1 Establishment of Community-based Flood Management System | | | | | | | | | | | | | | | | | | | |
| | S4 | Kisumu | | | | | | | | | | | | | | | | | | | |
| | | S4.1 Construction of Multipurpose Dam | | | | | | | | | | | | | | | | | | | Kibos Dam |
| | | S4.2 Implementation of Urban Drainage Measures | | | | | | | | | | | | | | | | | | | |

*Drought Disaster Management Plan*

| No. | Description | Implementation Schedule | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Short Term | | | | | Medium Term | | | | | Long Term | | | | | | | |
| | | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
| | | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 | 19/20 | 20/21 | 21/22 | 22/23 | 23/24 | 24/25 | 25/26 | 26/27 | 27/28 | 28/29 | 29/30 | 30/31 |
| 1 | Preparation of Water Use Restriction Rule for Reservoirs | | | | | | | | | | | | | | | | | | |
| 2 | Establishment of Basin Drought Conciliation Councils | | | | | | | | | | | | | | | | | | |
| 3 | Development of Drought Early Forecast System | | | | | | | | | | | | | | | | | | |

Legend: Establishment Update / Expansion

Source: JICA Study Team

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**Figure 7.3.7**
**Implementation Schedule of Proposed Flood and Drought Disaster Management Plan (LVSCA)**

| WRMA Catchment | No. | Name of Project | Target | Related Project (Dams and Irrigation) | Implementation Schedule | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Short Term | | | | | Medium Term | | | | | Long Term | | | | | | | |
| | | | | | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
| | | | | | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 | 19/20 | 20/21 | 21/22 | 22/23 | 23/24 | 24/25 | 25/26 | 26/27 | 27/28 | 28/29 | 29/30 | 30/31 |
| LVS | 1 | Setting of Environmental Flow | Nyando River | Nyando and Londiani Dams | | | | Set | | | | | | | | | | | | | | |
| | | | Sondu River | Magwagwa and Itare Dams | | Set | | | | | | | | | | | | | | | | |
| | | | Gucha River | Bunyunyu and Katieno Dams | | | Set | | | | | | | | | | | | | | | |
| | | | Migori River | Ilooiterre Dam | | | | | Set | | | | | | | | | | | | | |
| | | | Mara River | Amala Dam | Set | (Confirmation of current status only) | | | | | | | | | | | | | | | | |
| | 2 | Environmental Monitoring | Nyando River | Nyando and Londiani Dams | | | | | | | | | | | | | | | | | | |
| | | | Sondu River | Magwagwa and Itare Dams | | | | | | | | | | | | | | | | | | |
| | | | Gucha River | Bunyunyu and Katieno Dams | | | | | | | | | | | | | | | | | | |
| | | | Migori River | Ilooiterre Dam | | | | | | | | | | | | | | | | | | |
| | | | Mara River | Amala Dam | | | | | | | | | | | | | | | | | | |
| | | | L. Victoria | - | | | | | | | | | | | | | | | | | | |
| | | | Kisumu Town | - | | | | | | | | | | | | | | | | | | |
| | | | Homa Bay Town | - | | | | | | | | | | | | | | | | | | |

Environmental Survey for Setting Environmental Flow

Set: Setting of Environmental Flow (including Key Stakeholder Meeting)

Environmental Monitoring (including Planning)

Source: JICA Study Team

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**Figure 7.3.8**
**Implementation Schedule of Proposed Environmental Management Plan (LVSCA)**

# Part D
# Rift Valley Catchment Area


**Location Map (RVCA)**

# 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 D: RIFT VALLEY CATCHMENT AREA

**Location Map**
**Abbreviation**

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# List of Abbreviations and Acronyms

| | | |
|---|---|---|
| ALRMP | : | Arid Land Resources Management Project |
| ASAL | : | Arid and Semi-arid Land |
| B/C | : | Benefit and Cost |
| BOD | : | Biochemical Oxygen Demand |
| CBDM | : | Community-based disaster management |
| COD | : | Chemical Oxygen Demand |
| D/D | : | Detailed Design |
| DO | : | Dissolved oxygen |
| EIRR | : | Economic Internal Rate of Return |
| ENNCA | : | Ewaso Ng'iro North Catchment Area |
| ENSDA | : | Ewaso Ng'iro South Development Authority |
| F/S | : | Feasibility Study |
| JICA | : | Japan International Cooperation Agency |
| KMD | : | Kenya Meteorological Department |
| KVDA | : | Kerio Valley Development Authority |
| LCPDP | : | Least Cost Power Development Plan |
| LSRWSS | : | Large Scale Rural Water Supply System |
| LVNCA | : | Lake Victoria North Catchment Area |
| LVS | : | Lake Victoria South |
| LVSCA | : | Lake Victoria South Catchment Area |
| MDNKOAL | : | Ministry of State for Development of Northern Kenya and Other Arid Lands |
| MORDA | : | Ministry of Regional Development Authority |
| MWI | : | Ministry of Water and Irrigation |
| NRW | : | Non-Revenue Water |
| NWMP | : | National Water Master Plan |
| O&M | : | Operation and Maintenance |
| Pre-F/S | : | Prefeasibility Study |
| RVCA | : | Rift Valley Catchment Area |
| SS | : | Suspended Solids |
| SSRWSS | : | Small Scale Rural Water Supply System |
| UNESCO | : | United Nations Educational, Scientific and Cultural Organization |
| WASREB | : | Water Services Regulatory Board |
| WRMA | : | Water Resource Management Authority |
| WRUA | : | Water Resources Users Association |
| WSB | : | Water Service Board |
| WSC | : | Water Service Company / Water and Sewerage Company |
| WSP | : | Water Service Provider |
| WWTP | : | Waste Water Treatment Plant |

# 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

The National Water Master Plan 2030 (NWMP 2030) covers the whole area of Kenya. The plans for water resources development and management were formulated for six catchment areas of the Water Resources Management Authority (WRMA) designated by the National Water Resources Management Strategy (2007-2009) for water resources management purposes.

This volume, Main Report Part D, presents the water master plan for the Rift Valley Catchment Area (RVCA). The water master plan of RVCA consists of the following eight component plans as mentioned in Chapter 7 of the Main Report Part A.

<u>Development plans</u>

1) Water supply development plan
2) Sanitation development plan
3) Irrigation development plan
4) Hydropower development plan
5) Water resources development plan

<u>Management plans</u>

6) Water resources management plan
7) Flood and drought disaster management plan
8) Environmental management plan

The Main Report Part D for RVCA includes catchment area characteristics, water resources, water demands, water allocation plan, development and management plans, cost estimates economic evaluation, and implementation programmes. The plans were formulated based on the water resources assessment, water demand projection, objectives, and overall concepts of respective subsectors presented in the Main Report Part A. The development plans aim to provide a basis for future water demand projection, while the management plans aim to propose frameworks for sustainable water resources management including the aspects of flood, drought, and environment.

# CHAPTER 2 CATCHMENT CHARACTERISTICS

RVCA is located in the central-western part of the country. It includes the so-called Rift Valley. RVCA has a long and narrow shape with a length of about 800 km in the north-south direction, and about 100 km to 300 km wide in the east-west direction. RVCA borders the South Sudan and Ethiopia in the north, Ewaso Ng'iro, Tana, and Athi catchment areas in the eastern side, Tanzania in the south, and Uganda and Lake Victoria South and North catchment areas in the western side. The central part of RVCA is surrounded by Cherangani Hills, the Mau Forest Complex, and the Aberdare Range of the Five Water Towers.

The total area of RVCA is 130,452 km$^2$, corresponding to 22.7% of the country's area. Based on the Census 2009, population of the area in 2010 was estimated at 4.86 million, or 12.6% of the total population of Kenya. Population density is as low as 37 persons/km$^2$.

The topography of RVCA varies from Lake Turkana of 375 m above mean sea level (amsl) in the north to the mountain areas of more than 3,000 m amsl in the central part and to Lake Magadi of 579 m amsl in the south.

There are seven lakes along the Rift Valley, namely, Lakes Turkana, Baringo, Bogoria, Nakuru, Elementaita, Naivasha, and Magadi from the north. Only Lakes Baringo and Naivasha have fresh water. Other lakes have saline water. Rivers in RVCA originate from Cherangani Hills, the Mau Forest Complex, and the Aberdare Range. Most of them flow into the abovementioned seven lakes. The Ewaso Ng'iro South River in the southern part of RVCA originates from the Mau Forest Complex and flows southward across the border of Tanzania.

Lake Turkana is the largest lake in Kenya with a surface area of 6,400 km$^2$ and borders with Ethiopia in its northern end. Its water resources are shared with Ethiopia. Major rivers flowing into Lake Turkana are the Turkwel and Kerio rivers. The Turkwel River originates from Cherangani Hills and has a drainage area of 19,820 km$^2$. The Kerio River originates from the Mau Forest Complex and has a drainage area of 13,928 km$^2$.

A study on groundwater potential titled "Advanced Survey on Groundwater Resources of Northern and Central Turkana County, Kenya" was conducted with financial assistance from the government of Japan from June 2012 to February 2013[1]. The target area for the study is northern and central part of Turkana County with an area of 36,000 km$^2$. The study was conducted through integration of remote sensing and geophysical exploration technologies to identify groundwater potential, then confirmed through drilling of boreholes at target locations. As detailed information on analytical method and water quality are not sufficiently provided, the result of the study is not able to be applied to the master plan study. It is recommended to utilise the data for scrutinising groundwater potential as described in "Chapter 11 Recommendations" of Main Report Part A.

[1] The master plan report is prepared based on the result of field survey as of November 2012. During the explanation of the draft final report in August 2013, information on groundwater potential study was provided from the Kenyan government side on the Northern and Central Turkana County. Descriptions were given based on advices from Kenyan government side.

The Omo River also flows into Lake Turkana, but its entire drainage area lies in the territory of Ethiopia. The total drainage area of the rivers that flow into Lake Turkana accounts for about 70,000 $km^2$, which is more than half of RVCA. Most of the rivers are seasonal ones except the Turkwel and Kerio rivers. Even Turkwel and Kerio rivers flow underground in their downstream reaches before Lake Turkana.

Lake Magadi located in the southern part of RVCA has the second largest drainage area of 8349 $km^2$, but the rivers pouring into this lake flow underground. Lake Baringo has the third largest drainage area of 6,530 $km^2$ having the Perkerra and Mala rivers, and followed by Lake Naivasha with a drainage area of 3,128 $km^2$, Lake Nakuru with 1,624 $km^2$, Lake Bogoria with 1,137 $km^2$ and Lake Elementaita with 543 $km^2$. Of these lakes, Lake Naivasha is recently facing significant water level decrease in the dry season due to increase of water use due to rapid population growth.

The northern part of RVCA is classified as an arid land, while the central part as a humid land (non-ASAL) and southern part as a semi-arid land. The mean annual rainfall ranges between 200 mm and 700 mm in the northern part of RVCA, from 700 mm to 1,200 mm in the central part, and from 700 mm to 800 mm in the southern part. The catchment area average mean annual rainfall for the entire RVCA comes to 510 mm. The renewable water resources which is defined by precipitation minus evapotranspiration was estimated at 3.6 BCM/year in 2010 for RVCA and the per capita renewable water resources was calculated at 737 $m^3$/year/capita.

Major cities and towns in RVCA are Nakuru, Narok, Kabarnet, and Lodwar. The catchment area includes the whole area or most area of Turkana, West Pokot, Baringo, Laikipia, Nakuru, and Nandarua counties, a part of Marsabit, Samburu, Narok, and Kajiado counties.

Nakuru is the largest city in RVCA hosting many kinds of industries such as agricultural equipment, brewing and beverages, food processing, chemicals and pharmaceuticals, glass, leather, timber and timber products, textiles, and light engineering. In Lodwar, the largest town in the northern part is located in the west of Lake Turkana, food processing industry is famous.

# CHAPTER 3 WATER RESOURCES, WATER DEMANDS, AND WATER ALLOCATION

## 3.1 General

Future water demand will increase due to population growth and economic activities. On the other hand, available water resources are limited and affected by climate change. The water resources development and management plans in this study must be formulated to have an appropriate allocation of the limited and climate affected water resources to meet the increasing water demands of various water users in the future.

The available water resources consisting of surface water and groundwater were estimated for the years 2010 (considered as present) and 2030, as detailed in Chapter 5 of the Main Report Part A and Sectoral Report (B). The estimates for 2030 include impacts of climate change.

The present water uses were estimated and future water demands for the year 2030 were projected for the subsectors of domestic, industrial, irrigation, livestock, wildlife, and inland fisheries uses. Since records available for the actual water usage at present were insufficient, the present water demands were estimated and will be utilised as water uses. The future water demand projections were based on the socioeconomic frameworks set in Kenya Vision 2030. The estimates and projections are detailed in Chapter 6 of the Main Report Part A and Sectoral Reports (C) and (E).

The appropriate allocation of available water resources for 2030 was studied based on water balance studies to meet the 2030 water demands. The allocation was based on concepts and strategies for planning of the water resources development, as well as, the allocation policies derived from the current situations of the water balance between the present water resources and water demands and future trends as represented in Chapter 7 of the Main Report Part A and Section 4.6 of this report. Through the allocation study, the water demands were modified to be supplied within the resources capacity.

The following sections are brief explanation of the available water resources, present water uses and future water demands, and proposed water allocation plan for RVCA, which are basis of the water resources development and management plans.

## 3.2 Available Water Resources

The available water resources consisting of the surface water runoff and sustainable yield of groundwater were estimated in RVCA for the years 2010 (present) and 2030 as follows:

**Annual Available Water Resources (RVCA)**

(Unit: MCM/year)

| Year | Surface Water | Groundwater | Total |
|---|---|---|---|
| 2010 | 2,457 | 102 | 2,559 |
| 2030 | 3,045 | 102 | 3,147 |
| Percentage of 2010 values | 124% | 100% | 123% |

Source: JICA Study Team, (Ref. Main Report Part A, Sub-section 5.2.3)

The sustainable yield of groundwater was derived as 10% of the groundwater recharge in the catchment area excluding river courses and riparian areas with a width of 1 km, where groundwater abstraction will need to be restricted. The impacts of climate change were incorporated into the above estimates for 2030. Details of the above values for annual available water resources are presented in Section 5.2 of the Main Report Part A.

The above table shows that the 2030 surface water runoff will increase to 124% of 2010 runoff due to climate change impacts, while the 2030 sustainable yield of groundwater will remain unchanged from the 2010 yield, resulting in an increase of 2030 available water resources to 123% of 2010 resources.

The hydrological analysis of this study explained in the Sectoral Report (B) disclosed also that the rainfall may increase in the western highland areas and may be unchanged or decrease in the coastal areas in the long rainy season, but the rainfall may be almost unchanged throughout the country and slightly decrease in the coastal areas in the dry season in the future. This implies that availability of water resources is expected to be more unevenly distributed spatially and temporally in the future.

## 3.3 Present Water Uses and Future Water Demands under the Kenya Vision 2030

The annual water demands were estimated for the year 2010 and projected for 2030 in RVCA for use of subsectors such as domestic, industrial, irrigation, livestock, wildlife, and inland fisheries. The projection for 2030 followed the national development targets of Kenya Vision 2030 and socioeconomic framework. Basic conditions of the estimates and projection and their results are described in Chapter 6 of the Main Report Part A.

The annual water demands for 2010 and 2030 are summarised below.

**Water Demands by Subsector (RVCA)**

(Unit: MCM/year)

| Year | Domestic | Industrial | Irrigation | Livestock | Wildlife | Fisheries | Total |
|---|---|---|---|---|---|---|---|
| 2010 | 129 | 10 | 143 | 70 | 1 | 4 | 357 |
| 2030 | 264 | 23 | 1,075 | 123 | 1 | 8 | 1,494 |

Source: JICA Study Team, (Ref. Main Report Part A, Section 6.10 and Setoral Report (G), Sub-section 3.3.1 (3))

The total projected water demands of 1,494 MCM/year in 2030 amount to approximately 4.2 times of the present water demands of 357 MCM/year mainly due to the increase in population from 4.86 million to 7.45 million and irrigation areas from 9,587 ha to 73,080 ha mentioned in Chapter 6 of the Main Report Part A. Monthly water demands in 2030 by sub-basin are shown in Table 3.3.1.

## 3.4 Proposed Water Allocation Plan

(1) Water Balance Study

The available water resources and water demands for both 2010 and 2030 as presented in the preceding sections are compared as follows:

**Available Water Resources and Water Demands (RVCA)**

(Unit: MCM/year)

| 2010 | | | 2030 | | |
|---|---|---|---|---|---|
| Water Resources | Water Demands | Percentage | Water Resources | Water Demands | Percentage |
| 2,559 | 357 | 14% | 3,147 | 1,494 | 47% |

Source: JICA Study Team

Although the present water demands in 2010 are estimated to be 14% of the available water resources, the water demands for 2030 are expected to increase largely having the percentage of 47% of the 2030 available water resources in 2030. The percentage of 47% of water demand to water resources, which is called a water stress ratio, indicates severe situation in the water balance for the catchment area compared with the ratio of 40% regarded to indicate severe water stress.

In order to examine in more details the situation of future water balance from the spatial and temporal viewpoints, a surface water balance study for 2030 was carried out. Since the surface water demands occupy more than 80% of the total demands nationwide, it was judged that the surface water balance would give general situation of water deficits. This study divided the catchment area into 35 sub-basins and applying a study model with the existing dams and water transfers only as discussed in Section 6.11 of the Main Report Part A. Conditions of the water balance study are described in Subsection 4.6.3 of this report and detailed in Chapter 4 of the Sectoral Report (G).

Results of the surface water balance study showed water deficits estimated in most of the sub-basins in RVCA as seen in Figure 6.11.2 of the Main Report Part A. The water deficits derived from the water balance study for 2010 and 2030, and a comparison with water demands are summarised below.

**Water Demands and Water Deficits (RVCA)**

(Unit: MCM/year)

| 2010 | | | 2030 | | |
|---|---|---|---|---|---|
| Water Demands | Water Deficits | Percentage | Water Demands | Water Deficits | Percentage |
| 357 | 92 | 26% | 1,494 | 867 | 58% |

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

The water deficits for 2030 in the above table suggest requirements for planning to maximise utilisation of water recourses such as maximum development of the water resources, introduction of the water demand management, and limitation of water demands within the water supply capacity, as detailed in Section 6.11 of the Main Report Part A.

(2) Modified Future Water Demands

Following the suggested requirements mentioned above, the water demands for 2030 described in Section 3.3 were modified in terms of irrigation water demand considering water saving and efficient water use measures. The water balance study was carried out between the water resources and the modified water demands for 2030 with provision of various water storages and supply facilities proposed in the water resources development plan stated in Section 4.6 of this report and Sectoral Report(G).

The modified water demands are summarised below.

**Modified Water Demands for 2030 (RVCA)**

(Unit: MCM/year)

| Year | Domestic | Industrial | Irrigation | Livestock | Wildlife | Fisheries | Total |
|---|---|---|---|---|---|---|---|
| 2030 | 264 | 23 | 1,393 | 123 | 1 | 8 | 1,812 |

Source: JICA Study Team

The modified irrigation water demand of 1,393 MCM/year in the above table is a sum of the demand of 833 MCM/year calculated by the water balance study using the water resources of RVCA and the demand of 560 MCM/year to be supplied from a proposed dam located in Ethiopia for the new Todonyang-Omo irrigation project of RVCA using the water resources of Ethiopia. The projected irrigation water demand of 1,075 MCM/year following Kenya Vision 2030 as stated in Section 3.3 was reduced to 833 MCM/year due to limited water resources of RVCA. The proposed irrigation area in 2030 for RVCA is 101,753 ha including the area of 35,000 ha for the Todonyang-Omo irrigation project.

(3) Proposed Water Allocation Plan

Results of the balance study mentioned in the above clause (2) showing the allocated amount of the surface water and groundwater to satisfy the 2030 modified water demands are as follows:

**Water Resources Allocation Plan in 2030 (RVCA)**

(Unit: MCM/year)

| Subsector | Water Demand | Water Resources Allocation | |
|---|---|---|---|
| | | Surface Water | Groundwater |
| Domestic | 264 | 213 | 51 |
| Industrial | 23 | 12 | 11 |
| Irrigation | 1,393 | *1,377 | 16 |
| Livestock | 123 | 123 | 0 |
| Wildlife | 1 | 1 | 0 |
| Fisheries | 8 | 8 | 0 |
| Total | 1,812 | 1,734 | 78 |

Note: *=Including water demand to be supplied by water resources of Ethiopia of 560 MCM/year.
Source: JICA Study Team

The total amount of allocated surface water is 1,734 MCM/year, which is about 96% of the total water demand and about 57% of the available surface water resources. The total amount of allocated groudwater is 78 MCM/year, which is about 4% of the total water demand and about 76% of the available groundwater resources. The above percentages in terms of water resources imply that the water balance situation in 2030 is expected to be almost severe or severe judging from the water stress ratio.

The allocation plan should be considered as a guide in the water resources management in RVCA.

# CHAPTER 4 DEVELOPMENT AND MANAGEMENT PLANS

## 4.1 General

Based on the overall concepts and framework by subsector as described in Chapter 7 of Main Report Part A, eight component plans were prepared.

Eight component plans include water supply, sanitation, irrigation, hydropower, and water resources development plans (five development plans); and water resources, flood and drought disaster, and environmental management plans (three management plans).

Current situations, development/management strategies, and proposed plans for the above eight component plans are explained in the next sections.

## 4.2 Water Supply Development Plan

### 4.2.1 Current Situation of Water Supply

As shown in Section 3.2 of Main Report Part A, the current population of RVCA as of 2010 is estimated to be 4.86 million including 1.41 million of urban population and 3.45 million of rural population. Its population is concentrated in Nakuru area and Naivasha area. Based on the 2009 Census data, the current situation of water connection of RVCA was estimated as shown below.

**Current Situation of Water Connection (RVCA)**

| Type | Piped by WSPs | Spring/Well/Borehole | Water Vendor | Stream/Lake/Pond/Others |
|---|---|---|---|---|
| Urban Population | 52% | 22% | 19% | 8% |
| Rural Population | 14% | 37% | 4% | 45% |
| Total Population | 28% | 32% | 9% | 31% |

Source: JICA Study Team, based on Census 2009 data (Ref. Sectoral Report (C), Sub-section 2.3.5.)

The water provided by unregistered water vendors, and water taken from streams, lakes, and ponds without proper treatment are categorised as unimproved drinking water sources. Around 40% of the population get drinking water from such unimproved drinking water source. Also, around 31% of the population get water from springs, wells, or boreholes. Unprotected wells and springs are categorised as an unimproved drinking water source, but the utilisation ratio of unprotected sources is unknown.

It is projected that the urban population will increase by 3.08 million while the rural population will decrease by 0.49 million in 2030 as shown in Section 3.2 of Main Report Part A. Hence, the total population will become 7.45 million in 2030 as shown below.

**Projected Population for Rift Valley Catchment**

(Unit: million persons)

| Year | Urban Population | Rural Population | Total |
|---|---|---|---|
| 2010 | 1.41 | 3.45 | 4.86 |
| 2030 | 4.49 | 2.96 | 7.45 |

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

Currently, the piped water supply covers 52% of the urban population of RVCA, of which target coverage ratio for 2030 is 100%. It is therefore required to implement a large-scale urban water supply system development to cope with the rapid growth of urban population and achieve the target coverage ratio of 100%.

As for registered water service providers (WSPs) in RVCA, nine urban WSPs and five rural WSPs carry out water supply services. It is recorded that the total water supply capacity is 96,886 $m^3$/day, and the total service population is 777,309. Therefore, the average water supply amount per person is 125 L/p/day inclusive of non-revenue water (NRW). It is higher than the national average of urban water supply amount of 65 L/p/day including NRW (36 L/p/day excluding NRW). Out of the seven urban WSPs, four WSPs have records of more than 50% of NRW. The current situations of the WSPs in RVCA are shown in Table 4.2.1.

### 4.2.2 Development Strategy

RVCA is divided into three areas, namely, Nakuru central populated area, north arid area, and the south surrounding areas. Urban water supply system (UWSS) planning and the characteristics of the three areas are shown below.

**Characteristics of the Areas (RVCA)**

| Area | Feature |
|---|---|
| Nakuru, Naivasha and Surrounding Areas (Central Area) | Out of the 13 urban centres in RVCA, seven urban centres are in this area. It is estimated that the population is around 60% of the total population (2010). Water sources seem not enough for future population in this area, therefore, it is essential to get new water sources somewhere else. |
| Arid Area | It has a low population density. There are three urban centres in the arid area, and groundwater is the major water source. |
| Other Area | This is the outskirt of the abovementioned areas, there are four urban centres, basically depending on surface water. For the future demand, water supply development plan with groundwater use will be considered. |

Source: JICA Study Team

Based on the overall concept mentioned in Section 7.3.2 of the Main Report Part A, UWSS are planned for 13 urban centres (UCs) in RVCA. In case that the same water resources are used for several UCs like seven UCs ,i.e., Nakuru, Naivasha, Gilgil, Molo, Njoro, Eldama Ravine, and Ol Kalou, one water supply system is planned to cover several UCs. However, UWSS in other six UCs are planned for each UC independently.

The water supply capacity required for UWSS in RVCA is 398,000 $m^3$/day in 2030 against the current water supply capacity (including capacity under construction) of 129,000 $m^3$/day, so an additional capacity of 269,000 $m^3$/day will be developed by 2030. This will be developed under the following three types of projects.

a) Rehabilitation of existing UWSS

In order to achieve 20% of NRW ratio, water meters will be installed for all households and old pipes of exiting UWSS of 10 UCs, which have 129,000 $m^3$/day of water supply capacity, need to be replaced. In addition, the rehabilitation includes replacement and repair of mechanical and electrical equipment in water treatment plants and pumping stations.

b) Expansion of UWSS

Expansion of UWSS is planned for above 10 UCs to meet the water demand in 2030. The total expansion capacity is 254,000 $m^3$/day.

c) Construction of new UWSS

The construction of new UWSS is planned for 3 UCs, which have no UWSS. The total capacity of the new UWSS is 15,000 $m^3$/day.

d) Incorporation of existing plans

According to data from WSBs, there are four plans of water supply development projects to cover nine UCs and surrounding areas, which have 135,000 $m^3$/day of total water supply capacity. (Refer to Sectoral Report (C), Section 2.4) These plans are to be incorporated in NWMP 2030.

UWSS prioritise the use of surface water. On the other hand, there is a large-scale groundwater source in Nakuru and Naivasha, and the dependence ratio of groundwater is 46%. It is relatively high compared to the other catchment. Out of the Nakuru surrounding areas, the dependence ratio of groundwater in Nakuru, Naivasha, Gilgil, and Njoro is expected to decrease at 10% of the target ratio in 2030. Also, the target ratio is 5% in other areas.

Based on the overall concept mentioned in Section 7.3.2 of the Main Report Part A, large-scale rural water supply system (LSRWSS) and small-scale rural water supply system (SSRWSS) are planned to be developed.

a) Development of LSRWSS

LSRWSS is proposed mainly for areas with high population density or areas with difficulties using groundwater for personal or community use. LSRWSS will be developed for 1.70 million residents in 18 counties of RVCA.

b) Development of SSRWSS

SSRWSS is proposed for 2.40 million residents in 18 counties of RVCA, and it includes construction and improvement of boreholes, wells, and springs for personal and community use, which will be implemented by individuals or communities.

### 4.2.3 Proposed Water Supply Development Plan

The proposed UWSS is presented in Table 4.2.2, while the proposed LSRWSS and SSRWSS are shown in Tables 4.2.3 and 4.2.4, respectively. The proposed water supply development plan for RVCA is outlined below.

**Proposed Water Supply Development Plan (RVCA)**

| Type of Project | | Target Area | Total Capacity ($m^3$/day) | Service Population (million persons) |
|---|---|---|---|---|
| Urban Water Supply | Rehabilitation | 10 UCs | 129,000 | 3.34 |
| | Expansion | 10 UCs | 254,000 | |
| | New Construction | 3 UCs | 15,000 | |
| | Total | 13 UCs | 398,000 | |
| Rural Water Supply | LSRWSS | 18 Counties | 178,000 | 4.11 |
| | SSRWSS | 18 Counties | 120,000 | |
| | Total | 18 Counties | 298,000 | |

Source: JICA Study Team based on Tables 4.2.2 to 4.2.4.

With the above water supply development, the water supply situation of RVCA in 2030 will be as follows.

**Water Supply Situation in 2030 (RVCA)**

| Items | | Urban Water Supply | Large-scale Rural Water Supply | Small-scale Rural Water Supply | Total |
|---|---|---|---|---|---|
| Service Population (million) | 2010 | 1.36 | | 1.55 | 2.91 |
| | 2030 | 3.34 | 1.70 | 2.41 | 7.45 |
| Required Treatment Capacity ($m^3$/day) | 2010 | 129,000 | 7,000 | 78,000 | 214,000 |
| | 2030 | 398,000 | 178,000 | 120,000 | 696,000 |
| Operating Body | | Registered WSPs | Registered WSPs | Individual, Community, etc. | -- |
| Target Towns/ Areas | | 13 UCs | 18 Counties | | -- |

Source: JICA Study Team (Figures for 2010 were referred to Sectoral Report (C), Section 2.3. Figures for 2030 were based on Tables 4.2.2 to 4.2.4.)

In order to ensure water sources required for the water supply systems mentioned above, it is proposed to construct nine new dams in RVCA and two new dams in LVSCA, as the result of the water balance study. (Ref. Sectoral Report (G), Chapter 4.6)

## 4.3 Sanitation Development Plan

### 4.3.1 Current Situation of Sanitation Development

Based on the Census 2009 data, the current situation on the accessibility to sanitation facilities in RVCA was estimated as shown below.

**Current Situation on Access to Sanitation Facilities (RVCA)**

| Type | Sewerage System | Septic Tank, Pit Latrine, Cesspool (On-site Treatment Facilities) | Bush, etc (No Treatment) |
|---|---|---|---|
| Urban Population | 10% | 87% | 3% |
| Rural Population | 0% | 59% | 41% |
| Total Population | 4% | 69% | 27% |

Source: JICA Study Team, based on Census 2009 data (Ref. Main Report Part D, Sub-section 2.3.4.)

Sewerage system has been developed in limited area of RVCA, and current sewerage coverage ratio is only 4%. There are four small-scale waste water treatment plants located in Nakuru, Naivasha and Molo, where total treatment capacity is about 18,393 $m^3$/day. Around 69% of the population use on-site sanitation facilities such as septic tank, etc. The on-site sanitation facilities include unimproved ones, but the ratio of the unimproved facilities is unknown. Around 27% of the population does not have any treatment facilities, and resort to unsanitary waste disposal.

### 4.3.2 Development Strategy

Based on the overall concept and framework for planning described in Section 7.4 of the Main Report Part A, sewerage system development is planned for nine UCs in RVCA. The sewerage system development is conducted under the following three types of projects:

a) Rehabilitation of existing sewerage system

The rehabilitation includes repair and replacement of mechanical and electrical equipment of wastewater treatment plants (WWTPs) and pumping stations, as well as replacement of damaged sewer pipes in three UCs. This rehabilitation will be carried out for existing sewerage systems with the capacity of 18,000 $m^3$/day.

b) Expansion of sewerage system

In order to cover the demand in 2030, the capacities of existing sewerage systems of three UCs will be expanded. This type of project includes the expansion and/or new construction of sewerage pipes, pumping stations, and WWTPs. The expansion will provide an additional capacity of 150,000 $m^3$/day.

c) Construction of New Sewerage System

There are no sewerage systems in six UCs. New sewerage systems will be constructed in these UCs that will provide an additional capacity of 72,000 $m^3$/day to meet the demand in 2030.

d) Incorporation of existing plans

According to data from WSBs, there are seven plans of sewerage development projects to cover seven urban centres, which have 106,000 $m^3$/day of total treatment capacity. (Refer to Sectoral Report (D), Section 2.4) These plans are to be incorporated in NWMP 2030.

Outside the sewerage service area, the improved on-site treatment facilities will be provided for the remaining 4.29 million residents in 2030. Currently, 3.38 million residents (69% of entire population) are using the existing on-site treatment facilities, while unimproved ones will be improved with new housing facilities. Development of on-site sanitation facilities is planned for 18 counties in RVCA.

### 4.3.3 Proposed Sanitation Development Plan

The sewerage development plan is shown in Table 4.3.1, and the on-site treatment development plan is in Table 4.3.2. The proposed sanitation development plan for RVCA is outlined as shown below.

**Proposed Sanitation Development Plan (RVCA)**

| Type of Project | | Target Area | Total Capacity ($m^3$/day) | Service Population (million persons) |
|---|---|---|---|---|
| Sewerage System (Off-site Treatment) | Rehabilitation | 3 UCs | 18,000 | 3.16 |
| | Expansion | 3 UCs | 150,000 | |
| | New Construction | 6 UCs | 72,000 | |
| | Total | 9 UCs | 240,000 | |
| On-site Treatment Facilities | | 18 Counties | -- | 4.29 |

Source: JICA Study Team based on Tables 4.3.1 and 4.3.2.

Out of 4.49 million urban population in RVCA, 70% of the urban population is expected to be covered by the sewerage system. The ratio of RVCA is little lower than the national target of 80%, because there are limited large-scale UCs, that prioritised sewerage development. With the above sanitation development, the sanitation situation of RVCA in 2030 will be as follows.

**Sanitation Situation in 2030 (RVCA)**

| Items | | Sewerage System | Septic Tank, etc (On-site Treatment Facilities) |
|---|---|---|---|
| Service Population (million) | 2010 | 0.19 | 3.35 |
| | 2030 | 3.16 | 4.29 |
| Required Treatment Capacity ($m^3$/day) | 2010 | 18,000 | ----- |
| | 2030 | 240,000 | ----- |
| Operating Body | | Registered WSPs | Individual, Community, etc. |
| Target Town/Areas | | 9 UCs | 18 Counties |

Source: JICA Study Team (Figures for 2010 above are referred to Sectoral Report (D), Section 2.3, and figures for 2030 above are based on Tables 4.3.1 and 4.3.2.)

## 4.4 Irrigation Development

### 4.4.1 Current Situation of Irrigation Development

RVCA stretches 870 km from north to south. The central part of RVCA is a highland. The climate in RVCA widely varies by elevation from wet zones in the highlands to semi-arid and arid zones in the lowlands. The crop area in 2011 was 303,856 ha in total. The irrigation area in RVCA is located mostly in the highlands. The existing irrigation area in 2010 was 9587 ha in total, consisting of 774 ha (8%) of public irrigation schemes, 5791 ha (60%) of smallholder irrigation schemes, and 3022 ha (32%) of private schemes. Almost all the existing irrigation systems (excluding private schemes) have deteriorated mainly due to poor maintenance.

### 4.4.2 Development Strategy

Following the overall concept and framework for irrigation development mentioned in Section 7.5 of the Main Report Part A, strategy for irrigation development in RVCA was set as follows.

a) In order to utilise available water resources efficiently for the maximisation of irrigation development, the water-saving irrigation methods should be introduced to improve water productivity of all irrigation areas;

b) In order to strengthen the agricultural sector in RVCA, irrigation should be expanded in rainfed agricultural areas in arid and semi-arid lands to increase agricultural productivity and production; and

c) Owing to the sufficient land resources available, but limited water resources for irrigation in RVCA, priority to maximise irrigation area should be given to dam irrigation in arid and semi-arid lands. Furthermore, small-scale dam irrigation and groundwater irrigation should be developed as far as water resources are available.

### 4.4.3 Proposed Irrigation Development Plan

As a result of the water balance study for each sub-basin in RVCA, the maximum irrigation development areas under the application of water-saving irrigation methods were estimated as summarised below.

**Proposed Irrigation Areas in 2030 (RVCA)**

(Unit: ha)

| Category | Existing Irrigation Area in 2010 | New Irrigation Area in 2030 | | | | | | Total Irrigation Area in 2030 |
|---|---|---|---|---|---|---|---|---|
| | | Surface Water Irrigation | | | Ground-water Irrigation (Borehole) | Water Harvesting Irrigation (Small Dam/ Water Pan) | Total New Irrigation Area | |
| | | Weir | Dam | Total | | | | |
| Large-scale | 774 | 7,000 | 71,850 | 78,850 | 0 | 0 | 78,850 | 79,624 |
| Small-scale | 5,791 | 5,335 | 0 | 5,335 | 1,046 | 2,890 | 9,271 | 15,062 |
| Private | 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 |

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

Against the provisional target of new irrigation development area of 63,493 ha (distributed to RVCA for the national target of 1.2 million ha) mentioned in Section 7.5 of the Main Report Part A, the possible new irrigation development area comes to 92,166 ha (increase of 28,673 ha) with maximum water resources development presented in Section 4.6.

As for the large-scale irrigation projects (more than 500 ha), 30 projects proposed by the goverment authorities listed in Table 7.5.1 in the Main Report Part A were taken up for the water balance study, and nine projects were selected for implementation by 2030 as suitable projects to contribute to the maximisation of irrigation area in RVCA as shown in Table 4.4.1 and their locations are shown in Figure 4.4.1. They are listed as below.

a) Arror Dam Irrigation Project (10,850 ha, Arror multipurpose dam);
b) Perkera Irrigation Extension Project (3000 ha, Existing Perkera dam);
c) Turkwel Irrigation Project (5000 ha, Existing Turkwel dam);
d) Norea Dam Irrigation Project (2000 ha, Upper Narok multipurpose dam);
e) Lower Ewaso Ng'iro Dam Irrigation Project (15,000 ha, Oldorko multipurpose dam);
f) Todonyang-Omo Irrigation Project (35,000 ha, Gibe 3 hydropower dam in Ethiopia);
g) Kimwarer Dam Irrigation Project (2000 ha, Kimwarer multipurpose dam);
h) Oldekesi Irrigation Project (2000 ha, Weir); and
i) Embobut Dam Irrigation Project (2000 ha, Embobut multipurpose dam).

The irrigation water demands necessary for the above new irrigation development were estimated at 1,377 MCM/year for surface irrigation area and 16 MCM/year for groundwater irrigation area as shown in Table 6.5.7 in the Main Report Part A.

## 4.5 Hydropower Development Plan

### 4.5.1 Current Situation of Hydropower

(1) Existing Hydropower Station

There is only one existing hydropower station in the catchment area, namely, Turkwel Hydropower Station located in the upstream reach of the Turkwel River with an installed capacity of 106 MW.

Location of existing hydropower station is shown in Figure 4.5.1.

(2) Multipurpose Dam Development Project by the Kerio Valley Development Authority (KVDA)

There is a proposed multipurpose dam project called Arror Dam, which is located in the Arror River, a tributary of the Kerio River in its upstream reach. The dam is designed for hydropower and irrigation. According to the information from KVDA, hydropower component of Arror Dam has an installed capacity of 80 MW.

There is another multipurpose dam project called Embobut Dam, which is located in Embobut River, a tributary of Turkwel River in the upstream reach. The dam is designed for hydropower and irrigation. According to the information from KVDA, hydropower component of Embobut Dam has an installed capacity of 45 MW.

Another multipurpose dam project called Kimwarer Dam is located in the most upstream reach of the Kerio River. The dam is designed for hydropower and irrigation. According to the information from KVDA, hydropower component of Kimwarer Dam has an installed capacity of 20 MW.

(3) Multipurpose Dam Development Project by the Ewaso Ng'iro South Development Authority (ENSDA)

There are three multipurpose dam development projects which have hydropower component. These are Oletukat, Leshota, and Oldorko dams with cascade development along Ewaso Ng'iro South River. These three projects are commonly called as "Lower Ewaso Ng'iro South River Multipurpose Dam" project. According to the information from ENSDA, feasibility study which started in June 2012 is ongoing for a period of 18 months. Although the figures are still tentative, the project has a total installed capacity of 180 MW, consisted of Oletukat at 36 MW, Leshota at 54 MW, and Oldorko at 90 MW.

### 4.5.2 Development Strategy

Following the overall planning concept and framework as mentioned in Section 7.6 of the Main Report Part A, the following three strategies will be applied for development:

a) Apply development plans based on the Least Cost Power Development Plan (LCPDP).

b) Apply hydropower components of multipurpose dam development schemes.

The above strategy will be applied to RVCA as follows:

c) LCPDP projects: There is no plan proposed for LCPDP.

d) Multipurpose dam development schemes: There are six multipurpose dam schemes which have hydropower component, namely Arror, Oletukat, Leshota, Oldorko, Kimwarer, and Embobut dams. These dams will be taken up as proposed plan.

### 4.5.3 Proposed Hydropower Development Plan

Based on the development strategy as mentioned in Subsection 4.5.2, the following hydropower development plans will be incorporated in the NWMP 2030.

(1) Arror Multipurpose Dam

As one of the proposed multipurpose dam projects by the MORDA, Arror Dam is considered as a candidate project of NWMP 2030. Arror Dam is planned in the Arror River, a tributary of the Kerio River in the upstream reach. According to information provided by KVDA in November 2012, the pre-feasibility of Arror Dam is completed. Arror Dam is planned in the middle reach of the Sondu River, which will have an installed capacity of 80 MW.

(2) Lower Ewaso Ng'iro South Multipurpose Dam (Oletukat, Leshota, and Oldorko)

ENSDA has three development plans for (i) Oletukat, (ii) Leshota, and (iii) Oldorko hydropower projects in the Ewaso Ng'iro South River in the upstream reach. These projects are called "Lower Ewaso Ng'iro South Multipurpose Dam," which are cascade scheme for development. For these three projects, a feasibility study which started in June 2012 is ongoing for a scheduled period of 18 months.

(3) Kimwarer Multipurpose Dam

The Kimwarer Multipurpose Dam is planned at the most upstream part of the Kerio River. According to the information from KVDA in November 2012, the pre-feasibility study of Kimwarer Dam is completed. Kimwarer Dam is planned to have an installed capacity of 20 MW.

(4) Embobut Multipurpose Dam

The Embobut Multipurpose Dam is planned at the most upstream part of Kerio River. According to the information from KVDA in November 2012, the pre-feasibility study of Embobut Dam is completed. Embobut Dam is planned to have an installed capacity of 45 MW.

**Proposed Hydropower Development Schemes (RVCA)**

| No. | Name of Scheme | Installed Capacity (MW) | Purpose | Source of Information |
|---|---|---|---|---|
| 1 | Arror Multipurpose Dam | 80 | Water Supply, Irrigation, Hydropower | KVDA |
| 2 | Oletukat Multipurpose Dam | 36 | Water Supply, Hydropower | ENSDA |
| 3 | Leshota Multipurpose Dam | 54 | Water Supply, Hydropower | ENSDA |
| 4 | Oldorko Multipurpose Dam | 90 | Water Supply, Irrigation, Hydropower | ENSDA |
| 5 | Kimwarer Multipurpose Dam | 20 | Water Supply, Irrigation, Hydropower | KVDA |
| 6 | Embobut Multipurpose Dam | 45 | Water Supply, Irrigation, Hydropower | KVDA |
| Total | | 325 | | |

Source: JICA Study Team based on information from MORDA, KVDA and ENSDA

Locations of Hydropower Development Projects are shown in Figure 4.5.2.

## 4.6 Water Resources Development Plan

### 4.6.1 Current Situation of Water Resources Development

RVCA has a total catchment area of 130,452 km$^2$, and an annual average rainfall of 510 mm which is similar to that of ENNCA and the smallest among the six WRMA catchment areas. The annual rainfall differs spatially within the catchment area, ranging from around 200 mm near Turkana Lake to 1000 mm near the Kenya water towers. The main rivers in RVCA are Turkwel, Kerio, Perkerra, Malewa, and Ewaso Ng'iro South rivers. The available water resources estimated in RVCA for 2010 (present) are 2,457 MCM/year for surface water and 102 MCM/year for groundwater.

The present water demands in RVCA were estimated to be 357 MCM/year based on the population of 4.86 million and irrigation area of 9,587 ha as presented in Chapter 3. Listed below are the existing water resources structures/facilities, except for the direct intake facilities from the rivers, that satisfy the present water demands. Locations of the dams and water transfers are shown in Figure 4.6.1.

**Existing Water Resources Structures/Facilities (RVCA)**

| Existing Structures/ Facilities | Name of Structures/ Facilities | Purposes | Notes |
|---|---|---|---|
| Dam | Turkwel Dam | Hydropower (106 MW), irrigation | Storage volume of 1,650 MCM |
| Dam | Chemeron Dam | Domestic and irrigation water supply | Reservoir is almost filled with sand. |
| Dam | Kirandich Dam | Domestic water supply | Storage volume of 3 MCM |
| Dam | Turasha Dam | Domestic water supply to Nakuru | - |
| Dam | Aram Dam | Domestic water supply | - |
| Inter-basin Water Transfer | From Kirandich Dam | Domestic water supply to Kabarnet | 1 MCM/year |
| Small Dam/ Water Pan | 660 in total | Domestic and livestock water supply | Total storage volume of 11.8 MCM, average volume per facility of 18,000 m$^3$ |
| Borehole | 2,094 in total | Domestic water supply mainly | Total abstraction volume of 115 MCM/year |

Source: JICA Study Team based on NWMP (1992) and data from MWI, WRMA, NWCPC, and RVWSB

The total storage volume of the existing water resources structures/facilities in RVCA is approximately 1,665 MCM summing the volumes of dams and small dams/ water pans listed in the above table. Out of the 26 existing dams nationwide as described in Chapter 2 of the Sectoral Report (G), there are five dams in RVCA. Among which are the Turkwel Dam with 155 m high dam supplying hydropower generation (106 MW) and irrigation water; the Chemeron Dam serving domestic and irrigation water supply and has a reservoir almost filled with sand; and the other three existing dams are all for domestic water supply purposes.

The Chemususu Dam with intra-basin water transfer facility is under construction for domestic water supply purpose (storage volume of 10 MCM). Oloibortoto River Water Transfer Work is also under construction. The Arror Dam (domestic and irrigation water supply, hydropower and flood control) completed its detailed design. The structures under planning and/or designing in the catchment area are Oletukat, Leshota, and Oldorko dams under the Lower Ewaso Ng'iro South River Multipurpose Dam Development Project (domestic and irrigation water supply, and hydropower).

There are 660 small dams/water pans and their total storage volume is 12 MCM. There are 2,094 boreholes in the catchment area, which is approximately 17% of the national total 12,444 boreholes (MWI).
The values of present water supply reliability in RVCA were estimated by the water balance study to be 1/20 at the reference point of Lodwar (2B21) in Turkwel River, 1/7 at Kolowa (2C16) in Kerio River, 1/2 at Narok (2K06) in Ewaso Ng'iro South River and 1/3 at Naivasha (2GB01) in Malewa River under the condition of existing water resource structures/facilities mentioned above. The water supply reliability of 1/2, 1/3, 1/7 or 1/20 means that the present water demands are satisfied with the available water resources with existing water resources structures under drought condition with probability of once in 2, 3, 7 or 20 years.

### 4.6.2 Development Strategy

The water demands projection for 2030 as well as the estimated present water demands in RVCA are explained in Chapter 3 and summarised as follows:

**Present and Future Water Demands (RVCA)**

(Unit: MCM/year)

| Subsector | Present Water Demand (2010) | Future Water Demand (2030) |
|---|---|---|
| Domestic | 129 | 264 |
| Industrial | 10 | 23 |
| Irrigation | 143 | 1,393 |
| Livestock | 70 | 123 |
| Wildlife | 1 | 1 |
| Fisheries | 4 | 8 |
| Total | 357 | 1,812 |

Source: JICA Study Team (Ref. Main Report Part A, Chapter 6 and Table 6.10.1)

The projected 2030 water demands show a great increase of about 5.1 times compared with the present demands due to increase in population to 7.45 million and irrigation areas to 101,753 ha as mentioned in Chapter 6 of the Main Report Part A.

Judging from the estimated 2030 water deficits discussed in Section 3.4 (1), it is certain that the existing water resources structures/facilities will not be able to satisfy the great increase of water demands in 2030, therefore new structures/facilities are required to be developed. Although the projected available 2030 surface water of 3,045 MCM/year is larger in amount than the groundwater of 102 MCM/year in the catchment area, majority of the surface water is distributed along the catchment borders with the LVNCA and LVSCA and at the areas adjacent to the most upstream of the

Athi and Tana rivers, therefore, the development plan will focus on the efficient combination of surface water and groundwater to meet the wide distributed water demands.

Strategies for the water resources development in RVCA were set as enumerated below, following the overall planning concept and framework as stated in Chapter 7 of the Main Report Part A, and based on the current situation of the catchment area and future water demands.

a) The inter-basin water transfer facility from Itare and Londiani dams in LVSCA to RVCA will be developed to supply domestic water to the Greater Nakuru area where heavily concentrated domestic water demands are expected in 2030, however both surface water and groundwater resources are insufficient. Amala Transfer from LVSCA to RVCA is also included for hydropower generation, irrigation and domestic water supply purposes. The volumes of water transferred from Itare, Londiani and Amala dams to RVCA are included in the water demands mentioned in the above table for RVCA.

b) Dam development is essential and required to be promoted to satisfy the increased future large water demands such as domestic, industrial and irrigation water demands at locations where demands exist, particularly, in the central and southern parts of the catchment area. Candidates of the dam development for the maximum surface water exploitation include in principle i) dams proposed by the NWMP (1992), and ii) dams under designing and/or planning by the government including the Kenya Vision 2030 flagship projects.

c) Small dams and/or water pans will be developed in small rivers for small and scattered demands including rural domestic, livestock, small scale irrigation, wildlife and inland fisheries water supply purposes, at locations where suitable dam sites are not expected for large dams but the surface water is available. The small dams and water pans will be constructed in almost entire catchment area except for the northernmost part where rainfall is minimal.

d) The groundwater will be exploited for domestic, industrial and irrigation uses where the surface water is not available or insufficient.

### 4.6.3 Proposed Water Resources Development Plan

(1) Water Balance Study

The water balance study was carried out for the year 2030 on the available water resources and water demand projections in order to assess magnitudes of water shortage, and to quantify the water resources volumes to be stored or transferred. Estimated figures of the available 2030 water resources consisting of the surface water and groundwater covering a 20-year period from 2021 to 2040, and the water demand projections for 2030. The available 2030 water resources are shown by sub-basin in Table 4.6.1 in terms of monthly mean surface water and annual mean groundwater. The 2030 water demands are shown by water use sub-sectors and by sub-basin in Table 4.6.2.

The water balance study followed the policies of water allocation as stated in Section 7.2 of the Main Report Part A, a summary of which are tabulated 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 surface water balance study for 2030 was conducted on the monthly basis by dividing the catchment area into sub-basins as shown in Figure 4.6.2 and by applying the surface water resources and demands to a computation model developed for RVCA as shown in Figure 4.6.3. Prior to the surface water balance study, the amount of the water demand to be supplied by the groundwater was subtracted from the total water demand as explained in Section 4.3 of the Sectoral Report (G). Water demands of livestock, wildlife, and inland fisheries to be supplied by surface water were excluded from the surface water demand applied for the balance study. It is because these demands are small in amount representing about 2% of the surface water resources nationwide, and distributed widely apart from the rivers. The livestock, wildlife, and fishery demands will be supplied by surface water with small dams/water pans.

Conditions of the surface water balance study are explained in Section 4.3 of the Sectoral Report (G) and are summarised as follows; i) the model consists of 35 sub-basins, water demand points, and the existing water resources infrastructures and candidates for future development such as dams and water transfer facilities; ii) monthly mean values of the naturalised water resources and demands are applied; iii) an amount of the reserve is determined as 95% value of the naturalised present daily flow duration curve in Figure 4.6.4 with the probability of once in 10 years as shown in Table 4.6.3; and iv) return flow rates of 25%, 5%, and 100% for urban domestic water supply, paddy irrigation, and hydropower generation are applied.

Although most dam candidates studied by the government or proposed by the NWMP (1992) were incorporated in the water balance study, some of the dams were compared and selected as follows:

a) Kimwarer Dam and Kipsang Dam: Kimwarer Dam site (catchment area of 160 km$^2$) and Kipsang Dam site (catchment area of 66 km$^2$) are closely located on the tributaries of the Kerio River. Kimwarer Dam was selected to be studied in the water balance, since Kimwarer Dam had larger storage efficiency compared with Kipsang Dam and some studies were made by the government for Kimwarer Dam.

Lists of the dams studied by the government or proposed by NWMP (1992) are given in Table 4.6.4. Lists of the water transfer candidates are shown in Table 4.6.5.

(2) Proposed Water Resources Development Plan

As to the results of the water balance study for 2030 as described in the preceding clause (1), the required new water resources structures/facilities in RVCA are as follows:

1) Dams

Proposed storage volumes of the dams for domestic, industrial and irrigation uses as tabulated below were derived from the water balance study as the volumes from which water would be supplied to the deficits caused by the respective water demands.

**Proposed Dams (RVCA)**

(Unit: MCM)

| Name of Dams | Storage Volume for Domestic/ Industrial | Storage Volume for Irrigation | Storage Volume for Hydropower | Total Storage Volume | | Remarks |
|---|---|---|---|---|---|---|
| Murung-Sebit Dam | 0.0 | 40.0 | 0.0 | 40.0 | * | (KVDA) |
| Kimwarer Dam | 17.0 | 90.0 | 0.0 | 107.0 | | Pre-F/S done (KVDA) |
| Arror Dam | 2.0 | (60.0) | 60.0 | 62.0 | * | D/D completed (MORDA) |
| Embobut Dam | 1.0 | 29.0 | 0.0 | 30.0 | * | Pre-F/S done (KVDA) |
| Waseges Dam | 4.0 | 0.0 | 0.0 | 4.0 | | |
| Malewa Dam | 34.0 | 0.0 | 0.0 | 34.0 | | |
| Upper Narok Dam | 5.0 | 24.0 | 0.0 | 29.0 | | Flagship Project |
| Oletukat Dam | 10.0 | (290.0) | 290.0 | 300.0 | * | D/D ongoing (ENSDA) |
| Leshota Dam | 5.0 | 0.0 | 28.0 | 33.0 | * | D/D ongoing (ENSDA) |
| Oldorko Dam | 5.0 | 0.0 | 15.0 | 20.0 | * | D/D ongoing (ENSDA) |
| Total | 83.0 | 183.0 | 393.0 | 659.0 | | |

Note: * Total storage volumes planned or designed by the government.
D/D=Detailed design, F/S=Feasibility study, Pre-F/S=Prefeasibility study
Source: JICA Study Team, based on information from relevant government agencies

The development plan is formulated for domestic and industrial water supply to ensure the supply for 10-year probable drought and irrigation water supply for 5-year probable drought as stated in Section 7.1 of the Main Report Part A. The storage volumes determined are the volume of the second largest estimated in the water balance study for 20 years for domestic and industrial use, and that of the fourth largest for irrigation use.

The respective total storage volumes of Murung-Sebit, Arror, Embobut, Oletukat, Leshota and Oldorko dams followed the detailed designs which are on-going or completed, pre-feasibility study or information from the government agencies as shown in the above table.

The storage volumes of hydropower use for Arror, Oletukat, Leshota and Ordorko dams were estimated by subtracting the volumes of estimated domestic/industrial use from the total storage volumes proposed by the government. Water for irrigation use will be supplied from Arror and Oletukat dams after hydropower generation.

Table 4.6.6 presents details of the proposed dams, and Figure 4.6.1 shows the location of the proposed dams.

2) Water Transfers

The proposed amount of inter-basin water transfer from Itare and Londiani dams to Nakuru as mentioned below was derived from the water balance study as the amount to meet domestic water demands in Nakuru. The proposed amount of inter-basin water transfer from Amala Dam in LVSCA to Ewaso Ng'iro South River followed the amount of Amala Transfer designed by ENSDA.

**Proposed Water Transfers to RVCA**

(Unit: MCM/year)

| Structures | Amount for Domestic | Amount for Hydropower/ Irrigation | Total Water Transfer Amount | Remarks |
|---|---|---|---|---|
| Inter-basin Water Transfer from Itare and Londiani Dams (LVS) to Nakuru | 41 | 0 | 41 | |
| Inter-basin Water Transfer from Amala Dam (LVS) to Ewaso Ng'iro South River | 0 | 82 | 82 | (ENSDA) |

Source: JICA Study Team, based on information from relevant government agencies

Table 4.6.6 presents details of the proposed water transfers, and Figure 4.6.1 shows the location of the proposed water transfers.

3) Small Dams/Water Pans

The proposed storage volumes of small dams/water pans for irrigation use were estimated considering the conditions of the irrigation subsector.

The proposed storage volumes of small dams/water pans for livestock, wildlife and fisheries are volumes of their water demands for 2030.

**Proposed Small Dams/Water Pans (RVCA)**

(Unit: MCM)

| Structures | Volume for Domestic | Volume for Irrigation | Volume for Livestock | Volume for Wildlife/ Fisheries | Total Storage Volume | Remarks |
|---|---|---|---|---|---|---|
| Small Dam/Water Pan | 27 | 23 | 123 | 9 | 182 | Total No. of small dams/ water pans = 3,640 |

Note : Excluding the 12 MCM storage volume of the existing small dams and water pans.
Source: JICA Study Team

The total number of the small dams / water pans of 3,640 was estimated by applying the volume per dam/ pan of 50,000 $m^3$ as the minimum capacity following the volume applied in NWMP (1992) and assumed based on the existing volumes.

4) Boreholes

The proposed groundwater abstraction volumes of boreholes for domestic and industrial uses were estimated by applying assumed percentages to the total water demands. The percentages of 5%, 50%, 100% and 50% were assumed for urban domestic, large rural domestic, small rural domestic and industrial water supply respectively as explained in Sub-section 4.3.1 (1) of the Sectoral Report (G). In the case that some water deficits were calculated in the surface water balance study and only groundwater was available, the deficits were added to the groundwater abstraction volumes estimated above.

The proposed groundwater abstraction volume of boreholes for irrigation use was estimated considering the conditions of the irrigation subsector mentioned in Section 7.5 of the Main Report Part A. The estimated volumes are as follows:

**Proposed Boreholes (RVCA)**

(Unit: MCM/year)

| Facilities | Volume for Domestic/ Industrial | Volume for Irrigation | Total Abstraction Volume | Remarks |
|---|---|---|---|---|
| Borehole | 0 | 16 | 16 | Total No. of boreholes = 160 |

Note : Excluding the 115 MCM/year abstraction volume of existing boreholes.
Source: JICA Study Team

The total number of the boreholes of 160 was estimated by applying the capacity per borehole of 100,000 $m^3$/year assumed based on the existing data.

(3) Evaluation of Proposed Water Resources Development Plan

Results of the water balance between water demand and supply for 2030 in RVCA are summarised in Table 4.6.7 showing 2030 water demands, water supply from river water and new water resources structures such as dams, water transfers, small dams/water pans and groundwater (boreholes), and water balance between demand and supply. This table proves that 2030 water demands will be satisfied by the river water and new water resources structures under the target water supply reliabilities of 1/10 for domestic and industrial uses and 1/5 for irrigation use.

The water supply reliability for 2030 at the reference points proposed for water resources management in RVCA is summarised below as well as that for 2010:

**Water Supply Reliability at Reference Point (RVCA)**

| Reference Point | Present (2010) Water Supply Reliability | Future (2030) Water Supply Reliability |
|---|---|---|
| Turkwel River (2B21), Lodwar | 1/20 | 1/20 |
| Kerio River (2C16), Kolowa | 1/7 | 1/10 |
| Ewaso Ng'iro South River (2K06), Narok | 1/2 | 1/20 |
| Malewa River (2GB01), Naivasha | 1/3 | 1/10 |

Source: JICA Study Team (Ref. Sectral Report (G), Sub-section 4.4.3 (3) and Table 4.4.4)

The future water supply reliability at the reference points of Lodwar in Turkwel River and Narok in Ewaso Ng'iro South River is estimated at 1/20 due to constant water release from Turkwel Dam in Turkwel River, and Oletukat, Leshota and Oldorko dams in Ewaso Ng'iro South River for hydropower generation. The future water supply reliability at the reference points of Kolowa in Kerio River and Naivasha in Malewa River is estimated at 1/10, since water demand downstream of the reference points is domestic use only.

The naturalised surface water resources, reserves, water demands, yields of the water resources development structures, and water supply reliabilities estimated at the reference points are tabulated in Table 4.6.8.

Figure 4.6.5 shows estimated river flow for 2010 and 2030 at the reference points in RVCA under 2010 and 2030 surface water resources, demands and structures conditions.

### 4.7 Water Resources Management Plan

#### 4.7.1 Current Situation of Water Resources Management

RVCA ranges about 800 km in north and south direction, and has different water resource characteristics by different regions in the catchment area.

In the northern part of the catchment area, which includes the lower reaches of Turkwel and Kerio rivers, and other arid and semi-arid areas in the northern part, there is little rainfall. People rely more on groundwater than surface water.

In the central part, which includes high lands with Nakuru Town in the center has relatively much rainfall areas, and it is expected to have water demand and supply balance in the future. The southern part includes Ewaso Ng'iro South River, an international river that flows south toward Tanzania and Lake Magadi.

The Water Resources Management Authority (WRMA) has its Rift Valley Regional Office located in Nakuru. Under the regional office, there are five subregional offices, namely;

a) Lodwar that covers the northern part (Tarach River, east and west part along Lake Turkana, downstream reach of the Turkwel River, and the middle reach of the Kerio River);
b) Kapenguria that covers the central-western part (upstream reach of the Turkwel River and the middle reach of the Kerio River);
c) Kabarnet that covers the central part (Suguta River, upstream reach of the Keio River and the lakes of Baringo and Bogoria);
d) Naivasha that covers the central-southern part (the lakes of Nakuru, Elementeita, and Naivasha); and
e) Narok that covers the southern part (Lake Magadi and Ewaso Ng'iro South River) of the catchment.

Figure 4.7.1 shows the Management Unit Boundary and Subregional Office Management Boundary.

There are three major rivers and seven major lakes in the catchment, namely, Turkwel, Kerio and Ewaso Ng'iro South rivers and Lakes Turkana, Baringo, Bogoria, Nakuru, Elementaita, Naivasha and Magadi. The following table shows the current monitoring targets of WRMA, numbers of operational stations and their achievement ratio for surface water and groundwater, water quality, and rainfall. Both surface water level and groundwater level monitoring stations are not well maintained.

**Current Monitoring Situations of Water Resources (RVCA)**

(Unit: nos)

| Item | Surface Water (SW) Level | Groundwater (GW) Level | Surface Water Quality | Groundwater Quality | Rainfall |
|---|---|---|---|---|---|
| Target | 40 | 37 | 20 | 8 | 60 |
| Operational | 20 | 24 | 18 | 8 | 45 |
| Achievement (%) | 50 | 65 | 90 | 100 | 75 |

Source: WRMA Performance Report 1 (July 2010)

The current situations of water permit issuance and management by WRMA are as shown below. Ratio of valid permits against issued permits is relatively low, especially for surface water permits.

**Current Situations of Water Permits Issuance (RVCA)**

(Unit: nos)

| Item | Application | Authorised | Issued Permits | Valid Permits | Ratio of Validity (%) |
|---|---|---|---|---|---|
| Surface Water | 252 | 663 | 503 | 162 | 32 |
| Groundwater | 389 | 1,390 | 183 | 124 | 68 |
| Total | 641 | 2,053 | 686 | 286 | 42 |

Source: WRMA Performance Report 1 (July 2010)

As for the watershed conservation of RVCA, it is important to conserve the Mau Forest Complex, Cherangani Hills, and the Aberdare Range, which are major water sources of the rivers and lakes in the catchment. Deforestation and forest degradation are rampant in these water source forests, especially in the Mau Forest Complex and private forests in the west of Lake Naivasha.

According to the results of satellite image analysis in this study[2], the forest area in RVCA in 2010 was about 261,000 ha which corresponded to 2.0% of forest cover in RVCA. The deforested areas during the last two decades were about 178,000 ha, which meant there was a decrease of about 40% of the forest areas in 20 years since 1990.

According to the interviews with stakeholders of watershed conservation including WRMA and KFS in RVCA, there were deteriorations on small water sources such as 11 springs and 12 wetlands. Such issues affect badly the availability of water resources in the catchment area as there were many arid and semi-arid lands (ASALs) in RVCA which highly depend on the small water sources. However, as detailed information on deterioration of small water sources such as location, magnitude, water use, water quality, vegetation and method of management are unknown, further study is required.

On the other hand, issues on soil erosion are not significant in RVCA.

### 4.7.2 Management Strategy

Based on the overall planning concept and framework as mentioned in Section 7.8 of the Main Report Part A: water resources management strategy for RVCA was set for the following major components of; i) Monitoring, ii) Evaluation, iii) Water Permit Issuance and Control, and iv) Watershed Conservation, as shown below:

(1) Monitoring

Monitoring strategies are described for five monitoring items, which are i) surface water level, ii) surface water quality, iii) groundwater level, iv) groundwater quality, and v) rainfall.

1) Surface Water Level

The Turkwel, Kerio, and Ewaso Ng'iro South rivers are selected as representative rivers for capturing runoff characteristics of the basin. As major lakes, seven lakes in RVCA are selected. Surface water level monitoring stations are reviewed to capture major points of these three rivers, seven major lakes, as well as the rivers flowing into these lakes (refer to Figure 4.7.1).

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2) Surface Water Quality

The surface water quality monitoring points were also selected from three representative rivers and seven major lakes, as well as the rivers flowing into these lakes.

For the three rivers, selected monitoring points should be located at the downstream of pollution sources, such as major cities and irrigation schemes. Such points should be monitored monthly.

One location for lake water quality should be monitored on a quarterly basis as lake water quality does not change so frequently compared with river water quality.

In addition, other surface water level monitoring points are selected for water quality monitoring which should be monitored done on a quarterly basis. Such monitoring data is required as reference water quality for the evaluation of water permit application in the relevant basin.

3) Groundwater Level

Groundwater monitoring points were set at locations where significant groundwater uses are expected in the future. Such points are in urban centres which have both water supply and sanitation plans. In the selected monitoring points, groundwater levels are monitored monthly with dedicated boreholes. It is important to monitor and confirm that the groundwater levels are recoverable in an annual cycle for sustainable use.

4) Groundwater Quality

Groundwater quality is monitored at the same point as groundwater level monitoring.

5) Rainfall

The rainfall station density should be considered by climatic regions for arid, semi-arid, or humid areas. In the arid area of the northern part, a criterion of one station in 8,000 $km^2$ to 10,000 $km^2$ is applied. For the semi-arid areas in central western part in the upper Turkwel River and whole of Ewaso Ng'iro South River, a criterion of one station in 3,000 $km^2$ to 5,000 $km^2$ is applied. For the rest of the basin in the central part, that belongs to humid areas, a criterion of one station in 500 to 1,000 $km^2$ is applied for selection of rainfall monitoring stations.

(2) Evaluation

1) Water Resources Quantity Evaluation

The water resources quantity evaluation is conducted annually based on i) monitoring data for surface water, groundwater, and rainfall and ii) water permit issuance data. Abstraction survey data will be used as necessary to determine the status of actual water use. For surface water resources evaluation, three major rivers namely, Turkewl, Kerio, and Ewaso Ng'iro South should be focused as these are representative rivers in RVCA. In the northern part, evaluation of groundwater resources is quite important.

2) Water Resources Quality Evaluation

The water resources quality evaluation is also conducted annually based on the monitoring data for surface water and groundwater quality.

(3) Water Permit Issuance and Control

Prior to future impeding water demand in the basin, water permits should be duly controlled and issued based on the actual status of water use. For this, the latest version of issued permits should be controlled. In addition, water allocation guidelines should be revised considering the future demand and water resources development plans. To conduct these activities, the enforcement of water rights officers should be considered by reflecting the current situation of staffing.

(4) Watershed Conservation

Of the three major items of: a) recovery of forest areas; b) conservation of small water sources; and c) control of soil erosion, item c) is not significant in RVCA. Therefore, in RVCA, items a) and b) will be considered.

1) Recovery of Forest Areas

Forest recovery will be implemented through reforestation focusing on Cherangani Hills and the Mau Forest Complex of the Five Water Towers.

2) Conservation of Small Water Sources

Conservation of small water sources in the catchment area will be considered.

### 4.7.3 Proposed Water Resources Management Plan

Based on the management strategy described in Subsection 4.7.2, the water resources management plan for RVCA is proposed as follows:

(1) Monitoring

Monitoring plan are described for five monitoring items, which are i) surface water level, ii) surface water quality, iii) groundwater level, iv) groundwater quality, and v) rainfall. Locations of proposed monitoring stations are shown in Figure 4.7.2.

1) Surface Water Level

Surface water level is observed twice a day by an honorarium gauge reader. 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. As to the major rivers and lakes in the catchment area, two monitoring points were selected as representative points for each of Turkwel, Kerio and Ewaso Ng'iro South rivers, one monitoring point each for the seven lakes, and 11 locations for rivers flowing into major lakes. In total, 24 monitoring points were selected for daily monitoring. For major rivers, the following reference points were selected as follows:

a) 2B21 located in the lower reach of the Turkwel River. Monitoring started in 1974, with relatively long term data which seems to be sufficient for evaluation of water resources in the river.

b) 2C16 located in the upper reach of the Kerio River. Monitoring started in 1988. The station has a dam development plan in the upstream and irrigation development plan in the downstream.

c) 2K06 located in the upper reach of the Ewaso Ng'iro South River. It is appropriate to set a reference point at this location as the downstream reach is not a perennial river.

d) 2GB01 located in the lower reach of the Malewa River before the river flows into Lake Naivasha. Monitoring started in 1931 with long term data which is required for evaluation of water resources in the river.

All the above reference points are set to check the flow regime of the river after satisfying upstream water demand and confirming available discharge to satisfy the downstream demand. For that purpose, based on the management strategy described in Subsection 4.7.2, normal discharge values are set at the above four reference points as shown below. These normal discharge values are used for low water management.

**Normal Discharge at Reference Point (RVCA)**

(Unit: $m^3$/sec)

| Reference Point | Normal Discharge (Reserve + Water Demand for the Downstream of Reference Point) | |
|---|---|---|
| | 2010 | 2030 |
| Turkwel River (2B21) | 0.3 (=0.0+0.3) | 0.3 (=0.0+0.3) |
| Kerio River (2C16) | 0.1 (=0.0+0.1) | 0.1 (=0.0+0.1) |
| Ewaso Ng'iro South River (2K06) | 0.1 (=0.0+0.1) | 0.1 (=0.0+0.1) |
| Malewa River (2GB01) | 0.1 (=0.0+0.1) | 2.0 (=0.0+2.0) |

Source: JICA Study Team (Ref. Sectral Report (G), Sub-section 4.4.3 (3) and Table 4.4.4)

The above normal discharges are to be reviewed and revised as necessary in the "Water Resources Quantity Evaluation" based on monitoring, which is to be mentioned in the following clause. Such review and revision works are to be made based on issued water permits (water demand) and reserve of that year. In case the observed discharge at a reference point is lower than the normal discharge, it is probable that there would be over-abstraction of water in the upstream or decreased reserve caused by an extreme drought. In such a case it is necessary to identify the reason and take measures such as increase of the level of oversight for water abstraction or drought conciliation.

2) Surface Water Quality

Stations with monthly basis monitoring

Based on the management strategy, water quality of the following five points is monitored on a monthly basis. This monitoring is for watching and detecting possible pollutant sources that may affect the water usage in relevant river.

a) 2B21 (Downstream area of the Turkwel River near Lodwar Town, as the Reference Point): To monitor the impact on the river water quality caused by effluent from irrigation.

b) 2GB01 (Downstream area of the Malewa River, as the Reference Point): To monitor the river water quality before flowing into the lake.

c) 2GD06 (Lake Naivasha): To monitor the lake water quality.

<u>Stations with quarterly basis monitoring</u>

Apart from the above three monitoring stations, water quality of the other surface water monitoring stations (21 points) should be monitored on a quarterly basis (January, April, July, and October every year). These monitoring points are; 2B13, 2B33, 2C14, 2C16, 2EB03, 2EB10, 2ED01, 2ED02, 2ED03, 2EH01, 2FA08, 2FA09, 2FC04, 2FC19, 2GA01, 2GD07, 2H03, 2K04, 2K06, and Lake Magadi (newly proposed). These data are used as reference when WRMA issues water permits.

3) Groundwater Level

Based on the management strategy, the following ten points, namely, Tambach, Njoro, Nakuru, Ol Kalou, Gilgil, Naivasha, Narok, Molo, Eldama Ravine, and Kabarnet, were selected for groundwater level monitoring by dedicated boreholes for monthly basis monitoring. These points are located near urban centres where both water supply and sanitation plans are built with expected high growth of groundwater demand in the future.

4) Groundwater Quality

Groundwater quality is monitored at the same location where groundwater level monitoring stations are located. As groundwater quality does not change so frequently compared with surface water, monitoring is conducted twice a year (once in the rainy season and once in the dry season).

5) Rainfall

Based on the management strategy, distribution of current rainfall monitoring stations was reviewed. As a result, 47 rainfall monitoring stations were selected for daily basis monitoring.

(2) Evaluation

1) Water Resources Quantity Evaluation

Based on the management strategy, water resources quantity evaluation is conducted annually based on i) monitoring data for surface water, groundwater, and rainfall and ii) water permit issuance data. For this, a water resources evaluation team is formed composed of: i) one chief hydrologist in the Nakuru Regional Office and ii) one assistant hydrologist each from Naivasha, Narok, Kabarnet, Kapenguria and Lodwar subregional offices. Water resources evaluation works are done for the whole catchment area of RVCA on both surface water and groundwater.

2) Water Resources Quality Evaluation

Based on the management strategy, water resources quality evaluation is also conducted annually based on the monitoring data for surface water and groundwater quality.

For this, a chief water quality expert is assigned in the water quality test laboratory in Nakuru.

(3) Water Permit Issuance and Control

Based on the management strategy, the following activities are proposed:

a) Controlling the latest version of issued water permits.
- Periodical updating of water permit database.
- Establishment and enhancement of notification system of permit expiry.

b) Revision of guidelines for water allocation
- Formulation of water allocation plans considering future water demand

c) Increase of the number of water rights officers shown below for smooth implementation of water permit issuance and control.

**Number of Required Water Rights Officers (RVCA)**

| Offices | Number of Water Rights Officers | | |
|---|---|---|---|
| | Current | Required | Future |
| RV RO | 1 | No change | 1 |
| Naivasha SRO | 1 | +3 | 4 |
| Narok SRO | 2 | No change | 2 |
| Kabarnet SRO | 1 | +2 | 3 |
| Kapenguria SRO | 1 | +1 | 2 |
| Lodwar SRO | 0 | +3 | 3 |
| Total | 6 | +9 | 15 |

Note : RO=Regional Office, SRO=Subregional Office

Source: JICA Study Team, based on interview with WRMA Regional Office

(4) Watershed Conservation

Based on the management strategy, the following activities are proposed for watershed conservation;

1) Recovery of Forest Areas

As to the forest recovery for watershed conservation, about 1,010,000 ha of forestation is proposed in RVCA to achieve the targets of the Kenya Vision 2030. Current situation of the forest areas in RVCA and potential areas for forestation are shown in Figure 4.7.3.

The following steps were applied for the preparation of Figure 4.7.3.

a) Identify present forest areas and deforested areas (in this master plan, the satellite image analysis was used), and overlay the gazetted forest areas,

b) Identify the important forest areas including deforested areas as water source forests,

c) Delineate the potential forestation areas and the areas mentioned above (item b), and formulate the area with consideration of significant forest area, and d)Connect the isolated small gazette forest areas by corridor and delineate the potential forestation area with combination of these two areas.

Of the target forest, the gazetted forest is supposed to be recovered by the Kenya Forest Service (KFS).

2) Conservation of Small Water Sources

As to the conservation of small water sources, it is proposed to carry out a survey on small water sources, which includes location, scale, water use, water quality, vegetation condition, management method, major issues, etc.

## 4.8 Flood and Drought Disaster Management Plan

### 4.8.1 Current Situation of Flood Disaster Management

(1) Flood Situation

In RVCA, severe floods occur mainly around the water tower area. Particularly in recent years, a lot of deaths caused by flash floods have been reported in mountainous areas that are located in the central part of the catchment area.

Narok is located at the downstream of the confluence point of three rivers flowing from the Mau Forest and suffer from floods every rainy season. In 1993, only a 45-minute flash flood caused more than 50 deaths. The major cause of flash flood is considered to be the increase of runoff coefficient associated with watershed degradation in the Mau Forest in recent years. In Mogotio Town, the Melo River that flows into Baringo Lake overflows its banks in both urban and agricultural areas. The inundation depth of the flood in March 2010 was up to one meter height and casualties were reported in Mogotio Town. In the urban areas of Nakuru and Narok, occasional urban flooding occur due to poor drainage.

Meanwhile, even in other areas than the water tower, various parts of the catchment area have suffered from floods. In later 2002, flash floods in Baringo District resulted in six deaths, 3000 displaced people, and destruction of household items and crops. During short rainy season of 2009/2010, there was massive flood damage to properties and lives where series of flash floods occur in various parts of RVCA. At least four deaths were reported in Athinai caused by flash floods. During long rainy season in 2010 in North Rift, the banks of Terem River in Mt. Elgon burst and destroyed the Terem-Emia Bridge. Turkana East was hit by floods after the banks of Kerio River in Lokori burst in March 2010, destroying irrigation canals in Morulem and Lokubae irrigation schemes. However, the damages are not so severe compared with the water tower area.

(2) Flood Disaster Management

At present, it could be said that systematic flood management has not been implemented in RVCA because neither setting of warning water levels at major river gauge stations nor construction of flood control structures have been confirmed.

### 4.8.2 Current Situation of Drought Disaster Management

(1) Drought Situation

Most of RVCA except for its central part in and around Nakuru Town is categorised into arid land for the northern side and semi-arid land for the southern side.

The drought that happened in January 2011 caused civil insecurity and conflicts over water resources and grazing resources that occurred particularly in Turkana area. Insecurity resulted into displacement and destitution of households. Also dysentery outbreaks occurred in several areas including Turkana due to deterioration of water quality.

(2) Drought Disaster Management

As for drought disaster management at the local government and community levels, Arid Land Resources Management Project II was completed in December 2010 with the financial support of the World Bank. The project formulated institutional arrangement for drought disaster management at the local levels for all the arid and semi-arid land districts in Kenya.

On the other hand, as for drought management at the catchment level, in times of drought, WRMA RV Regional Office conducts water use restriction. However, reference water levels for restriction are not clearly determined in RVCA. This means there is an operational issue from the viewpoint of clear timing for actions against drought.

There are six existing dams for the hydropower, irrigation, and domestic water supply purposes, namely, Turkwel, Chemeron, Kirandich, Turasha, Aram, and Ratat dams. However, drought management including water use restriction of the reservoirs has not been implemented.

### 4.8.3 Flood Disaster Management Strategy

As explained in the concept and framework e) mentioned in Section 7.9 of the Main Report Part A, the proposed examination areas in RVCA are Middle/Lower Turkwel, Lower Kerio, Nakuru, Narok, and Mogotio. Out of these, urban areas are limited to Nakuru (population as of 2009: 308,000 people) and Narok (population as of 2009: 39,000 people).

Firstly, Lower/Middle Turkwel and Lower Kerio will be excluded from the NWMP 2030 because severe flood damage had been rarely reported while river-induced inundation was confirmed.

Narok has both river induced flood and urban drainage issues. Due to these complex causes, the primary route connecting Nairobi-Narok-Bomet frequently becomes impassable due to flooding. In consideration of the impact to major transportation as well as to the high population density and the high frequency of flood occurrence in Narok, this area should be protected by river structural measures. In addition, it is more effective to adopt a strategy that will mitigate damages to properties and loss of life since structural measures alone have limited safety capacity against extraordinary floods exceeding a design level. Hazard maps and evacuation plans should be prepared. Regarding urban drainage issue in Narok, the drainage system should also be improved in consideration of the high population density.

Mogotio is relatively small-scale urban centre (population as of 2009: 3,700 people). However, the Melo River passes through the urban area of Mogotio and it causes flood damages to the area. Since it is effective to drain flood water to downstream, the discharge capacity of the Melo River shall be improved by carrying out river improvement works. In addition, it is more effective to adopt a strategy that will mitigate damages to properties and loss of life since structural measures alone have limited safety capacity against extraordinary floods. Hazard maps and evacuation plans should be prepared.

The type of flood that occurred in Nakuru is not a river-induced floods, but rather an urban drainage issue. In consideration of the high population density in Nakuru, the drainage system should be improved.

The following basic policies are important to formulate the flood disaster management plan in RVCA:

a) Implementation of flood control measures as well as preparation of hazard maps and evacuation plan in Narok.
b) Implementation of flood control measures as well as preparation of hazard map and evacuation plan in Mogotio.
c) Implementation of urban drainage measures in Narok.
d) Implementation of urban drainage measures in Nakuru.

### 4.8.4 Drought Disaster Management Strategy

Based on the overall concepts mentioned in Section 7.9 of the Main Report Part A, drought management strategy for RVCA will be implemented through the i) preparation of water use restricted rules for existing and proposed reservoir, ii) establishment of the Basin Drought Conciliation Council, and iii) establishment of drought early warning system.

### 4.8.5 Proposed Flood Disaster Management Plan

In line with the above management strategies, the flood disaster management plan for RVCA is shown below. The proposed measures are illustrated in Figure 4.8.1.

(1) Implementation of Flood Control Measures in Narok

As to the flood control measures in Narok, the following alternatives are proposed. The alternatives are limited to the two cases presented below because construction of retarding basin in a relatively steep slope land around Narok is considered to be difficult.

a) River improvement works alone:
Construction of a new dike, reinforcing or heightening of existing dike, widening of high water channel by realignment of existing dike, widening of low water channel by excavation, etc.
b) Flood discharge control by multi-purpose dam and river improvement works:
Allocation of flood control capacity in the Upper Narok Dam, etc.

It is noted that it is unallowable to inundate landside-prone area as proposed in the NWMP 2030. Therefore, it is necessary to consider the possibility to adopt a strategy for natural retarding effects by the lands subject that are frequently flooded such as pastures, paddy and dry fields at the time of detailed planning in the future.

In addition, flood hazard map covering all flood plain areas in Narok shall be prepared and notified to the public. This map is assumed to be more accurate compared to a simplified hazard map prepared by communities and to show probable flood areas for several kinds of probable return periods and probable maximum flood. WRMA RV Regional Office should make a flood analysis by using hydrological and topographical data. Based on the hazard map, evacuation plan for Narok also should be formulated with attention to classification of flood warnings and evacuation orders, dissemination method of warnings and orders, clear indication of evacuation place and route, confirmation method of evacuation activities, etc.

(2) Implementation of Flood Control Measures in Mogotio

In order to improve the discharge capacity of the Melo River, it is proposed to implement measures by combining the construction of new dike, reinforcing or heightening of existing dike, widening of high water channel by realignment of existing dike, widening of low water channel by excavation, etc.

In addition, flood hazard map and evacuation plan should be prepared with the same method used in Narok mentioned above.

(3) Implementation of Urban Drainage Measures in Narok and Nakuru

It is proposed to implement urban drainage measures in Narok and Nakuru. The work is the responsibility of the local authorities, namely, Narok/Nakuru County and Narok/Nakuru Urban Centre. In the following section of cost estimates, preliminary estimated cost of the drainage works composing of gravity drains based on NWMP (1992) are presented. However, it is noted that drainage works include some major cases or associated works such as pumping station, retarding basin, improvement of receiving river channels, etc., which should be planned in details in the future.

### 4.8.6 Proposed Drought Disaster Management Plan

(1) Preparation of the Water Use Restriction Rule for Reservoirs

1) Target Dam

It is proposed to prepare the water use restriction rule for the respective reservoirs. The names of the target dams are shown in the table below. There are five existing and ten proposed dams in RVCA.

**Target Dams for Water Use Restriction Rules (RVCA)**

| River System | No. | Dam Name | Status | |
|---|---|---|---|---|
| | | | Existing | Proposed |
| Turkwel | 1 | Embobut | | O |
| | 2 | Turkwel | O | |
| Kerio | 3 | Kimwarer | | O |
| | 4 | Arror | | O |
| | 5 | Murung-Sebit | | O |
| Waseges | 6 | Waseges | | O |
| Perkerra | 7 | Chemususu | O | |
| | 8 | Aram | O | |
| Ndau | 9 | Kirandich | O | |
| | 10 | Chemeron | O | |
| Malewa | 11 | Malewa | | O |
| | 12 | Turasha | O | |
| Ewaso Ng'iro South | 13 | Upper Narok | | O |
| | 14 | Oletukat | | O |
| | 15 | Leshota | | O |
| | 16 | Oldorko | | O |
| Total | | | 6 | 10 |

Source: JICA Study Team (Ref. Sectoral Report (G), 2.3.1 (1) and Table 4.4.1)

2) Setting of Reference Reservoir Water Level

To understand clearly the timing of necessary actions for water use restriction, three-step of reference water level, namely, Normal, Alert and Alarm, shall be set for the respective reservoirs. The original water level should be determined by the percentage of reservoir water storage depending on season/month, water demand for each purpose, past experiences, etc. of each dam. The definitions of each reference water level are as follows:

- Normal: Water level where Basin Drought Conciliation Council is summoned to discuss actions to be taken when the reservoir water level is expected to become lower than normal
- Alert: Water level where water use restrictions should commence.
- Alarm: Water level where the reservoir water level shall not be lowered further by controlling the outflow discharge from the reservoir.

3) Determination of Reduction Rate

A method to determine the 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, subsequent water level shall be forecasted by considering future weather forecasts. Then, necessary reduction rate in water intake for all basins will be determined.
b) Based on clause a), reduction rate shall be determined for the respective intended purposes such as domestic water supply, industry, agriculture, etc., considering the possibility to save water volume for each purpose. At this time, it is essential to consider priority order that has been conventionally stipulated in Kenya.
c) While referring to the actual data on reduction rates during the past drought period, the final reduction rate shall be determined.

Figure 4.8.2 provides an example record of reservoir water use restriction implemented in the Sameura Dam on the Yoshino River in Japan, during the severe drought in 2005.

(2) Establishment of a Basin Drought Conciliation Council

It is proposed to establish a Basin Drought Conciliation Council on the basis of a river basin unit representing a river system/drainage system.

The table in the previous page shows all the dams, which are incorporated into the water resources development plan of NWMP 2030, and their river systems. One council shall be established for each river system. The number of councils to be established in RVCA will be seven units for Turkwel, Kerio, Waseges, Perkerra, Ndau, Malewa, and Ewaso Ng'iro South river systems as illustrated in Figure 4.8.1.

The council shall be basically composed of WRMA regional office, relevant counties, representative of water users (WRUAs), etc. The council shall be established with legal status to avoid water conflict at drought time.

(3) Drought Early Forecast

Water use restriction should be considered at the early stage, taking into account the weather conditions, water storage in the reservoirs, social impacts in the worst case scenario, etc.

Currently, the KMD issues long-term rainfall forecast of 4-day, 7-day, 1-month, and 3-month (seasonal), which are officially released on the website of the KMD or published in the newspaper. This information shall be utilised to commence timely water use restriction.

As described in Section 5.1 of the Sectoral Report (J), drought early warning system in terms of livelihood zone has been established through ALRMP II using KMD’s forecasts for the purpose of communities’ preparedness against drought damage or raising awareness to save water. In a similar way, specialised drought early forecast for water use restriction will be established.

## 4.9 Environmental Management Plan

### 4.9.1 Current Situation of the Environmental Management

RVCA has poor freshwater resources, since most of the rivers in RVCA are seasonal or small. RVCA is an important catchment from the aspect of natural environmental resources since many wetlands, national parks, and reserves are located in the surrounding areas of the lakes.

Main rivers are the Turkwel, Kerio, and Ewaso Ng'iro South rivers. Lower reaches of the Kerio and Ewaso Ng'iro South rivers have seasonal flow. The Kerio and Turkwel rivers supply water to Lake Turkana. Lake Turkana is the largest saline lake in East Africa and the largest desert lake in the world. The area including the lake is now listed as one of the UNESCO World Natural Heritage Sites in terms of rich biodiversity conservation and natural geographic characteristic. The lake has also an important ecosystem for migratory birds and world's biggest habitat of crocodiles. However, the lake has been threatened by environmental degradation such as water pollution and drawdown of lake water level. One of the reasons of the degradation is the dam development project in the Omo River which supplies 80% of the lake water. The Ewaso Ng'iro South River is feeding Lake Natron, which is situated in Tanzania.

On the other hand, there are many well-known lakes and marshes such as Lake Naivasha, as fresh water lake, and six famous saline lakes which are important habitats for wild birds in RVCA. Among the six saline lakes, Lake Nakuru, Lake Bogoria, and Lake Elementaita are listed in the UNESCO World Natural Heritage Site in 2011. The area is the habitat of 13 endangered bird species, as well as important breeding site for Pink Flamingo and Great White Pelican. The saline lakes are natural resources characteristic of Kenya and are concentrated in this catchment area. Though these lakes are not suitable water sources, these serve as important habitats for wild birds and large mammals such as *Hippopotamus amphibious*. These lake ecosystems are threatened by water pollution from inflow of human sewage, agricultural water, industrial wastewater, and water shortage by excessive abstract water in the upper reaches. Lake Naivasha located near the town area, is also threatened by water pollution caused by sewage associated with population growth. Despite the important water resources, water pollution in Lake Naivasha caused by agricultural water and sewage inflow has been accelerated. The lakes and surrounding wetlands should be officially protected as natural environment resources. It is required to consider adequate countermeasure based on periodic environmental monitoring to prevent any further environmental degradation.

The Mau Forest Complex, Cherangani Hills, and the Aberdare Range are located in RVCA. The decrease of the water conservation forest areas affects water resource conservation as well as other catchment areas.

**Natural Environmental Resources (RVCA)**

| Protected Area | | Total Area | Number of Wildlife Species | Location |
|---|---|---|---|---|
| National Park (N.P.) | | | | |
| 1 | Mt Longonot N.P | 52 (km$^2$) | 209 | Naivasha District, Rift Valley Province |
| 2 | Saiwa Swamp N.P | 2 (km$^2$) | No information | Trans- Nzoia District, Rift Valley Province |
| 3 | Central Island N.P | 5 (km$^2$) | 108 | Within Lake Turkana |
| 4 | Hells Gate N.P | 68 (km$^2$) | 214 | The south of Lake Naivasha |
| 5 | Lake Nakuru N.P | 52 (km$^2$) | 211 | Nakuru District, Rift Valley Province |
| 6 | South Island N.P | 39 (km$^2$) | 109 | Within Lake Turkana |
| 7 | Sibiloi N.P. | 1,570 (km$^2$) | 115 | The northeastern shore of Lake Turkana |
| National Reserve (N.R.) | | | | |
| 8 | South Turkana N.R | 1,109 (km$^2$) | 160 | Northern 125 km from Lodwar |
| 9 | Nasalot N.R | 194 (km$^2$) | 160 | Western of South Turkana N.R. |
| 10 | Kamnarok N.R | 87.7 (km$^2$) | No information | Central of Rift Valley, next to Lake Kamnarok |
| 11 | Kerio Valley N.R | 66 (km$^2$) | 189 | Between Cherangani Hills and Tugen Hills |
| Five Water Towers | | | | |
| 13 | Aberdare Range | 250,000 (ha) | No information | Central Kenya, on the eastern edge of RVCA |
| 14 | Cherangani Hills | 120,000 (ha) | No information | Western ridge of Great Rift Valley |
| 15 | Mau Forest Complex | 400,000 (ha) | No information | Central of RVCA |

Source: JICA Study Team based on ProtectedPlanet.net (http://www.protectedplanet.net/about) and Wildlife Bill, 2011

### 4.9.2 Management Strategy

Based on the overall concept and frameworks mentioned in Section 7.10 of the Main Report Part A, it is proposed to set environmental flow rate and to carry out environmental monitoring for the main rivers and lakes in RVCA.

The water resource development projects in the NWMP 2030 are mostly proposed in the Turkwel, Kerio, and Ewaso Ng'iro South rivers as main rivers of RVCA. Therefore, setting of environmental flow rate and environmental monitoring are proposed for these three rivers. Similarly, setting of environmental lake water level and environmental monitoring are proposed for six alkaline lakes which are important habitats for large mammals, amphibians, and bird species, and for Lake Naivasha as an important freshwater lake.

In addition, environmental monitoring is proposed for Nakuru City and Naivasha Town which are located near Lake Nakuru and Lake Naivasha, impact of future population growth of the cities will worsen the water pollution of the two lakes.

### 4.9.3 Proposed Environmental Management Plan

Based on the abovementioned management strategy and point selection criteria mentioned in the overall concept and framework, target points of environmental flow rate and environmental monitoring of environmental management plan for RVCA are shown in the following table. Locations of target points are shown in Figure 4.9.1.

**Environmental Flow Rate/Water Level Setting Points (RVCA)**

| Target | Environmental Flow Setting Point | | Proposed Major Development Projects | Vegetation | Reserve* ($m^3/s$) | Monitoring Point of WRM |
|---|---|---|---|---|---|---|
| Turkwel River | RV-F1 | Reference point (Lodwar Town) | Embobut Dam and Turkwel Irrigation | Semi-desert grassland | 0.0 | 2B21 |
| | RV-F2 | Confluence point with the Suam River (Downstream of Turkwel Dam) | | Deciduous bushland and thicket | 0.0 | - |
| Kerio River | RV-F3 | Reference point (Downstream of confluence with the Arror River) | Arror, Murung-Sebit and Kimwarer dams | Deciduous bushland and thicket | 0.0 | 2C16 |
| Ewaso Ng'iro South River | RV-F4 | Reference point (Narok Town) | Upper Narok, Oletukat, Leshota, and Ololorko dams | Evergreen bush land with wooded grassland | 0.0 | 2K06 |
| Lake Turkana | RV-F5 | Representative point | - | Semi-desert grassland | - | 2B13 |
| Lake Baringo | RV-F6 | Representative point | - | Deciduous bushland and thicket | - | 2EH1 |
| Lake Bogoria | RV-F7 | Representative point | Waseges Dam | Evergreen bush land with wooded grassland | - | 2EB10 |
| Lake Nakuru | RV-F8 | Representative point | - | Evergreen bush land with wooded grassland | - | 2FC04 |
| Lake Elementaita | RV-F9 | Representative point | - | Evergreen bush land with wooded grassland | - | 2FA08 |
| Lake Naivahsa | RV-F10 | Representative point | Malewa Dam | Evergreen bush land with wooded grassland | - | 2GD06 |
| Lake Magadi | RV-F11 | Representative point | - | Deciduous bushland and thicket | - | New |

Note: * Reserve includes the water for ecological needs and basic human needs as mentioned in WRMA Guidelines for Water Allocation.
Source: JICA Study Team (Ref. Sectoral Report (H), Section 3.2(1))

In addition, the environmental survey for setting the environmental flow rate (ccurrent river flow rate, water quality, and river ecosystem) shall be conducted in the Turkwel, Kerio, and Ewaso Ng'iro South rivers and above six saline lakes except Lake Naivasha.

**Environmental Monitoring Points (RVCA)**

| Target | Monitoring Point | | Reserve* ($m^3/s$) | Monitoring Point of WRM | Selection Criteria |
|---|---|---|---|---|---|
| Turkwel River | RV-M1 | Reference point (Lodwar Town) | 0.0 | 2B21 | a) Representative point to monitor the river ecosystem |
| | RV-M2 | Confluence point with the Suam River (Downstream of the Turkwel dam) | 0.0 | - | b) Points where rare or characteristic ecosystem exists (To monitor existing Turkwel Dam) |
| Kerio River | RV-M3 | Downstream of the South Turkana National Reserve | - | - | b) Points where rare or characteristic ecosystem exists (Semi-Arid Area) |
| | RV-M4 | Reference point (Downstream of confluence with the Arror River) | 0.0 | 2C16 | a) Representative point to monitor the river ecosystem |
| Ewaso Ng'iro South River | RV-M5 | Reference point | 0.0 | 2K04 | a) Representative point to monitor the river ecosystem<br>f) International rivers and lakes |
| Lake Turkana | RV-M6 | Representative point | - | 2B13 | e) Major lakes in the catchment area, and<br>f) International rivers and lakes |
| Lake Baringo | RV-M7 | Representative point | - | 2EH1 | e) Major lakes in the catchment area |
| Lake Bogoria | RV-M8 | Representative point | - | 2EB10 | e) Major lakes in the catchment area |
| Lake Nakuru | RV-M9 | Representative point | - | 2FC04 | d) Points upstream from the protected area, and<br>e) Major lakes in the catchment area |
| Lake Elementaita | RV-M10 | Representative point | - | 2FA08 | e) Major lakes in the catchment area |
| Lake Naivasha | RV-M11 | Representative point | - | 2GD06 | e) Major lakes in the catchment area |
| Lake Magadi | RV-M12 | Representative point | - | New | e) Major lakes in the catchment area |
| Nakuru and Naivasha towns | RV-M13 | Nakuru Town (Main discharge point) | - | - | c) Points where large city or town is located, and<br>d) Points upstream from the protected area |
| | RV-M14 | Naivasha Town (Main discharge point) | - | - | |

Note: * Reserve includes the water for ecological needs and basic human needs as mentioned in WRMA Guidelines for Water Allocation.

Source: JICA Study Team (Ref. Sectoral Report (H), Section 3.2(1))

# CHAPTER 5 COST ESTIMATES

## 5.1 Basic Conditions and Methodologies for Cost Estimates

### 5.1.1 Conditions and Methodologies of Cost Estimates for Development Plans

Costs of the projects proposed in the development plans formulated for RVCA including water supply, sanitation, irrigation, hydropower, and water resources development plans were estimated to know the overall cost in general, as well as to evaluate the general economic viability. A general idea or scheme of financing for the implementation of the proposed projects is also discussed.

The project costs (construction costs) together with the annual O&M costs and replacement costs were estimated for the proposed projects in the respective development plans using the following methods:

(1) Water Supply Development Projects

a) As for the expansion and new construction of water supply systems, the cost estimates were separately considered for the three categories, i.e., “dams and large-scale bulk water transfer systems”, “water intake, boreholes and water transmission lines with pump stations”, and “water distribution systems with water treatment plants and pumping stations”. Except for “dams and large-scale bulk water transfer systems”, the project costs were estimated by applying the unit cost of US$2250/m$^3$. If dams or large-scale water transfer systems are required for water supply system, the costs are estimated separately as described in paragraph e) below. As for the rehabilitation of water supply system, the project costs were estimated by applying the unit cost of US$675/m$^3$ of water supply capacity of existing water supply system.

b) The above unit costs were derived from the data on the existing reports prepared by the WSBs and the Aftercare Study Report with adjustments. The used data includes direct and indirect construction costs (administration and engineering services). Land acquisition costs were not estimated due to the marginal amount for water supply projects.

c) The annual O&M costs were estimated for the water supply projects by applying the unit cost of US$0.3/m$^3$ for water production. The unit cost was estimated based on the data in the existing reports prepared by the WASREB and WSBs. The replacement costs for electromechanical works were estimated by applying 30% of the total project costs. The replacement was assumed to be conducted every 15 years.

(2) Sanitation Development Projects

a) As to the expansion and new development of sewerage system, the project costs were estimated by applying the unit cost of US$2000/m$^3$ for required wastewater treatment capacity. As to the rehabilitation, the project costs were estimated by applying the unit cost of US$600/m$^3$ of treatment capacity of existing sewerage system. The unit costs were derived from the data in the existing reports prepared by the WSBs and the Aftercare Study Report with adjustments. The used data include direct and indirect construction costs (administration and engineering services). Land acquisition costs were not estimated due to the marginal amount for sewerage projects.

b) The annual O&M costs were estimated for the sewerage projects by applying the unit cost of US$0.2/m$^3$ for treatment capacity. The unit cost was estimated based on the data in the existing reports prepared by the WASREB and WSBs. The replacement costs for electromechanical works were estimated by applying the 30% of the total project costs. The replacement was assumed to be conducted every 15 years.

c) Other sanitation projects

(3) Irrigation Development Projects

a) For the large- and small-scale irrigation projects, the costs for civil works estimated by the government authorities were employed with adjustments, when necessary. The construction costs include the physical contingency at 15% of the direct construction cost. Land acquisition costs were assumed to be KSh100,000/ha based on the actual data for other projects, when data were not available.

b) For the new large- and small-scale irrigation projects without detailed cost data, the project costs were estimated by applying the unit costs per ha and indirect construction costs as calculated above. The unit construction costs were assumed at KSh900,000/ha for large-scale dam irrigation, KSh600,000/ha for small-scale dam irrigation, KSh400,000/ha for weir irrigation, and KSh900,000/ha for groundwater irrigation projects by applying actual costs of similar projects.

c) For private irrigation projects, the unit project cost was assumed at KSh1.5 million/ha referring to the actual investment cost data for drip irrigation system invested by private sectors. This unit cost includes all indirect costs such as engineering services, technical training, and contingencies due to their nature.

d) The annual O&M costs were estimated by applying the rate of 0.3% to the direct construction costs for the water source facilities (dams, weirs, boreholes) and 1% for the irrigation canal systems. The replacement costs such as mechanical works were assumed at 20% to the direct construction costs, which is assumed to be every 20 years.

(4) Hydropower Development Projects

a) For the hydropower projects, project costs were estimated based on the available cost data estimated by the government authorities with adjustments. The cost data were regarded to include direct and indirect construction costs. Land acquisition costs were not estimated due to their marginal amounts, in general.

b) Annual O&M costs were estimated by applying the amount of 0.5% of the project costs including replacement costs.

(5) Water Resources Development Projects

a) For dams, project costs were estimated by using a dam project cost curve showing the relationship between the costs and fill dam or embankment volumes in case that no cost data were available for dam projects. The cost curve was prepared based on the existing cost and dam volume information. In case that cost data were provided for the planned dams by the government, the data were used as the project costs with adjustments.

b) For water transfer facilities, the project costs were estimated based on the existing cost data prepared by the government with adjustments depending on pipe size.

c) The abovementioned existing cost data include the direct and indirect construction costs (administration and engineering services). Land acquisition costs for the dam and water transfer projects were estimated separately by applying the unit cost of KSh100,000/ha, which was assumed based on the actual data.

d) The annual O&M costs for dam projects and water transfer projects were estimated by applying 0.5% of the project costs. The percentage was assumed based on the values in the NWMP (1992) and figures usually used in planning of similar projects. The replacement costs were not considered for dams and water transfer facilities.

e) The project costs of small dams for rural water supply purpose were estimated based on actual construction data. The costs of the boreholes were estimated in the subsectors of water supply and irrigation.

Other basic conditions applied for the cost estimates are as follows:

a) The cost estimates were based on the November 1, 2012 price level.

b) The exchange rate used for the cost estimate was US$1.0 = KSh85.24 as of November 1, 2012.

The estimated project costs in this study are primarily used to grasp the financial status in general, therefore, these costs should not be used for specific purposes of financial arrangements of the projects.

### 5.1.2 Conditions and Methodologies of Cost Estimates for Management Plans

Costs for the respective proposed management plans for RVCA were estimated for the water resources management, flood and drought disaster management, and environmental management plans to know the costs in general and to discuss about the general idea of financing the implementation of the plans.

The costs were estimated considering two major items of development cost and recurrent cost as usually applied in the management sectors of the government. The development cost was estimated as the cost of construction or installation of facilities, equipment or systems for management activities including required studies and surveys. The recurrent cost was estimated as the cost of periodical monitoring and measurement works for management activities, which were required annually including operation and maintenance costs. Both the development and recurrent costs were estimated based on the prepared implementation programmes.

The development and recurrent costs were estimated for the proposed management plans through the following methods:

a) For water resources management plan, both the development and recurrent costs were estimated by applying the unit costs for management activities derived from interviews with WRMA staff in charge of related management activities.

b) For flood and drought disaster management plan, the development costs were estimated referring to the existing master plan studies such as the Nyando Flood Management Master Plan (2009) and NWMP (1992) with adjustments. The annual recurrent costs were assumed to be 0.5% of the development costs.

c) For environmental management plan, both the development and recurrent costs were estimated by applying the unit costs for management activities in terms of required manpower, meetings, surveys, and monitoring.

For water resources management plan, it was assumed that 40% of existing river and rainfall gauging stations need rehabilitation.

As to the cost estimates for flood and drought disaster management plans, the following are noted:

a) Project costs of dams with flood control allocation were excluded and were estimated separately in the water resources development plan.
b) Project costs for river improvement works were excluded because there were limited basic data necessary for planning and cost estimation.
c) Project costs for the drought management plan were excluded because these were considered to be within WRMA's regular tasks.

Other basic conditions applied in the cost estimates are as follows:

a) The cost estimate was based on the November 1, 2012 price level.
b) The exchange rate used for the cost estimate was US$1.0 = KSh85.24 as of November 1, 2012.

The development and recurrent costs estimated in this study are primarily used to grasp the financial status in general, therefore, these costs should not be used for other specific purposes of financial arrangements for the said plans.

## 5.2 Cost Estimate for Proposed Plans

### 5.2.1 Cost Estimate for Proposed Development Plans

(1) General Scopes of Proposed Plans for Cost Estimate

The general scopes for cost estimate of the proposed development plans include the following:

1) Water Supply Development Plan

The rehabilitation project includes work items of replacement of old pipes, installation/replacement of water meters, and repair/replacement works of mechanical and electrical equipment. Source works include construction of water intake facilities and boreholes with pumps. Water transmission system covers pipelines and pumping stations.

2) Sanitation Development Plan

The rehabilitation project includes replacement of old sewers, and repair/replacement works of mechanical and electrical equipment. For the cost estimates, waste stabilisation pond was assumed to be adopted for all wastewater treatment works.

3) Irrigation Development Plan

There are three categories of the irrigation projects, namely, large-scale, small-scale, and private irrigation. Water sources for irrigation projects include weirs, dams, groundwater, and rainwater harvesting facilities such as small dams/water pans.

4) Hydropower Development Plan

Of the 14 hydropower schemes, 13 schemes are multipurpose dam projects and one scheme is a single purpose project.

5) Water Resources Development Plan

The cost of dam includes the dam and related structures such as spillways, river outlets, river diversions, and so forth.

(2) Estimated Costs

The project costs and annual O&M as well as the replacement costs for the projects proposed in the development plans for RVCA were estimated based on the conditions and methodologies stated in the preceding section. Results of the estimates are shown in Tables 5.2.1 to 5.2.6 and summarised as follows:

**Estimated Costs for Proposed Projects in Development Plans (RVCA)**

(Unit: KSh million)

| Development Plan | Proposed Project | Type | Project Cost | Annual O&M Cost |
|---|---|---|---|---|
| Water Supply* | Urban Water Supply (13 UCs) | Rehabilitation | 7,416 | - |
| | | New construction | 93,977 | 2,721 |
| | | Sub-total | 101,393 | 2,721 |
| | Rural Water Supply (18 Counties) | Rehabilitation | 384 | - |
| | | New construction | 43,464 | 1,645 |
| | | Sub-total | 43,847 | 1,645 |
| | Sub-total | | 145,240 | 4,366 |
| Sanitation* | Sewerage System (9 UCs) | Rehabilitation | 941 | - |
| | | New construction | 37,869 | 2,073 |
| | Sub-total | | 38,810 | 2,073 |
| Irrigation** | Large-scale Irrigation (78,850 ha) | New construction | 109,959 | 330 |
| | Small-scale Irrigation (9,271 ha) | New construction | 5,991 | 30 |
| | Private Irrigation (4,045 ha) | New construction | 7,842 | 78 |
| | Sub-total | | 123,792 | 438 |
| Hydropower | 6 projects | New construction | 57,120 | 286 |
| Total | | | 364,962 | 7,163 |

Note: UC = Urban Centre

* O&M cost of existing water supply and sewerage facilities to be rehabilitated was not estimated due to lack of data required for cost estimate.

** Rehabilitation cost of existing irrigation facilities was not estimated due to lack of data required for cost estimate though there are needs of rehabilitation of them.

Source: JICA Study Team (Ref. Tables 5.2.1 – 5.2.5)

The costs for the proposed water resources development were estimated to be KSh98,964 million as the project cost and KSh495 million as the O&M cost, which include the costs of the ten dams. The costs had been allocated to the costs for water supply, irrigation, and hydropower subsectors.

### 5.2.2 Cost Estimate for the Proposed Management Plans

(1) General Scopes of Proposed Plans for Cost Estimate

The general scopes for cost estimate of the proposed management plans include the following:

1) Water Resources Management Plan

The development costs for the water resources management plan were estimated for the following activities; i) monitoring of river stage, groundwater level, and rainfall; ii) evaluation such as upgrading the hydrometeorological database and establishment of additional water quality test laboratory; iii) permitting (upgrade of permit database), and iv) watershed conservation (reforestation).

The recurrent costs for the water resources management plan were estimated for the following activities; i) monitoring of surface water and groundwater, rainfall and water quality and ii) operation of the catchment forum.

2) Flood and Drought Disaster Management Plan

The development costs for the flood disaster management plan were estimated for the construction of structures, as well as for the preparation of hazard maps and evacuation plans.

The recurrent costs for the flood disaster management plan were estimated for the O&M of the structures, updating of the documents and maps, and replacement of equipment.

3) Environmental Management Plan

The development costs for the environmental management plan were estimated for i) the environmental survey for setting the environmental flow rate and ii) setting of the environmental flow rate.

The recurrent costs for the environmental management plan were estimated for the environmental monitoring.

(2) Estimated Costs

The development and recurrent costs for the proposed management plans of RVCA were estimated based on the conditions and methodologies stated in the preceding section. Results of the estimates are shown in Tables 5.2.7 to 5.2.9, and summarised below.

**Estimated Costs for Proposed Management Plans (RVCA)**

(Unit: KSh million)

| Management Plan | Proposed Plans | Development Costs | Annual Recurrent Costs* |
|---|---|---|---|
| Water Resources Management | Monitoring | 103 | 120 |
| | Evaluation | 63 | - |
| | Permitting | 27 | - |
| | Watershed Conservation (1,006,000 ha) | 79,474 | - |
| | Operation of Catchment Forum | - | 1 |
| | Sub-total | 79,667 | 121 |
| Flood and Drought Disaster Management | Hazard Map (2 locations) | 60 | 0.3 |
| | Evacuation Plan (1 location) | 30 | 0.2 |
| | River Training Works (cost for F/S) (2 locations) | 320 | - |
| | Sub-total | 410 | 0.5 |
| Environmental Management | Setting of Environmental Flow Rate including Survey (11 locations) | 99 | - |
| | Environmental Monitoring (14 locations) | - | 1.6 |
| | Sub-total | 99 | 1.6 |
| Total | | 80,176 | 123.1 |

Note:* Recurrent cost includes operation and maintenance costs
Source: JICA Study Team (Ref. Tables 5.2.7 – 5.2.9)

# CHAPTER 6 ECONOMIC EVALUATION

## 6.1 Basic Conditions and Methodology for Economic Evaluation

The overall economic evaluation was performed for four sectors; 1) urban water supply (for 13 UCs, excluding rehabilitation works), 2) sewerage (for 9 UCs, excluding rehabilitation works), 3) large-scale irrigation (with 73,000 ha), and 4) hydropower (with six dams) in RVCA at the master plan level. The following assumptions were made for economic analysis:

a) Price Level

Investment costs and O&M costs are estimated at the November 1, 2012 price level. Exchange rate applied is US$1.0 = KSh85.24 = ¥79.98.

b) Social Discount Rate

The social discount rate reflects the opportunity cost of capital to the national economy. In this study, 10% of the prevailing opportunity cost of capital in the water sector of Kenya is applied.

c) Economic Life of Facilities

The economic life of project facilities is set at 50 years for irrigation and hydropower projects, and 30 years for water supply and sanitation projects which are generally applied for economic evaluation. Further, economic life of dam is set at 50 years while that for water transfer facility is set at 30 years which are generally applied.

d) Cost Allocation for Multipurpose Dams

The costs of multipurpose dams are allocated to the three subsectors of urban water supply, irrigation, and hydropower according to the degree of contribution of the dams to each subsector.

e) Economic Cost

The financial cost of the project is converted to the economic cost for economic evaluation. The prices of internationally tradable goods and services are valued on the basis of the international border prices, which can often be found in the World Bank’s “Commodity Prices and Price Forecast”. The prices of non-traded goods and services were converted from their financial values to economic values by applying a standard conversion factor of 0.90 based on the facts that the ratio of taxation against the GDP in Kenya is about 11%, as well as on the fact that the conversion factors widely applied in the water sector of Kenya are mostly around 0.90.

f) Economic Benefit

The details of the economic benefit calculations for four subsectors are described in the sectoral reports. The economic benefit was estimated by setting the items of economic benefits.

Based on the basic conditions for economic evaluation mentioned above, economic benefits were estimated as follows:

**Estimated Economic Benefits (RVCA)**

| Subsector | Items of Economic Benefits | Benefit at Net Present Value |
|---|---|---|
| a) Water Supply | - Cost saving for water users<br>- Increase of water supply amount | KSh 88.2 billion (30 years) |
| b) Sewerage | - Cost saving for users<br>- Affordability to pay<br>- Improvement of public health | KSh 47.7 billion (30 years) |
| c) Irrigation | - Crop production increase | KSh 100.3 billion (50 years) |
| d) Hydropower | - Capacity increase<br>- Energy increase | KSh 72.1 billion (50 years) |

Source: JICA Study Team

The details of the calculations are described in the sectoral reports.

## 6.2 Economic Evaluation for the Proposed Plan

The following table shows the estimated economic and financial costs and the results of economic evaluation in RVCA.

**Summary of Economic Evaluation Results (RVCA)**

(Unit: KSh billion)

| Subsector | Scope | Estimated Financial Cost | Estimated Economic Cost | Net Present Value | | B/C | EIRR |
|---|---|---|---|---|---|---|---|
| | | | | Cost | Benefit | | |
| Water Supply | 13 UCs | 92.2 | 87.5 | 92.9 | 88.2 | 0.95 | 9.30% |
| Sewerage | 9 UCs | 37.9 | 35.6 | 43.6 | 47.7 | 1.09 | 11.30% |
| Irrigation | 73,000 ha | 88.6 | 82.9 | 70.4 | 100.3 | 1.42 | 13.50% |
| Hydropower | 6 projects | 57.1 | 54.4 | 44.8 | 72.1 | 1.61 | 15.30% |

Source: JICA Study Team

The total economic costs for water resources development is estimated at KSh 260.4 billion, of which water supply projects are the largest (KSh 87.5 billion), followed by irrigation projects (KSh 82.9 billion). In terms of economic viability, the sewerage, irrigation and hydropower subsectors were found to be economically feasible with more than 10% of EIRR, while the water supply subsector had a low efficiency from the economic point of view. The results of the economic analysis for the four subsectors are summarised as follows;

a) The water supply projects in RVCA require high cost structures for water source development, such as large-scale dams and long length of water transmission systems for the Greater Nakuru area, which resulted in low economic viability. The water supply projects in the Greater Nakuru area should be planned/reviewed carefully in the future, and promoted as basic human needs.

b) All sewerage projects were estimated to be slightly over 10% in the evaluation. The sewerage projects should be promoted from the perspective of environmental conservation, human health, and water recycling.

c) The potentiality of irrigation projects in this catchment is high, as irrigation schemes in RVCA would produce KSh 100.3 billion in the national economy, and its economic viability is high with an EIRR greater than 14%.

d) The hydropower projects in RVCA are efficient due to topographic condition that could gain sufficient advantage for power generation, which resulted in positive economic viability of the hydropower subsector.

# CHAPTER 7 IMPLEMENTATION PROGRAMMES

## 7.1 General

Implementation programmes were prepared for the projects proposed in the water supply, sanitation, irrigation, hydropower, and water resources development plans as well as for the management plans proposed in the water resources management, flood and drought disaster management, and environmental management plans. The prepared implementation programmes will serve as a roadmap for the smooth realisation of the projects and plans by the target year 2030.

The implementation programmes for the projects are composed of the projects assessed to be technically, economically, and environmentally viable.

## 7.2 Criteria for Prioritisation for Implementation

### 7.2.1 Criteria for Prioritisation of Development Plans

In order to prepare the implementation programmes, the proposed projects and plans were prioritised for implementation in accordance with the following criteria in terms of project status and subsector:

(1) Prioritisation by Project Status

The priority ranking was set for the proposed projects in accordance with the following criteria by project status:

Priority ranking 1: Projects with finance,
Priority ranking 2: Projects with detailed designs completed,
Priority ranking 3: Projects with feasibility studies completed, and
Priority ranking 4: Projects other than the above.

It is noted that the national flagship projects and projects proposed by the government organisations in charge were included in the ranking above.

(2) Prioritisation by Subsector

For projects having the same ranking in project status derived from the abovementioned ranking study, the following criteria were applied for further prioritisation of respective subsectors:

1) Water supply:
  a) Rehabilitation of the existing facilities will be made prior to their expansion.
  b) Projects with large service population such as urban water supply and large-scale rural water supply projects have higher priority.
  c) Small-scale rural water supply projects will be implemented progressively by individuals or communities.

2) Sanitation:
  a) Rehabilitation of the existing facilities will be made prior to their expansion.

b) Sewerage projects in the urban area with severe impacts on the environment have higher priority.

c) On-site sanitation facilities will be installed progressively by individuals or communities.

3) Irrigation:

a) Rehabilitation of existing facilities will be made prior to their expansion.

b) Projects with higher economic viability including large-scale projects and small-scale projects proposed by the government organisations have higher priority.

c) Other small-scale projects and private projects will be implemented progressively under counties and by private companies, respectively.

4) Hydropower:

a) Hydropower project will be implemented following the water resources development for water supply and/or irrigation.

5) Water resources:

a) The water resources development such as dams, water transfers, small dams, pans, and boreholes will be implemented according to the requirements of the water supply and irrigation development.

### 7.2.2 Criteria for Prioritisation of Management Plans

Criteria for prioritisation of the proposed management plans for implementation were set as presented below for the water resources management, flood and drought disaster management, and environmental management.

(1) Criteria for Water Resources Management Plan

Considering the magnitude of contribution to stable and sustainable management works, the following activities were prioritised among development activities in water resources management:

a) Replacement of iron posts for river water gauges to concrete post.
b) Installation of dedicated boreholes for groundwater monitoring.
c) Installation/rehabilitation of river and rainfall gauging stations.
d) Establishment of additional water quality test laboratory.

Among the recurrent activities, items that can start immediately were prioritised.

(2) Criteria for Flood and Drought Disaster Management Plan

1) For Flood Disaster Management Plan

a) Non-structural measures are scheduled mostly in the short term because they serve as immediate measures to mitigate flood damage before the completion of structural measures.

b) The construction schedule of multipurpose dams is certainly in accordance with the water resources development subsector.

c) Urban drainage measures where studies have been completed are scheduled in the short term.

2) For Drought Disaster Management Plan

a) Drought disaster management plans such as preparation of water use restriction for reservoirs and establishment of a Basin Drought Conciliation Council should be implemented, as early as possible, wherever applicable.

(3) Environmental Management Plan

Prior to the implementation of development projects, environmental flow rate should be set as early as possible, because it will be rather difficult to revise the flow rate after starting certain development projects. For this, environmental survey should start immediately to set the environmental flow rate. Therefore, the following priorities were set:

a) Environmental survey to set the environmental flow rate which should be conducted during the short term.
b) Locations of setting environmental flow rate should be prioritised by referring to the implementation programme of development plans such as dams.

After setting of the environmental flow rate, environmental monitoring should be conducted to confirm the adequacy of the flow rate. Therefore, environmental monitoring for examining the established environmental flow rate should be conducted during the medium term.

Important points for environmental monitoring where currently there is no measurement by WRMA, environmental monitoring should start immediately. Such activities should be started in the short term.

## 7.3 Implementation Programmes of Proposed Plans

The implementation schedules of the proposed plans were prepared under the following conditions, as well as the criteria for prioritisation as described in the preceding sections:

a) All proposed projects and plans should be realised by the target year 2030.
b) The programmes must follow the existing implementation schedules prepared by the government.
d) The programmes should be prepared in close harmony with the requirements of other water subsectors.
e) The programmes must be prepared, of which annual disbursement costs are to be as even as possible.

The proposed implementation schedules are shown in Figures 7.3.1 to 7.3.5 for the development plans and Figures 7.3.6 to 7.3.8 for the management plans. Prior to implementation of the development projects, environmental impact assessment (EIA) should be implemented including the issues of compensation.

# *Tables*

## Table 3.3.1 Monthly Water Requirement by Sub-Basin in 2030 (RVCA)

($m^3/s$)

| Sub-basin | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Des | Annual (MCM/year) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2AA | 0.1 | 0.1 | 0.4 | 0.5 | 0.6 | 0.6 | 0.4 | 0.1 | 0.3 | 0.4 | 0.4 | 0.4 | 11 |
| 2AB | 0.2 | 0.2 | 1.2 | 1.6 | 1.9 | 2.0 | 1.2 | 0.3 | 0.8 | 1.4 | 1.3 | 1.3 | 35 |
| 2BA | 0.2 | 0.2 | 0.6 | 0.8 | 1.0 | 1.0 | 0.6 | 0.2 | 0.5 | 0.7 | 0.8 | 0.8 | 19 |
| 2BB | 0.2 | 0.2 | 0.7 | 1.0 | 1.1 | 1.2 | 0.7 | 0.2 | 0.5 | 0.9 | 0.9 | 1.0 | 23 |
| 2BC | 0.5 | 0.5 | 1.8 | 2.3 | 2.8 | 2.8 | 1.7 | 0.6 | 1.3 | 2.1 | 2.1 | 2.3 | 55 |
| 2BD | 0.6 | 0.6 | 2.5 | 3.4 | 3.9 | 4.0 | 2.6 | 0.9 | 1.9 | 2.9 | 2.8 | 2.9 | 76 |
| 2CA | 0.1 | 0.1 | 0.4 | 0.6 | 0.7 | 0.7 | 0.5 | 0.2 | 0.3 | 0.5 | 0.5 | 0.5 | 14 |
| 2CB | 0.6 | 0.6 | 2.5 | 3.7 | 4.2 | 4.1 | 2.4 | 0.8 | 1.9 | 3.2 | 3.0 | 3.2 | 80 |
| 2CC | 0.6 | 0.6 | 3.3 | 5.1 | 5.7 | 5.7 | 3.2 | 0.9 | 2.5 | 4.4 | 4.2 | 4.4 | 107 |
| 2D | 0.5 | 0.5 | 3.1 | 4.8 | 5.5 | 5.4 | 3.1 | 0.7 | 2.4 | 4.1 | 3.9 | 4.1 | 100 |
| 2EA | 0.2 | 0.2 | 0.4 | 0.4 | 0.3 | 0.4 | 0.3 | 0.2 | 0.3 | 0.4 | 0.3 | 0.4 | 10 |
| 2EB | 0.2 | 0.2 | 0.6 | 0.5 | 0.5 | 0.6 | 0.4 | 0.2 | 0.4 | 0.5 | 0.4 | 0.6 | 14 |
| 2EC | 0.4 | 0.4 | 0.9 | 0.8 | 0.7 | 0.9 | 0.6 | 0.4 | 0.6 | 0.8 | 0.7 | 0.9 | 22 |
| 2ED | 0.2 | 0.2 | 0.4 | 0.4 | 0.4 | 0.4 | 0.3 | 0.2 | 0.3 | 0.4 | 0.3 | 0.4 | 10 |
| 2EE | 0.0 | 0.0 | 0.5 | 0.7 | 0.7 | 0.7 | 0.4 | 0.1 | 0.3 | 0.6 | 0.5 | 0.6 | 14 |
| 2EF | 0.0 | 0.0 | 0.2 | 0.2 | 0.2 | 0.3 | 0.2 | 0.0 | 0.1 | 0.2 | 0.2 | 0.3 | 5 |
| 2EG1 | 0.4 | 0.4 | 0.6 | 0.6 | 0.6 | 0.6 | 0.5 | 0.4 | 0.5 | 0.6 | 0.6 | 0.7 | 17 |
| 2EG2 | 0.2 | 0.2 | 0.9 | 0.8 | 0.7 | 0.9 | 0.6 | 0.2 | 0.6 | 0.8 | 0.7 | 1.0 | 20 |
| 2EH | 0.0 | 0.0 | 0.3 | 0.4 | 0.3 | 0.4 | 0.3 | 0.1 | 0.2 | 0.4 | 0.3 | 0.4 | 8 |
| 2EJ | 0.1 | 0.1 | 0.9 | 0.9 | 0.9 | 1.1 | 0.7 | 0.2 | 0.6 | 0.9 | 0.7 | 1.0 | 22 |
| 2EK | 0.1 | 0.1 | 0.4 | 0.4 | 0.4 | 0.5 | 0.3 | 0.1 | 0.2 | 0.4 | 0.3 | 0.4 | 9 |
| 2FA | 0.1 | 0.1 | 0.4 | 0.4 | 0.3 | 0.4 | 0.3 | 0.1 | 0.2 | 0.4 | 0.3 | 0.4 | 9 |
| 2FB | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 3 |
| 2FC | 2.6 | 2.6 | 3.4 | 3.4 | 3.3 | 3.5 | 3.1 | 2.7 | 3.1 | 3.4 | 3.2 | 3.5 | 99 |
| 2GA | 0.3 | 0.3 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.3 | 0.4 | 0.5 | 0.5 | 0.5 | 15 |
| 2GB | 0.7 | 0.7 | 1.2 | 1.2 | 1.2 | 1.3 | 1.0 | 0.8 | 1.0 | 1.2 | 1.1 | 1.3 | 33 |
| 2GC | 0.2 | 0.2 | 0.6 | 0.7 | 0.7 | 0.8 | 0.6 | 0.3 | 0.5 | 0.7 | 0.7 | 0.7 | 18 |
| 2GD | 1.4 | 1.4 | 2.0 | 2.0 | 2.0 | 2.1 | 1.9 | 1.4 | 1.7 | 2.1 | 2.0 | 2.1 | 58 |
| 2H-1 | 0.5 | 0.5 | 3.9 | 6.1 | 7.0 | 6.9 | 4.2 | 0.9 | 2.9 | 5.2 | 5.0 | 5.2 | 127 |
| 2H-2 | 0.1 | 0.1 | 3.6 | 5.8 | 6.7 | 6.6 | 3.9 | 0.5 | 2.6 | 4.9 | 4.7 | 4.9 | 117 |
| 2H-3 | 0.0 | 0.0 | 3.5 | 5.7 | 6.7 | 6.6 | 3.8 | 0.5 | 2.5 | 4.9 | 4.6 | 4.8 | 116 |
| 2J | 0.6 | 0.6 | 3.2 | 4.4 | 5.3 | 5.4 | 3.4 | 0.9 | 2.4 | 3.8 | 3.7 | 3.8 | 99 |
| 2KA | 0.8 | 0.8 | 1.7 | 2.1 | 2.4 | 2.5 | 1.7 | 0.8 | 1.4 | 1.9 | 1.9 | 1.9 | 53 |
| 2KB | 0.1 | 0.1 | 0.8 | 1.1 | 1.2 | 1.3 | 0.8 | 0.2 | 0.6 | 1.0 | 0.9 | 1.0 | 24 |
| 2KC | 0.1 | 0.1 | 1.7 | 2.5 | 2.6 | 2.8 | 1.7 | 0.3 | 1.2 | 2.2 | 2.0 | 2.1 | 51 |
| Total | 13.3 | 13.3 | 49.3 | 66.0 | 73.2 | 75.2 | 47.8 | 16.7 | 37.3 | 59.0 | 55.6 | 60.1 | 1,494 |

Source: JICA Study Team

## Table 4.2.1 Water Service Providers (WSPs) (RVCA)

| WSPs | Service Towns/Areas | Service Population in 2010 | Capacity ($m^3$/day) | NRW |
|---|---|---|---|---|
| [Urban] | | | | |
| Nakuru WSC | Nakuru | 372,366 | 41,750 | 53% |
| Nakuru Rural WSC | Molo, Elburgon, Njoro, Rongai | 213,476 | 26,333 | 62% |
| Ol Kalou WSC | Olkalou | 10,240 | 2,087 | 30% |
| Lodwar WSC | Lodwar | 28,920 | 3,068 | 66% |
| Narok WSC | Narok | 12,540 | 1,880 | 45% |
| Eldama Ravine WSC | Eldama Ravine | 26,013 | 6,700 | 80% |
| Naivasha WSC | Naivasha, Gilgil, Suswa | 54,420 | 7,008 | 44% |
| Kabarnet WSC | Kabarnet | N.A | 2,496 | N.A |
| [Rural] | | | | |
| Engineer Town | Engineer | 5,700 | 300 | N.A |
| Mawingo | Mawingu | 10,000 | 800 | 95% |
| Kikana Mku | Njeru | 28,536 | 1,426 | 51% |
| Kinja | Kinja | 4,500 | 380 | N.A |
| Tachasis | Tachasis & Environs | 4,106 | 1,548 | 44% |
| Others | | | 2,140 | |
| Total | | 777,309 | 97,916 | |

Source: Performance Report of Kenya's Water Services, No. 4, 2011, and data from WSBs

## Table 4.2.2 Proposed Water Supply Development Plan for UWSS (RVCA)

| Urban Centre | | Service Population in 2030 | Water Demand in2030 ($m^3$/day) | Current Capacity in 2010 ($m^3$/day) | Under Construction ($m^3$/day) | Proposed Projects | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Rehabilitation Works ($m^3$/day) | Expansion Works ($m^3$/day) | New Construction ($m^3$/day) |
| Greater Naluru | | | | | | | | |
| 1 | Nakuru | 1,155,789 | 137,539 | 81,791 | 35,000 | 116,791 | 192,374 | 0 |
| 2 | Naivasha | 851,433 | 101,320 | | | | | |
| 3 | Molo | 204,630 | 24,351 | | | | | |
| 4 | Gilgil | 177,659 | 21,141 | | | | | |
| 5 | Njoro | 118,552 | 14,108 | | | | | |
| 6 | Eldama Ravine | 89,965 | 10,706 | | | | | |
| 7 | Ol Kalou | 332,309 | 39,545 | 2,087 | 2,600 | 4,687 | 34,858 | 0 |
| | Sub-total | 2,930,336 | 348,710 | 83,878 | 37,600 | 121,478 | 227,232 | **0** |
| Arid Area | | | | | | | | |
| 1 | Lodwar | 59,544 | 7,086 | 3,068 | 0 | 3,068 | 4,018 | 0 |
| 2 | Kakuma | 45,444 | 5,408 | 0 | 0 | 0 | 0 | 5,408 |
| 3 | Kabarnet | 31,236 | 3,717 | 2,496 | 0 | 2,496 | 1,221 | 0 |
| 4 | Lokichogio | 21,807 | 2,595 | 0 | 0 | 0 | 0 | 2,595 |
| | Sub-total | 158,032 | 18,806 | 5,564 | 0 | 5,564 | 5,239 | 8,003 |
| Others | | | | | | | | |
| 1 | Narok | 194,573 | 23,154 | 1,880 | 0 | 1,880 | 21,274 | 0 |
| 2 | Mai Mahiu | 58,689 | 6,984 | 0 | 0 | 0 | 0 | 6,984 |
| | Sub-total | 253,262 | 30,138 | 1,880 | 0 | 1,880 | 21,274 | 6,984 |
| | | | | | | | | |
| | Total | 3,341,630 | 397,654 | 91,322 | 37,600 | 128,922 | 253,745 | 14,987 |
| | | | | | | | 268,732 | |

Note: The service population of piped water supply (UWSS+LSRWSS) in 2010 was estimated at 1.36 million. The service population for each urban centre in 2010 is not clear. All urban population of urban centre in 2030 was counted as service population.

Source: JICA Study Team, based on data from WSBs and Census 2009

## Table 4.2.3 Proposed Water Supply Development Plan for LSRWSS (RVCA)

| Item | Service Population in 2030 | Water Demand in 2030 ($m^3$/day) | Current Capacity in 2010 ($m^3$/day) | Proposed Projects | |
|---|---|---|---|---|---|
| | | | | Rehabilitation Works ($m^3$/day) | New Construction ($m^3$/day) |
| Urban Pop. | 1.14 | 136,000 | 7,000 | 7,000 | 171,000 |
| Rural Pop. | 0.56 | 42,000 | | | |
| Total | 1.70 | 178,000 | | | |

Note: The service population of piped water supply (UWSS+LSRWSS) in 2010 is estimated at 1.36 million.

Source: JICA Study Team, based on data from WSBs and Census 2009

**Table 4.2.4 Proposed Water Supply Development Plan for SSRWSS (RVCA)**

| Counties | Service Population in 2010 | Service Population in 2030 | Difference (2010-2030) | Required Water Supply Amount in 2030 ($m^3$/day) |
|---|---|---|---|---|
| 18 | 1,320,000 | 2,403,537 | 1,083,537 | 119,700 |

Source: JICA Study Team, based on data from Census 2009

**Table 4.3.1 Proposed Sewerage Development Plan (RVCA)**

| Major Urban Area | | Service Population | Required Capacity ($m^3$/day) | Rehabilitation Works ($m^3$/day) | Expansion Works ($m^3$/day) | New Construction ($m^3$/day) |
|---|---|---|---|---|---|---|
| 1 | Nakuru | 1,155,789 | 88,071 | 16,200 | 71,871 | 0 |
| 2 | Naivasha | 851,433 | 64,879 | 933 | 63,946 | 0 |
| 3 | Ol Kalou | 332,309 | 25,322 | 0 | 0 | 25,322 |
| 4 | Molo | 204,630 | 15,593 | 1,260 | 14,333 | 0 |
| 5 | Narok | 194,573 | 14,826 | 0 | 0 | 14,826 |
| 6 | Gilgil | 177,659 | 13,538 | 0 | 0 | 13,538 |
| 7 | Njoro | 118,552 | 9,034 | 0 | 0 | 9,034 |
| 8 | Eldama Ravine | 89,965 | 6,855 | 0 | 0 | 6,855 |
| 9 | Kabarnet | 31,236 | 2,380 | 0 | 0 | 2,380 |
| | Total | 3,156,144 | 240,498 | 18,393 | 150,150 | 71,955 |

Note: Data of the service population for each urban centre in 2010 is not available. All urban population of urban centre in 2030 is counted as service population.

Source: JICA Study Team, based on data from WSBs and Census 2009

**Table 4.3.2 Users and Required Units of On-Site Sewerage Facilities (RVCA)**

| Counties | Users (2010) | Users (2030) | Difference (2010-2030) | Required Units of On-site Facilities |
|---|---|---|---|---|
| 18 | 3,350,000 | 4,290,000 | 940,000 | 858,000 |

Note: * 5 users/facilities
Source: JICA Study Team, based on data from Census 2009

## Table 4.4.1 Large Scale Irrigation Projects Selected for Implementation by 2030

| No | Name of Project | County | Sub-basin Code | Irrigation Area (ha) | Project Type*1 | Water Source Facilities*2 | | Present Status*3 | Estimated Cost*4 (KSh mil.) | Executing Agency |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Type | Name of Dam | | | |
| 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 Extention | Baringo | 2EE | 3,000 | Reh+Ext | 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 |

Note: *1: Reh = Rehabilitation, Ext = Extension; *2: Multi = Multipurpose, E = Existing; *3: F/S = Feasibility study, D/D = Detailed design,
*4: Estimated Cost = Construction cost for irrigation sytem (excluding cost allocation of multipurpose dam)

Source: JICA Study Team, based on information from government authorities.

## Table 4.6.1 Available Surface Water and Groundwater Resources for 2030 by Sub-basin (RVCA)

| | Surface Water ($m^3/s$) | | | | | | | | | | | | | Groundwater |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sub-basin | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Average | (MCM/year) |
| 2AA | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.4 |
| 2AB | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.7 |
| 2BA | 3.2 | 1.4 | 0.8 | 5.0 | 13.3 | 11.2 | 14.6 | 17.4 | 10.8 | 11.8 | 10.3 | 4.1 | 8.7 | 1.0 |
| 2BB | 5.1 | 2.3 | 1.2 | 8.1 | 21.3 | 18.0 | 23.4 | 28.0 | 17.4 | 19.0 | 16.6 | 6.5 | 13.9 | 1.7 |
| 2BC | 4.2 | 1.6 | 1.0 | 7.8 | 19.0 | 15.2 | 16.6 | 22.0 | 16.2 | 17.4 | 15.5 | 6.4 | 11.9 | 1.3 |
| 2BD | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.2 | 0.2 | 0.3 | 0.1 | 10.4 |
| 2CA | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 2CB | 10.3 | 5.7 | 3.1 | 24.5 | 34.6 | 21.6 | 27.2 | 33.6 | 16.0 | 14.8 | 20.1 | 13.2 | 18.7 | 3.7 |
| 2CC | 9.3 | 3.7 | 1.8 | 13.5 | 36.4 | 24.6 | 27.3 | 39.3 | 20.2 | 21.7 | 25.2 | 12.7 | 19.6 | 18.4 |
| 2D | 2.7 | 0.4 | 0.2 | 7.2 | 6.5 | 3.3 | 1.8 | 8.1 | 3.0 | 3.3 | 6.1 | 5.3 | 4.0 | 12.2 |
| 2EA | 0.8 | 0.4 | 0.2 | 1.1 | 1.8 | 1.2 | 1.7 | 2.4 | 1.5 | 1.0 | 1.3 | 1.1 | 1.2 | 0.2 |
| 2EB | 1.4 | 0.7 | 0.4 | 1.8 | 2.9 | 2.0 | 2.8 | 4.0 | 2.5 | 1.7 | 2.1 | 1.9 | 2.0 | 0.2 |
| 2EC | 1.3 | 0.9 | 0.6 | 1.3 | 3.1 | 2.1 | 2.1 | 3.4 | 3.0 | 2.2 | 2.1 | 2.4 | 2.0 | 0.3 |
| 2ED | 1.2 | 0.8 | 0.6 | 1.4 | 3.1 | 2.5 | 3.2 | 5.2 | 4.3 | 2.7 | 2.4 | 2.2 | 2.5 | 0.6 |
| 2EE | 2.2 | 1.2 | 0.7 | 4.9 | 7.1 | 4.8 | 6.9 | 9.7 | 5.1 | 3.5 | 4.2 | 3.1 | 4.5 | 0.5 |
| 2EF | 1.1 | 0.8 | 0.5 | 1.3 | 2.9 | 2.3 | 3.0 | 4.8 | 3.9 | 2.5 | 2.2 | 2.0 | 2.3 | 0.5 |
| 2EG1 | 0.7 | 0.5 | 0.3 | 1.1 | 1.9 | 1.3 | 1.5 | 2.6 | 1.7 | 1.2 | 1.3 | 1.2 | 1.3 | 1.8 |
| 2EG2 | 2.5 | 1.5 | 0.9 | 3.7 | 6.3 | 4.2 | 5.1 | 8.7 | 5.8 | 4.0 | 4.4 | 4.1 | 4.3 | 0.4 |
| 2EH | 1.2 | 0.5 | 0.4 | 3.3 | 3.5 | 2.2 | 2.7 | 4.0 | 1.5 | 1.2 | 2.0 | 1.4 | 2.0 | 1.5 |
| 2EJ | 0.6 | 0.2 | 0.1 | 1.3 | 0.8 | 0.3 | 0.3 | 1.6 | 0.6 | 0.7 | 1.2 | 1.2 | 0.7 | 1.3 |
| 2EK | 1.0 | 0.4 | 0.2 | 1.7 | 2.1 | 1.3 | 2.1 | 3.1 | 1.2 | 0.9 | 1.5 | 1.3 | 1.4 | 0.4 |
| 2FA | 0.6 | 0.4 | 0.3 | 0.5 | 1.2 | 0.8 | 0.8 | 1.0 | 1.0 | 0.8 | 1.1 | 1.0 | 0.8 | 0.2 |
| 2FB | 0.2 | 0.1 | 0.1 | 0.1 | 0.3 | 0.2 | 0.2 | 0.3 | 0.3 | 0.2 | 0.3 | 0.3 | 0.2 | 0.2 |
| 2FC | 1.7 | 1.2 | 0.8 | 1.9 | 3.3 | 2.3 | 2.0 | 2.7 | 2.5 | 2.0 | 2.5 | 2.4 | 2.1 | 1.8 |
| 2GA | 1.1 | 0.8 | 0.5 | 1.2 | 1.9 | 1.3 | 1.1 | 0.9 | 0.9 | 0.8 | 1.3 | 1.2 | 1.1 | 0.1 |
| 2GB | 3.5 | 2.1 | 1.4 | 4.5 | 6.7 | 4.4 | 3.9 | 3.6 | 3.6 | 3.4 | 5.5 | 4.3 | 3.9 | 0.2 |
| 2GC | 3.9 | 2.2 | 1.9 | 7.0 | 10.3 | 5.8 | 3.4 | 2.2 | 2.7 | 3.8 | 7.4 | 5.6 | 4.7 | 3.7 |
| 2GD | 5.5 | 3.2 | 2.7 | 9.9 | 14.5 | 8.2 | 4.7 | 3.2 | 3.7 | 5.3 | 10.4 | 7.9 | 6.6 | 5.2 |
| 2H-1 | 2.2 | 2.6 | 1.1 | 3.0 | 4.6 | 1.8 | 0.4 | 0.1 | 0.0 | 0.0 | 0.3 | 1.9 | 1.5 | 12.7 |
| 2H-2 | 2.9 | 3.6 | 1.4 | 4.5 | 6.5 | 1.6 | 0.4 | 0.1 | 0.0 | 0.0 | 0.4 | 2.5 | 2.0 | 3.7 |
| 2H-3 | 1.2 | 1.2 | 0.4 | 1.3 | 1.9 | 0.5 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.9 | 0.6 | 0.7 |
| 2J | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.4 |
| 2KA | 12.5 | 11.5 | 9.6 | 28.4 | 29.7 | 14.2 | 6.5 | 3.4 | 3.3 | 3.4 | 8.6 | 15.0 | 12.2 | 6.7 |
| 2KB | 3.2 | 2.8 | 1.9 | 5.1 | 6.3 | 2.1 | 1.2 | 1.1 | 1.0 | 0.9 | 1.8 | 3.7 | 2.6 | 1.2 |
| 2KC | 2.3 | 2.5 | 0.8 | 2.0 | 4.6 | 1.2 | 0.3 | 0.1 | 0.0 | 0.0 | 0.0 | 2.6 | 1.4 | 4.8 |

Source: JICA Study Team

## Table 4.6.2 Water Demands for 2030 by Sub-sector and Sub-basin (RVCA)

($m^3/s$)

| Sub-basin | Domestic | | Industrial | | Irrigation | | Livestock | | Wildlife | | Fisheries | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2010 | 2030 | 2010 | 2030 | 2010 | 2030 | 2010 | 2030 | 2010 | 2030 | 2010 | 2030 |
| 2AA | 0.01 | 0.03 | 0.00 | 0.00 | 0.00 | 0.01 | 0.05 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2AB | 0.04 | 0.07 | 0.00 | 0.00 | 0.27 | 0.27 | 0.10 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2BA | 0.06 | 0.07 | 0.00 | 0.00 | 0.22 | 1.37 | 0.04 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2BB | 0.04 | 0.06 | 0.00 | 0.00 | 0.27 | 6.32 | 0.06 | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2BC | 0.14 | 0.19 | 0.00 | 0.00 | 0.57 | 6.67 | 0.12 | 0.28 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2BD | 0.08 | 0.21 | 0.00 | 0.00 | 0.69 | 0.80 | 0.25 | 0.42 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2CA | 0.01 | 0.02 | 0.00 | 0.00 | 0.10 | 0.11 | 0.07 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2CB | 0.12 | 0.46 | 0.00 | 0.02 | 0.42 | 2.15 | 0.05 | 0.10 | 0.00 | 0.00 | 0.01 | 0.03 |
| 2CC | 0.12 | 0.18 | 0.00 | 0.00 | 0.73 | 8.97 | 0.30 | 0.42 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2D | 0.08 | 0.13 | 0.00 | 0.00 | 0.65 | 0.79 | 0.29 | 0.36 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2EA | 0.17 | 0.13 | 0.04 | 0.02 | 0.03 | 0.03 | 0.01 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2EB | 0.15 | 0.12 | 0.03 | 0.02 | 0.05 | 0.06 | 0.01 | 0.03 | 0.00 | 0.00 | 0.01 | 0.02 |
| 2EC | 0.37 | 0.29 | 0.08 | 0.05 | 0.05 | 0.07 | 0.02 | 0.06 | 0.00 | 0.00 | 0.00 | 0.01 |
| 2ED | 0.02 | 0.16 | 0.00 | 0.01 | 0.03 | 0.10 | 0.01 | 0.02 | 0.00 | 0.00 | 0.00 | 0.01 |
| 2EE | 0.02 | 0.03 | 0.00 | 0.00 | 0.09 | 0.13 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2EF | 0.01 | 0.03 | 0.00 | 0.00 | 0.03 | 0.06 | 0.01 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2EG1 | 0.07 | 0.36 | 0.00 | 0.02 | 0.03 | 0.03 | 0.01 | 0.03 | 0.00 | 0.00 | 0.01 | 0.01 |
| 2EG2 | 0.14 | 0.15 | 0.03 | 0.02 | 0.09 | 0.14 | 0.02 | 0.05 | 0.00 | 0.00 | 0.01 | 0.02 |
| 2EH | 0.02 | 0.02 | 0.00 | 0.00 | 0.04 | 0.08 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2EJ | 0.04 | 0.04 | 0.00 | 0.00 | 0.09 | 0.09 | 0.04 | 0.06 | 0.00 | 0.00 | 0.02 | 0.04 |
| 2EK | 0.02 | 0.02 | 0.00 | 0.00 | 0.04 | 0.05 | 0.01 | 0.01 | 0.00 | 0.00 | 0.01 | 0.02 |
| 2FA | 0.12 | 0.05 | 0.01 | 0.00 | 0.03 | 0.04 | 0.01 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2FB | 0.06 | 0.04 | 0.01 | 0.01 | 0.01 | 0.02 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2FC | 0.42 | 2.08 | 0.06 | 0.44 | 0.10 | 0.10 | 0.04 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2GA | 0.07 | 0.28 | 0.00 | 0.01 | 0.02 | 0.03 | 0.01 | 0.02 | 0.00 | 0.00 | 0.00 | 0.01 |
| 2GB | 0.15 | 0.61 | 0.00 | 0.03 | 0.04 | 0.04 | 0.03 | 0.07 | 0.00 | 0.00 | 0.02 | 0.04 |
| 2GC | 0.12 | 0.15 | 0.00 | 0.00 | 0.04 | 0.08 | 0.03 | 0.06 | 0.00 | 0.00 | 0.01 | 0.01 |
| 2GD | 0.21 | 1.24 | 0.01 | 0.06 | 0.09 | 0.10 | 0.03 | 0.07 | 0.00 | 0.00 | 0.00 | 0.01 |
| 2H-1 | 0.50 | 0.24 | 0.03 | 0.01 | 0.68 | 0.70 | 0.08 | 0.19 | 0.00 | 0.00 | 0.00 | 0.01 |
| 2H-2 | 0.25 | 0.08 | 0.01 | 0.00 | 0.40 | 0.41 | 0.03 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2H-3 | 0.01 | 0.02 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2J | 0.08 | 0.29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.26 | 0.32 | 0.01 | 0.01 | 0.00 | 0.00 |
| 2KA | 0.20 | 0.43 | 0.00 | 0.02 | 0.11 | 1.89 | 0.15 | 0.35 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2KB | 0.06 | 0.04 | 0.00 | 0.00 | 0.10 | 11.76 | 0.04 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2KC | 0.09 | 0.03 | 0.00 | 0.00 | 0.28 | 0.38 | 0.04 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 |

Source: JICA Study Team

**Table 4.6.3 Reserve Quantity by Sub-basin for Water Balance Study**

| | Catchment Area ($km^2$) | Accumulated Catchment Area ($km^2$) | River Name | Reserve *1 ($m^3/s$) | Node *2 |
|---|---|---|---|---|---|
| 2CB | 2,434 | | Kerio River | 0.0 | 14 |
| 2CC | 11,494 | 13,928 | | 0.0 | 17 |
| | | | | | |
| 2AA | 10,480 | | | 0.0 | 2 |
| | | | | | |
| 2AB | 10,143 | | | 0.0 | 5 |
| | | | | | |
| 2CA | 3,770 | | | 0.0 | 11 |
| | | | | | |
| 2BC | 3,446 | | Turkwel River | 0.0 | 9 |
| 2BA | 1,316 | | | 0.0 | 6 |
| 2BB | 2,116 | 3,431 | | 0.0 | 7 |
| 2BD | 12,943 | 19,820 | | 0.0 | 10 |
| | | | | | |
| 2D | 13,108 | | | 0.0 | 18 |
| | | | | | |
| 2EA | 428 | | | 0.0 | 19 |
| | | | | | |
| 2EB | 709 | | | 0.0 | 21 |
| | | | | | |
| 2ED | 420 | | | 0.0 | 24 |
| 2EF | 387 | | | 0.0 | 29 |
| 2EE | 593 | 1,400 | | 0.0 | 28 |
| | | | | | |
| 2EG1 | 389 | | | 0.0 | 30 |
| 2EC | 880 | | | 0.0 | 22 |
| 2EG2 | 1,298 | 2,567 | | 0.0 | 31 |
| | | | | | |
| 2EH | 554 | | | 0.0 | 33 |
| 2EJ | 1,399 | | | 0.0 | 34 |
| 2EK | 609 | | | 0.0 | 35 |
| 2FA | 543 | | | 0.0 | 36 |
| 2FB | 140 | | | 0.0 | 37 |
| 2FC | 1,484 | | | 0.0 | 38 |
| 2GA | 402 | | | 0.0 | 39 |
| 2GC | 745 | | Malewa River | 0.0 | 43 |
| 2GB | 931 | 1,676 | | 0.0 | 41 |
| | | | | | |
| 2GD | 1,051 | | | 0.0 | 44 |
| | | | | | |
| 2H-1 | 5,104 | | | 0.0 | 47 |
| 2H-2 | 2,257 | | | 0.0 | 48 |
| 2H-3 | 988 | | | 0.0 | 49 |
| | | | | | |
| 2J | 27,556 | | | 0.0 | 50 |
| | | | | | |
| 2KA | 5,130 | | Ewaso Ng'iro South River | 0.0 | 52 |
| 2KB | 1,663 | 6,793 | | 0.0 | 55 |
| 2KC | 1,999 | 8,792 | | 0.0 | 56 |

Note: *1 = Reserve was set at 95% value of the naturalized present daily flow duration curve with a probability of once in 10 years.
*2 = Node numbers in Figure 4.6.3.
Source: JICA Study Team

## Table 4.6.4 Dam Candidates (RVCA)

(1) Priority Dams proposed in NWMP (1992)

| Catchment Area | | Proposed Dams | Sub-basin | Stage | Purpose | Related Agency/ Owner | Status/ Construction Year | Source of Information | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| 3. | RV | 9. Chemususu | 2ED | D/D | W | NWCPC | U/C (to be completed in 2013) | NWCPC | 2008-12 Flagship Projects under Vision 2030 |
| | | 10. Kirandich | 2EH | D/D | W | RVWSB | Completed (2000) | NWCPC, WRMA | |
| | | 11. Malewa | 2GB | F/S | W | RVWSB | No further study is done. | RVWSB | |
| | | 12. Upper Narok | 2KA | M/P | W | RVWSB/ NWCPC | No further study is done. | NWCPC | 2008-12 Flagship Projects under Vision 2030 |
| | | 13. Oldorko | 2KB | Pre-F/S | P, I, W | ENSDA | F/S, D/D (to be completed in 2013) | MORDA/ ENSDA | MORDA 18 projects, Lower Ewaso Ng'iro South River Multipurpose Dam Development Project |

(2) Future Development Potential Dams at the time of NWMP (1992)

| Catchment Area | | Future Development Potential Dams | | Sub-basin | Purpose | Related Agency/ Owner | Status/ Construction Year | Source of Information | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| 3. | RV | 15 | Kimwarer | 2CB | W, P, I | KVDA | Pre-F/S done by KVDA | KVDA | |
| | | 16 | Kipsang (Kipsaa) | 2CB | W | - | No further study is done. | WRMA, KVDA | |
| | | 17 | Arror | 2CC | W | KVDA/ MORDA | F/S, D/D completed (2012) | MORDA | MORDA 18 Projects, Multipurpose (W, P, I) |
| | | 18 | Sererwa | 2CC | P, I, W | - | No further study is done. | WRMA | |
| | | 19 | Waseges | 2CC | W | - | No further study is done. | WRMA | |
| | | 20 | Kamukuny | 2CC | W, I | - | No further study is done. | WRMA | |
| | | 21 | Aram | 2EE | W | - | Dam completed (2010) | KVDA | No water supply yet. |
| | | 22 | Ratat | 2EE | W | NWCPC | No further study is done. | KVDA | |
| | | 23 | Leshota | 2KB | P, W | ENSDA | F/S, D/D ongoing (to be completed in 2013) | MORDA/ ENSDA | MORDA 18 Projects, Lower Ewaso Ng'iro South River Multipurpose Dam Development Project |

(3) Dam Schemes Studied by Government

| | | **Identified Dams** | | | | **Current Status** | | | |
|---|---|---|---|---|---|---|---|---|---|
| Catchment Area | | Dams not in NWMP (1992) | | Sub-basin | Purpose | Related Agency/ Owner | Status/ Construction Year | Source of Information | Remarks |
| 3. | RV | 7 | Murung-Sebit | 2BB | W, I, F | KVDA | No study is started. | KVDA | |
| | | 8 | Embobut | 2CC | W, I, P | KVDA | Pre-F/S done. | KVDA | |
| | | 9 | Perkerra | 2EE | I | NWCPC | No study is started. | NWCPC | NWCPC Plans for Vision 2030 |
| | | 10 | Oletukat | 2KA | W, P | ENSDA/ MORDA | F/S, D/D ongoing (to be completed in 2013) | MORDA/ ENSDA | MORDA 18 Projects, Lower Ewaso Ng'iro South River Multipurpose Dam Development Project |

Note:
Purpose: W=water supply, I=irrigation, P=hydropower, F=flood control
Project Stage: M/P=master plan, Pre-F/S=prefeasibility study, F/S=feasibility study, D/D=detailed design, T/D=tender documents, U/C=under construction

Source: JICA Study Team based on NWMP (1992) and information from the government agencies mentioned in the above tables.

## Table 4.6.5 Water Transfer Candidates (RVCA)

(1) Priority Water Transfer Schemes proposed in NWMP (1992)

a) Intra-basin Bulk Water Transfer Schemes

| Catchment Area | | | NWMP (1992) Intra- basin Water Transfer | | | | | Current Status | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No. | Sub-basin | Water Source | | Sub-basin | Notes | Related Agency / Owner | Status/ Construction Year | Source of Information | Remarks |
| 3. | RV | R7 | 2ED | Chemususu Dam | | 2EF | | NWCPC/ RVWSB | Under construction | NWCPC | |
| | | | | | | 2EF | | NWCPC/ RVWSB | Under construction | NWCPC | |
| | | R8 | 2GB | Malewa Dam | | 2GC | | RVWSB | No further study is done. | RVWSB | |
| | | | | | | 2GD | | RVWSB | No further study is done. | RVWSB | |
| | | R9 | 2KA | Upper Narok Dam | | 2KA | | RVWSB/ NWCPC | No further study is done. | RVWSB | |

b) Inter-basin Bulk Water Transfer Schemes

| Catchment Area | | | NWMP (1992) Inter- basin Water Transfer | | | | | Current Status | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No. | Sub-basin | Water Source | | Sub-basin | Notes | Related Agency / Owner | Status/ Construction Year | Source of Information | Remarks |
| 3. | RV | E4 | 2GB | Malewa Dam | | 2FC | | RVWSB | Some planning is done. | RVWSB | |
| | | E5 | 2EH | Kirandich Dam | | 2CB | | RVWSB | Operational | NWCPC, RVWSB | |
| | | E6 | 2KB | Oloibortoto River | without dam | 2H | | Tanathi WSB | Under construction | TWSB | Partly serviced. |

(2) Water Transfer Schemes Studied by Government

a) Intra-basin Bulk Water Transfer Schemes
None

b) Inter-basin Bulk Water Transfer Schemes
None

Note:
Project Stage: M/P=master plan, Pre-F/S=prefeasibility study, F/S=feasibility study, D/D=detailed design, T/D=tender documents, U/C=under construction
* = Listed by NWCPC as “Inter-basin Transfer Schemes.”

Source: JICA Study Team based on NWMP (1992) and information from the government agencies mentioned in the above tables.

## Table 4.6.6 Proposed of Dams and Water Transfer (RVCA)

(1) Proposed Dams

| No. | Name of Dam | Sub-basin | Relevant County | Purpose [1] | Effective Storage Volume (MCM) | Storage Volume Allocation (MCM) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Domestic and Industrial | Irrigation | Hydro-power | Flood Control |
| 18 | Murung-Sebit | 2BB | West Pokot | I (850 ha), F | 2) *40.0* | *0.0* | *40.0* | | |
| 19 | Kimwarer | 2CB | Elgiyo Marakwet | W, I (2,000 ha), P (20 MW) | 107.0 | 17.0 | 90.0 | | |
| 20 | Arror | 2CC | Elgiyo Marakwet | W, I (10,850 ha), P (80 MW), F | *62.0* | 4) 2.0 | 5) (60.0) | 60.0 | |
| 21 | Embobut | 2CC | West Pokot | W, I (2,000 ha), P (45 MW) | *30.0* | 4) 1.0 | 29.0 | | |
| 22 | Waseges | 2EB | Baringo | W | 4.0 | 4.0 | 0.0 | | |
| 23 | Malewa | 2GB | Nyandarua | W (Naivasha) | 34.0 | 34.0 | 0.0 | | |
| 24 | Upper Narok | 2KA | Narok | W (Narok), I (2,000 ha), F | 29.0 | 5.0 | 24.0 | | |
| 25 | Oletukat | 2KA | Narok | W, P (36 MW) | *300.0* | 4) 10.0 | 5) (290.0) | 290.0 | |
| 26 | Leshota | 2KB | Narok | W, P (54 MW) | *33.0* | 4) 5.0 | 0.0 | 28.0 | |
| 27 | Oldorko | 2KB | Narok | W, I (15,000 ha with Oletukat Dam), P (90 MW) | *20.0* | 4) 5.0 | 0.0 | 15.0 | |
| | Total | | | | 659.0 | 83.0 | 183.0 | 393.0 | |

Note:
1) W=Domestic and industrial water supply, I=Irrigation, P=Hydropower, F=Flood control
2) Figures in Italic Font are those proposed by the Kenyan Government.
3) An adjustment is made to the effective storage volume by deducting dead storage volume from the reservoir storage volume indicated in the existing reports.
4) Allocated storage volumes are estimated by the JICA Study Team, since these are not available in the existing design reports.
5) Storage volumes in parentheses mean that the volumes are to be used first for hydropower generation and then used for irrigation and/ or domestic water purpose.
Source: JICA Study Team

(2) Proposed Water Transfer

No Water Transfer Scheme proposed in RVCA.

## Table 4.6.7 Balance between Water Resources and Water Demands in 2030 (RVCA)

(Unit: MCM/year)

| No. | Sub basin | CA ($km^2$) | Major Domestic Demand Centre | Domestic and Industrial | | | | | | | | | | Irrigation | | | | | | | | Livestock | | | Wildlife | | | Fisheries | | | Summary | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Surface Water | | | | | | | | Surface Water | | | | | | | SW | | | SW | | | SW | | | Surface Water | | | | | |
| | | | | Demand | Demand (Domestic ) | Demand( Industrial) | Deficit | River Water | Dam | Transfer | Small Dam/ Water Pans | Groundwater | Balance | Demand | Deficit | River Water | Dam | Transfer | Small Dam/ Water Pans | Groundwater | Balance | Demand | Small Dam/ Water Pans | Balance | Demand | Small Dam/ Water Pans | Balance | Demand | Small Dam/ Water Pans | Balance | Demand | River Water | Dam | Transfer | Small Dam/ Water Pans | Groundwater | Balance |
| 1 | 2AA | 10,480 | | 0.8 | 0.8 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 1.9 | 1.9 | 0.0 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 3.2 | 0.3 | 0.0 | 0.0 | 2.0 | 0.8 | 0.0 |
| 2 | 2AB | 10,143 | | 2.3 | 2.3 | 0.0 | -1.2 | 0.5 | 0.0 | 0.0 | 1.2 | 0.7 | 0.0 | 6.0 | 0.0 | 6.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.9 | 3.9 | 0.0 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 12.3 | 6.5 | 0.0 | 0.0 | 5.2 | 0.7 | 0.0 |
| 3 | 2BA | 1,316 | | 2.1 | 2.1 | 0.0 | -0.5 | 0.6 | 0.0 | 0.0 | 0.5 | 1.0 | 0.0 | 12.3 | 0.0 | 12.1 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 2.8 | 2.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 17.2 | 12.7 | 0.0 | 0.0 | 3.4 | 1.0 | 0.0 |
| 4 | 2BB | 2,116 | | 2.0 | 2.0 | 0.0 | -0.1 | 0.2 | 0.1 | 0.0 | 0.0 | 1.7 | 0.0 | 86.0 | -21.4 | 66.0 | 19.9 | 0.0 | 0.2 | 0.0 | 0.0 | 4.2 | 4.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.0 | 92.4 | 66.2 | 20.0 | 0.0 | 4.5 | 1.7 | 0.0 |
| 5 | 2BC | 3,446 | | 6.1 | 6.0 | 0.1 | -2.2 | 2.7 | 0.0 | 0.0 | 2.2 | 1.3 | 0.0 | 112.0 | 0.0 | 41.7 | 70.0 | 0.0 | 0.3 | 0.0 | 0.0 | 9.0 | 9.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.0 | 127.2 | 44.4 | 70.0 | 0.0 | 11.6 | 1.3 | 0.0 |
| | Reference Point (2B21) | | | | | | | | | | | | | | | 0.0 | | | | | | | | | | | | | | | | | | | | | |
| 6 | 2BD | 12,943 | Lodwar | 6.5 | 6.5 | 0.0 | 0.0 | 3.1 | 0.0 | 0.0 | 0.0 | 3.4 | 0.0 | 18.6 | 0.0 | 15.1 | 0.0 | 0.0 | 1.2 | 2.3 | 0.0 | 13.3 | 13.3 | 0.0 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 38.5 | 18.2 | 0.0 | 0.0 | 14.6 | 5.6 | 0.0 |
| 7 | 2CA | 3,770 | | 0.7 | 0.7 | 0.0 | -0.5 | 0.0 | 0.0 | 0.0 | 0.5 | 0.2 | 0.0 | 2.5 | 0.0 | 2.2 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 2.8 | 2.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 5.9 | 2.2 | 0.0 | 0.0 | 3.5 | 0.2 | 0.0 |
| 8 | 2CB | 2,434 | Iten/Tambach, Kabarnet | 15.1 | 14.6 | 0.5 | -4.7 | 6.9 | 4.7 | 0.0 | 0.0 | 3.5 | 0.0 | 42.9 | -15.5 | 26.9 | 15.7 | 0.0 | 0.2 | 0.1 | 0.0 | 3.2 | 3.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.9 | 0.9 | 0.0 | 62.1 | 33.8 | 20.4 | 0.0 | 4.3 | 3.6 | 0.0 |
| | Reference Point (2C16) | | | | | | | | | | | | | | | 0.0 | | | | | | | | | | | | | | | | | | | | | |
| 9 | 2CC | 11,494 | | 5.7 | 5.7 | 0.0 | -0.6 | 0.9 | 0.6 | 0.0 | 0.0 | 4.2 | 0.0 | 182.2 | -86.2 | 33.3 | 142.5 | 0.0 | 0.9 | 5.4 | 0.0 | 13.2 | 13.2 | 0.0 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 201.2 | 34.3 | 143.1 | 0.0 | 14.2 | 9.7 | 0.0 |
| 10 | 2D | 13,108 | | 4.1 | 4.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 5.3 | 0.0 | 19.6 | 0.0 | 15.3 | 0.0 | 0.0 | 1.6 | 2.6 | 0.0 | 11.4 | 11.4 | 0.0 | 0.1 | 0.1 | 0.0 | 0.1 | 0.1 | 0.0 | 35.2 | 15.3 | 0.0 | 0.0 | 13.1 | 7.9 | 0.0 |
| 11 | 2EA | 428 | | 4.8 | 4.0 | 0.8 | -3.2 | 1.4 | 0.0 | 0.0 | 2.1 | 0.2 | 0.0 | 0.9 | 0.0 | 0.7 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.8 | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 6.5 | 2.1 | 0.0 | 0.0 | 3.0 | 0.2 | 0.0 |
| 12 | 2EB | 709 | | 4.4 | 3.9 | 0.6 | -3.0 | 1.2 | 1.7 | 0.0 | 1.3 | 0.2 | 0.0 | 1.7 | 0.0 | 1.4 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 1.1 | 1.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.5 | 0.0 | 7.8 | 2.7 | 1.7 | 0.0 | 3.2 | 0.2 | 0.0 |
| 13 | 2ED | 420 | Eldama Ravine | 5.2 | 5.0 | 0.2 | -2.6 | 2.0 | 0.0 | 0.0 | 2.6 | 0.6 | 0.0 | 1.8 | 0.0 | 1.6 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.6 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.0 | 7.8 | 3.5 | 0.0 | 0.0 | 3.6 | 0.6 | 0.0 |
| 14 | 2EE | 593 | | 1.0 | 0.9 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 2.8 | 0.0 | 2.5 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.5 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.0 | 4.3 | 3.0 | 0.0 | 0.0 | 0.8 | 0.5 | 0.0 |
| 15 | 2EF | 387 | | 0.9 | 0.9 | 0.0 | -0.1 | 0.3 | 0.0 | 0.0 | 0.1 | 0.5 | 0.0 | 0.8 | 0.0 | 0.6 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.6 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.0 | 2.3 | 0.8 | 0.0 | 0.0 | 1.0 | 0.5 | 0.0 |
| 16 | 2EC | 880 | | 10.9 | 9.3 | 1.6 | -8.6 | 7.9 | 0.0 | 0.0 | 2.7 | 0.3 | 0.0 | 2.0 | 0.0 | 1.6 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 1.8 | 1.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.3 | 0.0 | 14.9 | 9.5 | 0.0 | 0.0 | 5.2 | 0.3 | 0.0 |
| 17 | 2EG1 | 389 | Molo | 12.0 | 11.5 | 0.5 | -7.7 | 9.7 | 0.0 | 0.0 | 0.5 | 1.8 | 0.0 | 0.4 | 0.0 | 0.3 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.9 | 0.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.3 | 0.0 | 13.7 | 9.9 | 0.0 | 0.0 | 1.9 | 1.8 | 0.0 |
| 18 | 2EG2 | 1,298 | | 5.2 | 4.7 | 0.6 | -3.4 | 1.5 | 0.0 | 0.0 | 3.4 | 0.4 | 0.0 | 1.8 | 0.0 | 1.2 | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 | 1.6 | 1.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.5 | 0.0 | 9.3 | 2.7 | 0.0 | 0.0 | 6.2 | 0.4 | 0.0 |
| 19 | 2EH | 554 | | 0.6 | 0.6 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 2.3 | 0.0 | 1.1 | 0.0 | 0.0 | 0.3 | 0.9 | 0.0 | 0.2 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.1 | 1.3 | 0.0 | 0.0 | 0.5 | 1.3 | 0.0 |
| 20 | 2EJ | 1,399 | | 1.2 | 1.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.3 | 0.0 | 3.2 | 0.0 | 2.6 | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 | 1.8 | 1.8 | 0.0 | 0.0 | 0.0 | 0.0 | 1.2 | 1.2 | 0.0 | 7.4 | 2.6 | 0.0 | 0.0 | 3.6 | 1.3 | 0.0 |
| 21 | 2EK | 609 | | 0.7 | 0.7 | 0.0 | -0.2 | 0.1 | 0.0 | 0.0 | 0.1 | 0.4 | 0.0 | 1.3 | 0.0 | 1.0 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.3 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.7 | 0.7 | 0.0 | 3.0 | 1.1 | 0.0 | 0.0 | 1.4 | 0.4 | 0.0 |
| 22 | 2FA | 543 | | 1.6 | 1.6 | 0.1 | -1.2 | 0.3 | 0.0 | 0.0 | 1.2 | 0.2 | 0.0 | 1.6 | 0.0 | 0.9 | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 | 1.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.0 | 4.3 | 1.2 | 0.0 | 0.0 | 3.0 | 0.2 | 0.0 |
| 23 | 2FB | 140 | | 1.5 | 1.3 | 0.2 | -1.1 | 0.3 | 0.0 | 0.0 | 1.1 | 0.2 | 0.0 | 0.4 | 0.0 | 0.2 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.3 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.2 | 0.5 | 0.0 | 0.0 | 1.5 | 0.2 | 0.0 |
| 24 | 2FC | 1,484 | Nakuru, Njoro | 79.8 | 65.7 | 14.0 | -51.9 | 27.8 | 0.0 | 41.0 | 9.1 | 1.8 | 0.0 | 4.7 | 0.0 | 2.8 | 0.0 | 0.0 | 1.9 | 0.0 | 0.0 | 3.1 | 3.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 87.6 | 30.6 | 0.0 | 41.0 | 14.2 | 1.8 | 0.0 |
| 25 | 2GA | 402 | Gilgil | 9.2 | 8.8 | 0.4 | -6.7 | 2.4 | 5.8 | 0.0 | 0.9 | 0.1 | 0.0 | 1.1 | 0.0 | 0.6 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.7 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.0 | 11.2 | 3.0 | 5.8 | 0.0 | 2.4 | 0.1 | 0.0 |
| 26 | 2GB | 931 | Ol Kalou | 20.1 | 19.2 | 0.8 | -2.9 | 16.9 | 0.0 | 0.0 | 2.9 | 0.2 | 0.0 | 2.2 | 0.0 | 1.1 | 0.0 | 0.0 | 1.1 | 0.0 | 0.0 | 2.1 | 2.1 | 0.0 | 0.0 | 0.0 | 0.0 | 1.1 | 1.1 | 0.0 | 25.5 | 18.0 | 0.0 | 0.0 | 7.3 | 0.2 | 0.0 |
| | Reference Point (2GB01) | | | | | | | | | | | | | | | 0.0 | | | | | | | | | | | | | | | | | | | | | |
| 27 | 2GC | 745 | | 5.0 | 4.9 | 0.1 | 0.0 | 2.8 | 0.0 | 0.0 | 0.0 | 2.2 | 0.0 | 3.0 | 0.0 | 0.9 | 0.0 | 0.0 | 0.9 | 1.2 | 0.0 | 1.9 | 1.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.4 | 0.0 | 10.3 | 3.7 | 0.0 | 0.0 | 3.2 | 3.4 | 0.0 |
| 28 | 2GD | 1,051 | Naivasha | 41.2 | 39.3 | 1.9 | -27.4 | 8.6 | 26.8 | 0.0 | 0.6 | 5.2 | 0.0 | 3.5 | 0.0 | 2.2 | 0.0 | 0.0 | 1.3 | 0.0 | 0.0 | 2.1 | 2.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.0 | 47.0 | 10.8 | 26.8 | 0.0 | 4.2 | 5.2 | 0.0 |
| 29 | 2H-1 | 5,104 | , Mai Mahiu | 7.8 | 7.6 | 0.2 | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 11.6 | 0.0 | 19.6 | 0.0 | 18.3 | 0.0 | 0.0 | 0.9 | 0.4 | 0.0 | 6.1 | 6.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.4 | 0.0 | 33.9 | 18.7 | 0.0 | 0.0 | 7.4 | 12.0 | 0.0 |
| 30 | 2H-2 | 2,257 | | 2.7 | 2.6 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.7 | 0.0 | 10.4 | 0.0 | 10.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 1.9 | 1.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 15.0 | 10.0 | 0.0 | 0.0 | 2.3 | 3.7 | 0.0 |
| 31 | 2H-3 | 988 | | 0.8 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.7 | 0.0 | 0.3 | 0.0 | 0.2 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.5 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.6 | 0.2 | 0.0 | 0.0 | 0.7 | 0.7 | 0.0 |
| 32 | 2J | 27,556 | Lokichogio, Kakuma | 9.0 | 9.0 | 0.0 | -6.6 | 0.0 | 0.0 | 0.0 | 6.6 | 2.4 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 10.0 | 10.0 | 0.0 | 0.2 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 19.2 | 0.0 | 0.0 | 0.0 | 16.9 | 2.4 | 0.0 |
| 33 | 2KA | 5,130 | Narok | 13.9 | 13.4 | 0.5 | -1.5 | 8.4 | 1.5 | 0.0 | 0.0 | 4.1 | 0.0 | 40.5 | -9.3 | 4.1 | 32.0 | 0.0 | 3.5 | 0.9 | 0.0 | 11.2 | 11.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 65.6 | 12.5 | 33.5 | 0.0 | 14.8 | 4.9 | 0.0 |
| | Reference Point (2K06) | | | | | | | | | | | | | | | 0.0 | | | | | | | | | | | | | | | | | | | | | |
| 34 | 2KB | 1,663 | | 1.2 | 1.1 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.9 | 0.0 | 240.7 | -161.1 | 8.5 | 231.0 | 0.0 | 1.1 | 0.1 | 0.0 | 3.3 | 3.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 245.2 | 8.7 | 231.0 | 0.0 | 4.4 | 1.0 | 0.0 |
| 35 | 2KC | 1,999 | | 0.9 | 0.9 | 0.0 | -0.1 | 0.0 | 0.1 | 0.0 | 0.0 | 0.8 | 0.0 | 9.7 | 0.0 | 6.3 | 0.0 | 0.0 | 1.9 | 1.4 | 0.0 | 3.1 | 3.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 13.7 | 6.4 | 0.1 | 0.0 | 5.0 | 2.2 | 0.0 |
| | | | | 287.1 | 263.7 | 23.4 | -137.8 | 108.4 | 41.1 | 41.0 | 39.5 | 62.4 | 0.0 | 839.0 | -293.6 | 289.0 | 511.0 | 0.0 | 23.2 | 15.7 | 0.0 | 122.9 | 122.9 | 0.0 | 0.8 | 0.8 | 0.0 | 7.6 | 7.6 | 0.0 | 1,257.4 | 397.4 | 552.2 | 41.0 | 194.0 | 78.1 | 0.0 |

Note: Irrigation Demand: Excluding the Todonyang- Omo irrigation project (35,000 ha, 560MCM/year) to be supplied water by a dam in Ethiopia

2BB:Embobut Dam, 2CB:Kimwarer Dam, 2CC:Arror Dam and Murung-Sebit 2EB:Waseges Dam, 2GA:Malewa Dam, 2KA:Upper Narok Dam, 2KB:Oletukat Dam 2KB:Leshota Dam, 2KB:Oldorko Dam

2BA; Turkwel Dam

Source: JICA Study Team

**Table 4.6.8 Naturalised River Flow, Reserve, Water Demand, Yield and Water Supply Reliability at Reference Points (RVCA)**

| Catch-ment Area | Reference Point | River Name | Catchment Area at Reference Point ($km^2$) | Naturalised River Flow (1/10 Drought Discharge) *3 | Reserve ($m^3/s$) *1 | Present (2010) Water Demand ($m^3/s$) *2 | | Future (2030) Water Demand ($m^3/s$) *2 | | Yield of Water Resources Development ($m^3/s$) | Present (2010) Water Supply Reliability | Future (2030) Water Supply Reliability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Upstream of Reference Point | Downstream of Reference Point | Upstream of Reference Point | Downstream of Reference Point | | | |
| RVCA | 2B21 | Turkwel | 13,510 | 0.0 | 0.0 | 1.7 | 0.9 | 15.2 | 1.0 | 13.6 | 1/20 | 1/20 |
| | 2C16 | Kerio | 3,710 | 0.0 | 0.0 | 1.1 | 0.7 | 10.2 | 9.4 | 17.8 | 1/7 | 1/10 |
| | 2K06 | Ewaso Ng'iro South | 581 | 0.0 | 0.0 | 0.1 | 0.4 | 1.6 | 2.3 | 3.4 | 1/2 | 1/20 |
| | 2GB01 | Malewa | 1,596 | 0.0 | 0.0 | 0.1 | 0.1 | 0.7 | 0.6 | 1.1 | 1/3 | 1/10 |

Note: *1 = Reserve was set at 95% value of the naturalized present daily flow duration curve with a probability of once in 10 years.
*2 = Water demand was estimated by averaging the monthly demands of all water users during active irrigation period.
*3 = 1/10 drought discharge is the 355-day (97.3%) value of the naturalized daily flow duration curve with a probability of once in 10 years.

Source: JICA Study Team

## Table 5.2.1 Cost Estimate for Proposed Urban Water Supply Development (RVCA)

| | Urban Centre | Service Population in 2030 | Water Demand in 2030 ($m^3$/day) | Rehabilitation Works ($m^3$/day) | Development Capacity ($m^3$/day) | Project Cost (KSh million) | | | | | O&M Cost (KSh million/year) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Total | Rehabilitation Works | Major Dam/ Major Transmission | Intake/ Minor Transmission | Distribution | |
| Greater Naluru | | | | | | | | | | | |
| 1 | Nakuru | 1,155,789 | 137,539 | 116,791 | 192,374 | 43,615 | 6,720 | | 6,149 | 30,746 | 1,796 |
| 2 | Naivasha | 851,433 | 101,320 | | | | | | | | |
| 3 | Molo | 204,630 | 24,351 | | | | | | | | |
| 4 | Gilgil | 177,659 | 21,141 | | | | | | | | |
| 5 | Njoro | 118,552 | 14,108 | | | | | | | | |
| 6 | Eldama Ravine | 89,965 | 10,706 | | | | | | | | |
| 7 | Ol Kalou | 332,309 | 39,545 | 4,687 | 34,858 | 6,955 | 270 | | 1,114 | 5,571 | 325 |
| | Major Water Sourece Works | | | | | | | | | | |
| | Itare | | | | | 5,131 | | 5,131 | | | 26 |
| | Londiani | | | | | 6,223 | | 6,223 | | | 31 |
| | Malewa | | | | | 4,305 | | 4,305 | | | 22 |
| | Transmission (fromm Itale and Longiani)) | | | | | 25,742 | | 25,742 | | | 129 |
| | Sub-total | 2,930,336 | 348,710 | 121,478 | 227,232 | 91,971 | 6,989 | 41,401 | 7,263 | 36,317 | 2,328 |
| Arid Area | | | | | | | | | | | |
| 1 | Lodwar | 59,544 | 7,086 | 3,068 | 4,018 | 947 | 177 | | 128 | 642 | 38 |
| 2 | Kakuma | 45,444 | 5,408 | 0 | 5,408 | 1,037 | 0 | | 173 | 864 | 50 |
| 3 | Kabarnet | 31,236 | 3,717 | 2,496 | 1,221 | 378 | 144 | | 39 | 195 | 11 |
| 4 | Lokichogio | 21,807 | 2,595 | 0 | 2,595 | 498 | 0 | | 83 | 415 | 24 |
| | Sub-total | 158,032 | 18,806 | 5,564 | 13,242 | 2,860 | 320 | | 423 | 2,116 | 124 |
| Others | | | | | | | 0 | | | | |
| 1 | Narok | 194,573 | 23,154 | 1,880 | 21,274 | 4,188 | 108 | | 680 | 3,400 | 199 |
| | Upper Narok Dam | | | | | 1,031 | | 1,031 | | | 5 |
| 2 | Mai Mahiu | 58,689 | 6,984 | 0 | 6,984 | 1,340 | 0 | | 223 | 1,116 | 65 |
| | Sub-total | 253,262 | 30,138 | 1,880 | 28,258 | 6,560 | 109 | 1,031 | 903 | 4,516 | 269 |
| | | | | | | | | | | | |
| | Total | 3,341,630 | 397,654 | 128,922 | 268,732 | 101,393 | 7,416 | 42,432 | 8,590 | 42,955 | 2,721 |

Source: JICA Study Team

## Table 5.2.2 Cost Estimate for Proposed Large Scale Rural Water Supply Development (RVCA)

| | Item | Service Population in 2030 | Water Demand in 2030 ($m^3$/day) | Rehabilitation Works ($m^3$/day) | Development Capacity ($m^3$/day) | Project Cost (KSh million) | | | | | O&M Cost (KSh million/year) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Total | Rehabilitation Works | Major Dam/ Major Transmission | Intake/ Minor Transmission | Distribution | |
| 1 | Other Urban Pop. | 1,144,266 | 136,168 | 6,594 | 129,574 | 25,230 | 384 | | 4,142 | 20,704 | 1,209 |
| 2 | Rural Pop. | 556,753 | 42,313 | 0 | 42,313 | 8,115 | 0 | | 1,353 | 6,763 | 395 |
| | Major Water Sourece Works | | | | | | | | | | |
| | Murung-Sebit | | | | | 0 | | 0 | | | 0 |
| | Kimwarer | | | | | 1,492 | | 1,492 | | | 7 |
| | Arror | | | | | 188 | | 188 | | | 1 |
| | Embobut | | | | | 0 | | 0 | | | 0 |
| | Waseges | | | | | 3,273 | | 3,273 | | | 16 |
| | Oletukat | | | | | 1,304 | | 1,304 | | | 7 |
| | Leshota | | | | | 1,202 | | 1,202 | | | 6 |
| | Oldorko | | | | | 742 | | 742 | | | 4 |
| | Transmission (fromm Azuala) | | | | | 2,301 | | 2,301 | | | 12 |
| | Total | 1,701,019 | 178,481 | 6,594 | 171,887 | 43,847 | 384 | 10,502 | 5,494 | 27,467 | 1,645 |

Source: JICA Study Team

**Table 5.2.3 Cost Estimate for Proposed Sewerage Development (RVCA)**

| Major Urban Area | | Service Population in 2030 | Required Capacity in 2030 ($m^3$/day) | Current Capacity in 2010 ($m^3$/day) | Capacity to be developed ($m^3$/day) | Project Cost (KSh million) | | | O&M Cost (KSh million/year) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Total | Rehabilitation Works | Expansion/ New Construct. | |
| 1 | Nakuru | 1,155,789 | 88,071 | 16,200 | 71,871 | 13,083 | 829 | 12,255 | 671 |
| 2 | Naivasha | 851,433 | 64,879 | 933 | 63,946 | 10,951 | 48 | 10,904 | 597 |
| 3 | Ol Kalou | 332,309 | 25,322 | 0 | 25,322 | 4,318 | 0 | 4,318 | 236 |
| 4 | Molo | 204,630 | 15,593 | 1,260 | 14,333 | 2,508 | 64 | 2,443 | 134 |
| 5 | Narok | 194,573 | 14,826 | 0 | 14,826 | 2,528 | 0 | 2,528 | 138 |
| 6 | Gilgil | 177,659 | 13,538 | 0 | 13,538 | 2,308 | 0 | 2,308 | 126 |
| 7 | Njoro | 118,552 | 9,034 | 0 | 9,034 | 1,540 | 0 | 1,540 | 84 |
| 8 | Eldama Ravine | 89,965 | 6,855 | 0 | 6,855 | 1,169 | 0 | 1,169 | 64 |
| 9 | Kabarnet | 31,236 | 2,380 | 0 | 2,380 | 406 | 0 | 406 | 22 |
| Total | | 3,156,144 | 240,498 | 18,393 | 222,105 | 38,810 | 941 | 37,869 | 2,073 |

Source: JICA Study Team

## Table 5.2.4 Cost Estimate for Proposed Irrigation Development (RVCA)

| Category | Irrigation Area in 2030 (ha) | Project Cost* (KSh million) | | | Annual O&M Cost (KSh million) |
|---|---|---|---|---|---|
| | | Irrigation System | Multipurpose Dam Cost Allocation** | Total Project Cost | |
| Large Scale Irrigation | 78,850 | 67,219 | 42,740 | 109,959 | 330 |
| Small Scale Irrigation | 9,271 | 5,991 | - | 5,991 | 30 |
| Private Irrigation | 4,045 | 7,842 | - | 7,842 | 78 |
| Total | 92,166 | 81,052 | 42,740 | 123,792 | 438 |

Note: *: Project cost includes direct construction cost, physical contingency, engineering services and indirect costs.

**: Refer to Sectoral Report (G)

Source: JICA Study Team, based on data from relevant government authorities

## Table 5.2.5 Cost Estimate for Proposed Hydropower Projects (RVCA)

| Catchment Area | No. | Name of Plan | Installed Capacity | Estimated Cost: Dam Allocation Cost (KSh million) | Estimated Cost: Hydropower Component cost (KSh million) | Estimated Cost: Total Project Cost (KSh million) | Estimated Cost: Annual O&M Cost (KSh million) | Purpose |
|---|---|---|---|---|---|---|---|---|
| RVCA | 5 | Embobut Multipurpose Dam Development Plan | 45 MW | 656 | 1,313 | 1,969 | 10 | Water Supply, Irrigation, Hydropower |
| | 6 | Arror Multipurpose Dam Development Plan | 80 MW | 5,498 | 4,586 | 10,084 | 50 | Water Supply, Irrigation, Hydropower |
| | 7 | Kimwarer Multipurpose Dam Development Plan | 20 MW | 1,372 | 3,427 | 4,799 | 24 | Water Supply, Irrigation, Hydropower |
| | 8 | Oletukat Multipurpose Dam Development Plan | 36 MW | 18,804 | 9,794 | 28,598 | 143 | Water Supply, Hydropower |
| | 9 | Leshota Multipurpose Dam Development Plan | 54 MW | 6,734 | 1,978 | 8,712 | 44 | Water Supply, Hydropower |
| | 10 | Oldorko Multipurpose Dam Development Plan | 90 MW | 2,216 | 742 | 2,958 | 15 | Water Supply, Irrigation, Hydropower |
| | | Total | 325 MW | 35,280 | 21,840 | 57,120 | 286 | |

Source: JICA Study Team based on information from MORDA, KenGen and Regional Development Authorities

**Table 5.2.6 Cost Estimate for Proposed Dams (RVCA)**

Dams

| | Name of Dam | Sub-basin | Purpose 1) | Effective Storage (MCM) | Study Stage 2) | Cost (KSh million) |
|---|---|---|---|---|---|---|
| 18 | Murung-Sebit | 2BB | I, F | 40.0 | Proposed by KVDA | 6,819 |
| 19 | Kimwarer | 2CB | W, I, P | 107.0 | Pre-F/S done | 13,638 |
| 20 | Arror | 2CC | W, I, P, F | 62.0 | D/D completed | 11,422 |
| 21 | Embobut | 2CC | W, I, P | 30.0 | Pre-F/S done | 3,239 |
| 22 | Waseges | 2EB | W | 4.0 | NWMP 2030 | 3,239 |
| 23 | Malewa | 2GB | W | 34.0 | NWMP 2030 | 4,262 |
| 24 | Upper Narok | 2KA | W, I, F | 29.0 | NWMP 2030 | 5,967 |
| 25 | Oletukat | 2KA | W, P | 300.0 | F/S, D/D to be completed in 2013 | 38,784 |
| 26 | Leshota | 2KB | W, P | 33.0 | F/S, D/D to be completed in 2013 | 7,842 |
| 27 | Oldorko | 2KB | W, I, P | 20.0 | F/S, D/D to be completed in 2013 | 2,898 |
| | Total | | | 659.0 | | 98,110 |

Note:1) W=Domestic and industrial water supply, I=Irrigation, P=Hydropower, F=Flood control
2) D/D=Detailed Design, F/S=Feasibility Study, Pre-F/S=Pre-Feasibility Study, M/P=Master Plan

Source: JICA Study Team based on NWMP (1992) and data from NWCPC, MORDA, RDAs, and WSBs

## Table 5.2.7 Cost Estimate for Proposed Water Resources Management Plan (RVCA)

**Development Cost** (Unit: KSh thousand)

| No. | Item | RVCA | | | |
|---|---|---|---|---|---|
| | | Unit cost | Q'ty | Unit of Q'ty | Cost |
| **1) Monitoring** | | | | | **103,360** |
| | Installation/Rehabilitation of River Gauging Stations | 240 | 9 | nos. | 2,160 |
| | Installation/Rehabilitation of Rainfall Gauging Stations | 100 | 19 | nos. | 1,900 |
| | Installation of Dedicated Boreholes for Groundwater Monitoring | 2,000 | 10 | nos. | 20,000 |
| | Replacement of iron post for river gauge to concrete post | 100 | 23 | nos. | 2,300 |
| | Upgrade manual gauge to automatic (surface water level) | 1,000 | 23 | nos. | 23,000 |
| | Upgrade manual gauge to automatic (groundwater level) | 200 | 10 | nos. | 2,000 |
| | Upgrade manual gauge to automatic (rainfall) | 1,000 | 47 | nos. | 47,000 |
| | Flood Discharge Measurement Equipment (each sub-region) | 1,000 | 5 | nos. | 5,000 |
| | | | | | |
| **2) Evaluation** | | | | | **62,710** |
| | Hydromet DB Upgrade (Software + Hardware) including training | 2,500 | 18 | nos. | 45,000 |
| | Establishment of additional Water Quality Test Laboratory (Lodwar, Kapenguria, Mombasa, Garissa, Marsabit, Wajir) - Building and Utility | 6,750 | 2 | nos. | 13,500 |
| | Laboratory Equipment and Reagents | 2,105 | 2 | nos. | 4,210 |
| | | | | | |
| **3) Permitting** | | | | | |
| | PDB Upgrade (Software + Hardware) including training | 1,500 | 18 | nos. | 27,000 |
| | | | | | |
| **4) Watershed Conservation** | | | | | |
| | Forestation to achieve 10% of Forest Cover | 79 | 1,006,000 | ha | 79,474,000 |
| | | | | | |
| | **Total** | | | | **79,667,070** |

**Recurrent Cost (Annual)** (Unit: KSh thousand)

| No. | Item | RVCA | | | |
|---|---|---|---|---|---|
| | | Unit cost | Q'ty | Unit of Q'ty | Cost* |
| **1) Monintoring and Analysis** | | | | | **120,480** |
| | Surface Water Monitoring (Daily) | 12 | 276 | nos. | 3,312 |
| | River Discharge Measurement (Monthly) | 80 | 276 | nos. | 22,080 |
| | Groundwater Monitoring (Monthly) | 12 | 120 | nos. | 1,440 |
| | Rainfall Monitoring (Daily) | 12 | 564 | nos. | 6,768 |
| | Flood Discharge Measurement (Three times a year) | 100 | 828 | nos. | 82,800 |
| | Surface Water Quality Monitoring (Monthly) | 30 | 36 | nos. | 1,080 |
| | Surface Water Quality Monitoring (Quarterly) | 30 | 80 | nos. | 2,400 |
| | Gruondwater Quality Monitoring (Twice a year) | 30 | 20 | nos. | 600 |
| | | | | | |
| **2) Others** | | | | | |
| | Catchment Forum Operation (Venue and Allowances to WRUAs) | 500 | 2 | times | 1,000 |
| | | | | | |
| | **Total** | | | | **121,480** |

Note: *Recurrent cost includes operation and maintenance costs
Source: JICA Study Team, based on data from relevant government authorities

**Table 5.2.8 Cost Estimate for Proposed Flood Disaster Management Plan (RVCA)**

| CA | No. | Description | | Project Cost for Structure (KSh million) | Project Cost for Non-Structure (KSh million) | Recurrent Cost* (KSh million /year) | Source | Remarks |
|---|---|---|---|---|---|---|---|---|
| RV | R1 | **Nakuru** | | **0.00** | **0.00** | **0.00** | | |
| | H | R1.1 | Implementation of Urban Drainage Measures | (5,506.73) | | - | NWMP (1992) | US$51.80 million in 1992 |
| | R2 | **Narok** | | **163.13** | **60.00** | **0.30** | | |
| | A | R2.1 | Construction of Multipurpose Dam | - | | - | | Upper Narok Dam |
| | B | R2.2 | River Training Works | 163.13 | | - | | |
| | D | R2.3 | Preparation of Hazard Map | | 30.00 | 0.15 | | 10M/M |
| | E | R2.4 | Formulation of Evacuation Plan | | 30.00 | 0.15 | | 10M/M |
| | H | R2.5 | Implementation of Urban Drainage Measures | (684.62) | | - | NWMP (1992) | US$6.44 million in 1992 |
| | R3 | **Mogotio** | | **157.20** | **30.00** | **0.15** | | |
| | B | R3.1 | River Training Works | 157.20 | | - | | |
| | D | R3.2 | Preparation of Hazard Map | | 30.00 | 0.15 | | 10M/M |

Note: 1. US$1.0 = KSh 85.24 (as of November 1, 2012)
2. Cost for non-structural measures was estimated by multiplying Nyando MP (2006)'s cost by 1.95.
3. Cost for urban drainage implementation was estimated by multiplying NWMP (1992)'s cost by 1.25 (MUV Index) as pro forma amount.
4. Cost for river training works except for Yala Swamp and Kano Plain is estimated as cost for F/S including necessary surveys. (Table 6.2.2 of Sectoral Report (J))
5. Cost for Community-based Disaster Management is estimated by multiplying Nyando MP (2006)'s cost by the percentage of Nyando inundation area and sub-locations (15/55).
*Recurrent cost includes operation and maintenance costs

Source: JICA Study team, based on existing master plan studies

## Table 5.2.9 Cost Estimate for Proposed Environmental Management Plan (RVCA)

| Description | | Development Cost | | Recurrent Cost* (KSh million /year) |
|---|---|---|---|---|
| | | River and Lake Environment Survey (KSh million) | Setting of Environmental Flow Rate (KSh million) | |
| 1.Environmental River Flow | | | | |
| 1.1 | Kerio River | 16.1 | 1.6 | - |
| 1.2 | Turkwel River | 12.2 | 1.6 | - |
| 1.3 | Ewas Ng'iro South River | 9.8 | 1.1 | - |
| 1.4 | L.Turkana | 12.0 | 1.1 | - |
| 1.5 | L.Bogoria | 7.3 | 1.1 | - |
| 1.6 | L.Baringo | 7.3 | 1.1 | - |
| 1.7 | L.Nakuru | 7.3 | 1.1 | - |
| 1.8 | L.Naivasha | - | 0.2 | - |
| 1.9 | L.Elementaita | 7.3 | 1.1 | - |
| 1.10 | L.Magadi | 7.3 | 1.1 | - |
| 2.Environmental Monitoring | | | | |
| 2.1 | Kerio River | - | - | 0.4 |
| 2.2 | Turkwel River | - | - | 0.0 |
| 2.3 | Ewas Ng'iro South River | - | - | 0.0 |
| 2.4 | L.Turkana | - | - | 0.0 |
| 2.5 | L.Bogoria | - | - | 0.0 |
| 2.6 | L.Baringo | - | - | 0.0 |
| 2.7 | L.Nakuru | - | - | 0.0 |
| 2.8 | L.Naivasha | - | - | 0.0 |
| 2.9 | L.Elementaita | - | - | 0.0 |
| 2.10 | L.Magadi | - | - | 0.0 |
| 2.11 | Nakuru City | - | - | 0.6 |
| 2.12 | Naivasha Town | - | - | 0.6 |

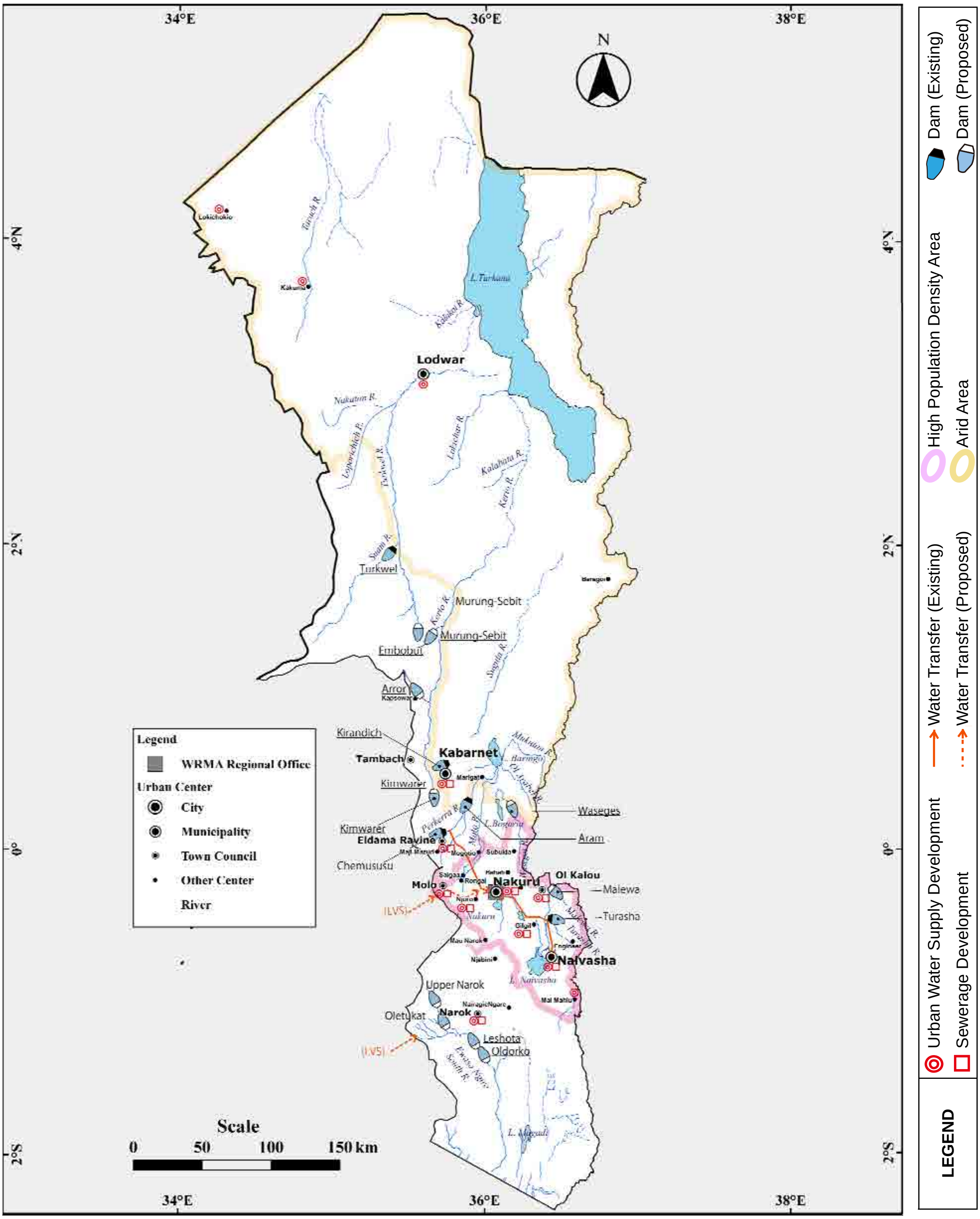
Note: Basic conditions for cost estimate are supposed as follows;

1. Unit cost of environmental experts based on hearing of environmental experts in Kenya,
2. Unit cost of field survey team, consisting of environmental experts, survey assistants, and others, for setting of environmental flow rate is assumed at KSh 130,000 / day,
3. Necessary days for field survey are assumed at one day / 10 km of river length, 10 days/lake (Lake Turkana is assumed to be 20 days),
4. Personnel costs for data analysis of field survey is assumed at KSh 2,000,000 for one water bodies (Tana River and Athi River is KSh 4,000,000),
5. Overhead cost of field survey, including transportation, accommodation, survey tool and others, is assumed at 30% of direct personnel costs,
6. Cost for stakeholder meeting for setting of environmental flow rate is assumed at KSh 200,000 / time (3 times for one setting point), and
7. Cost for latest data collection and analysis for setting of environmental flow rate is assumed at KSh 200,000 / setting point
8. Environmental monitoring cost is assumed at KSh 150,000 / time / one point
9. Environmental monitoring points of the Turkwel and Ewas Ng'iro South rivers and seven lakes are same as river gauging station of Water Resource Management Plan to monitor water quality and quantity. Thus, the monitoring cost is included in Cost of Water Resource Management Plan.

*Recurrent cost includes operation and maintenance costs

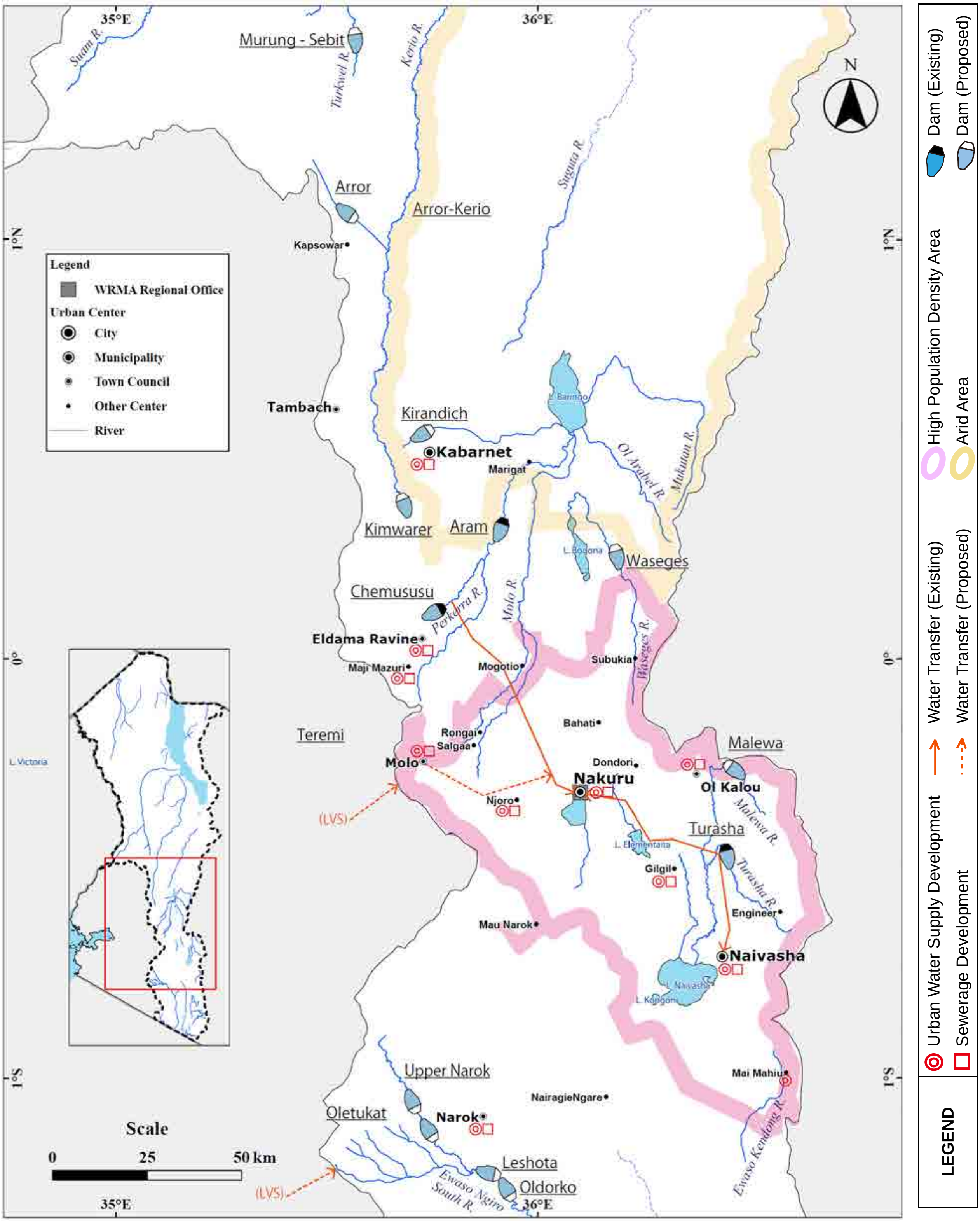
Source: JICA Study Team, based on information from environmental experts

# *Figures*



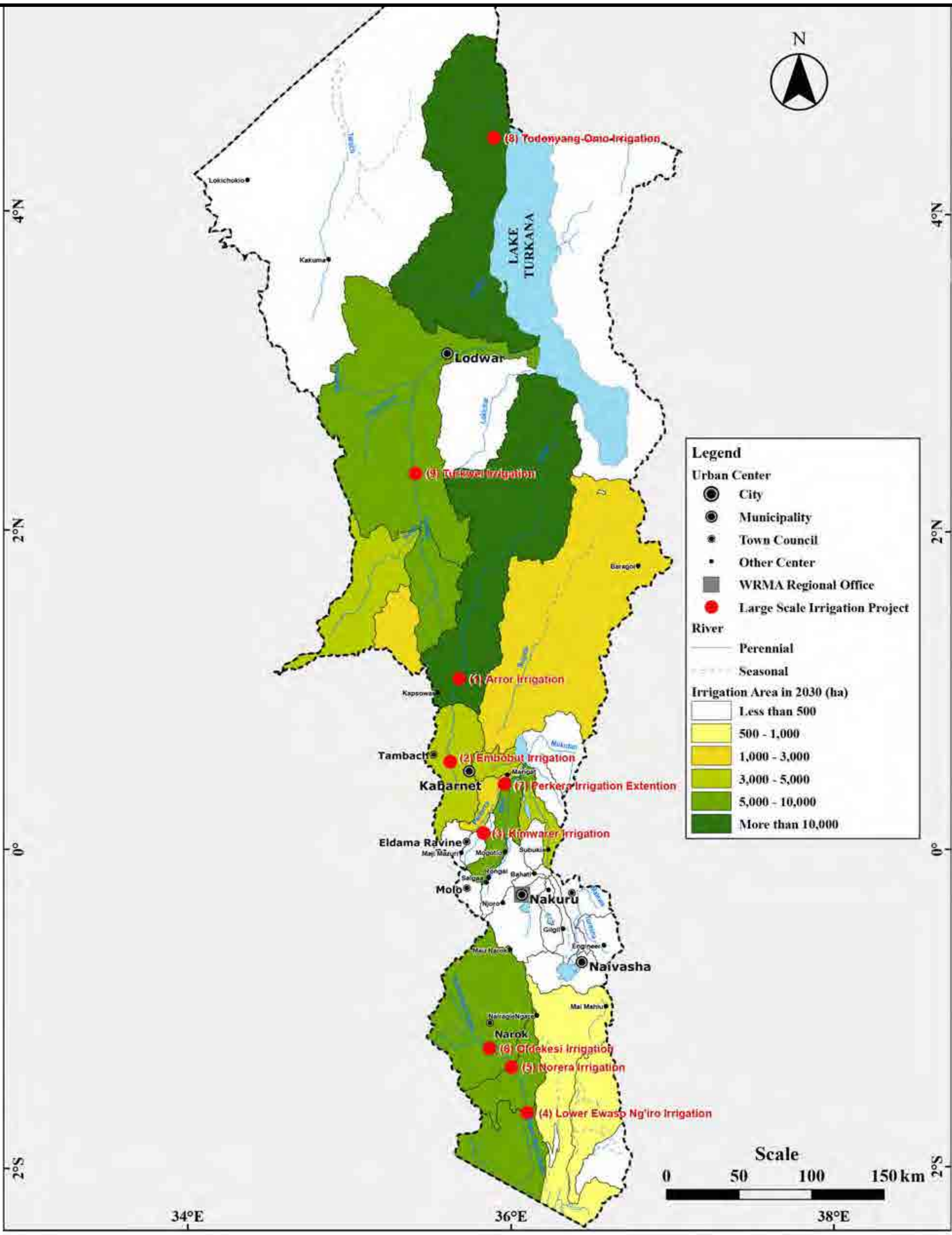

Source: JICA Study Team

| THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030 | **Figure 4.2.1 Proposed Urban Water Supply and Sewerage Development Plans (RVCA) (1/2)** |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | |



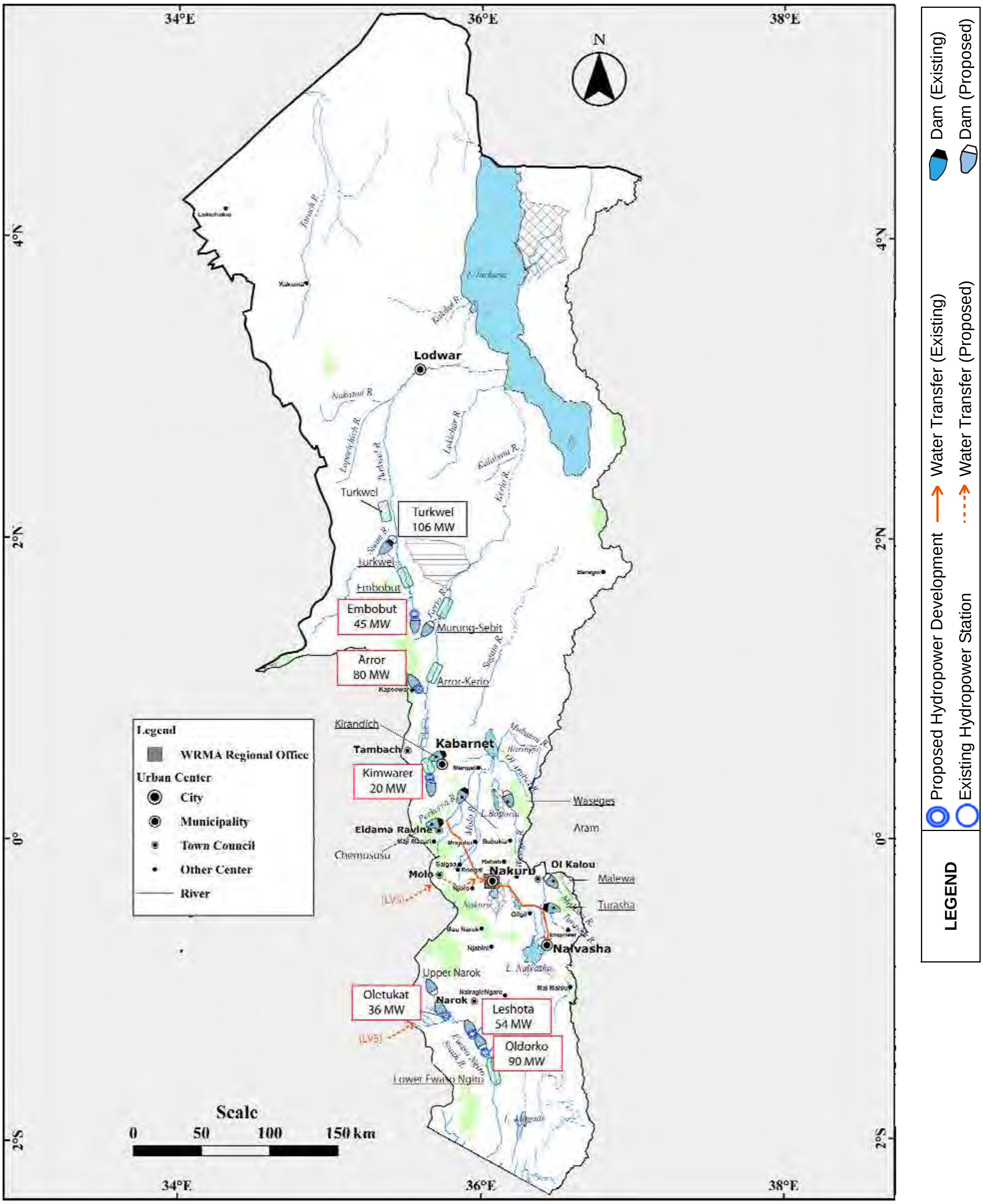

Source: JICA Study Team

| THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030 | **Figure 4.2.1** **Proposed Urban Water Supply and Sewerage Development Plans (RVCA) (2/2)** |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | |



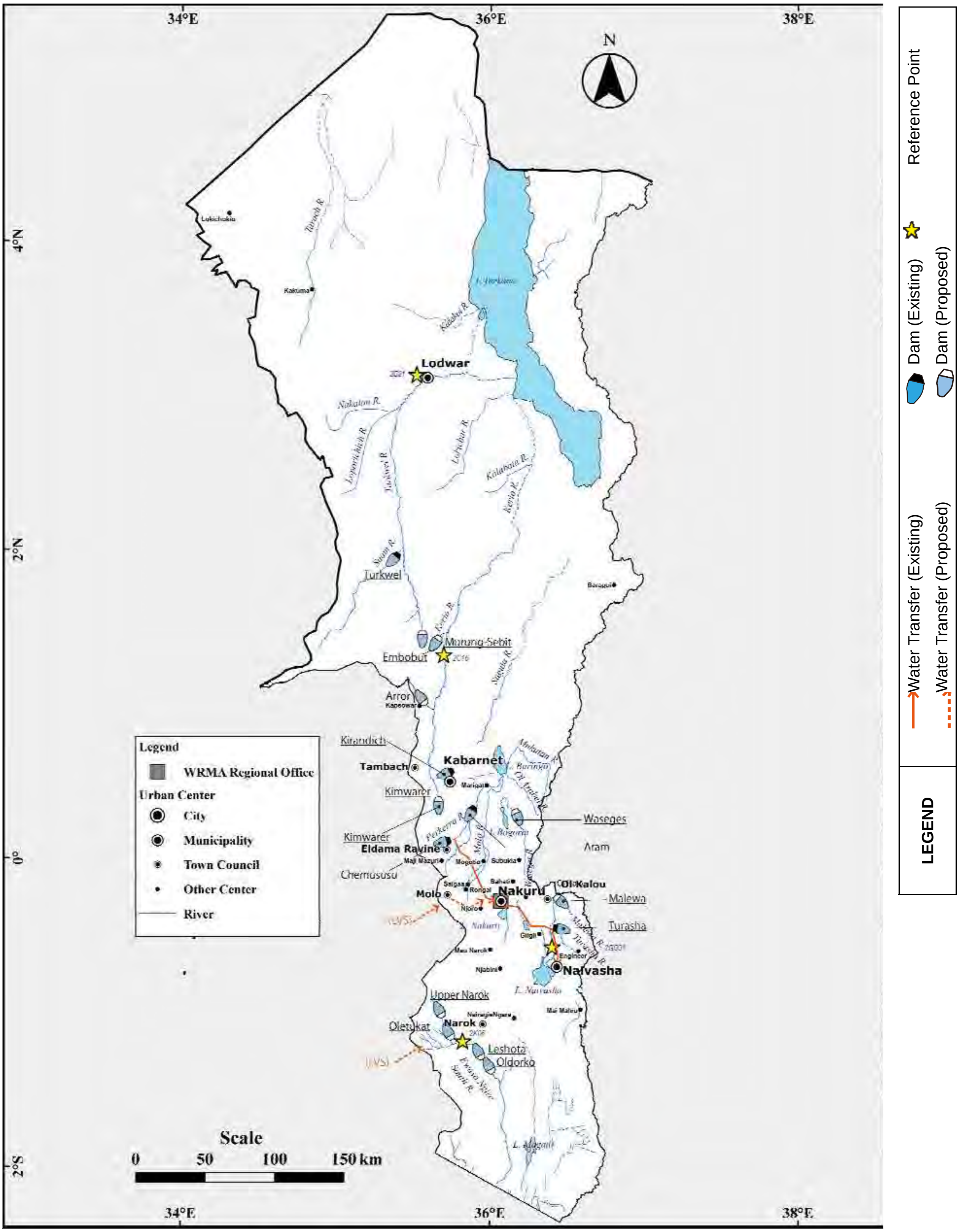

Source: JICA Study Team

| THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030 | **Figure 4.4.1 Proposed Irrigation Development Plan (RVCA)** |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | |



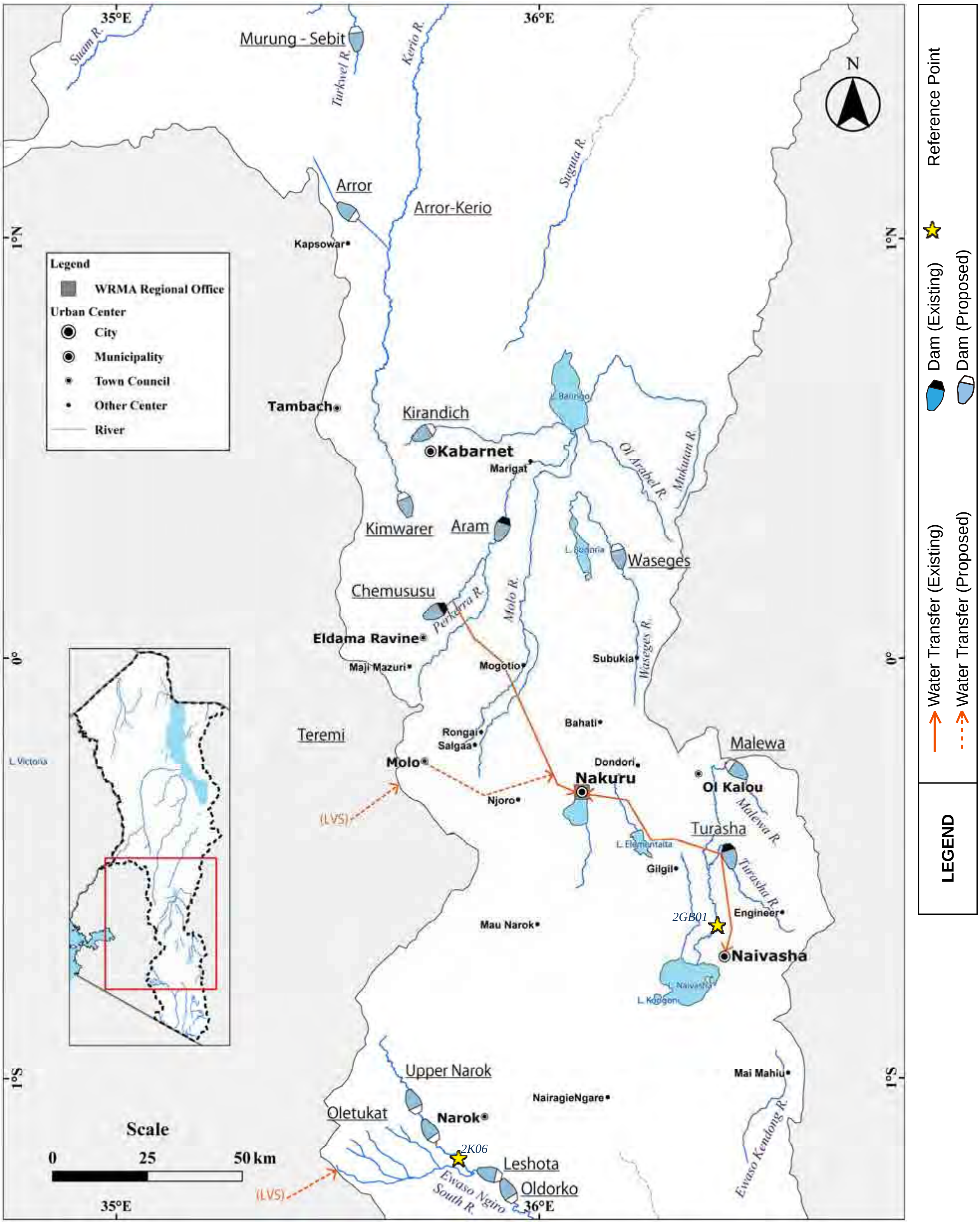

Source: JICA Study Team

| THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030 | **Figure 4.5.1** **Existing Hydropower Station and Proposed Hydropower Development Plan (RVCA)** |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | |



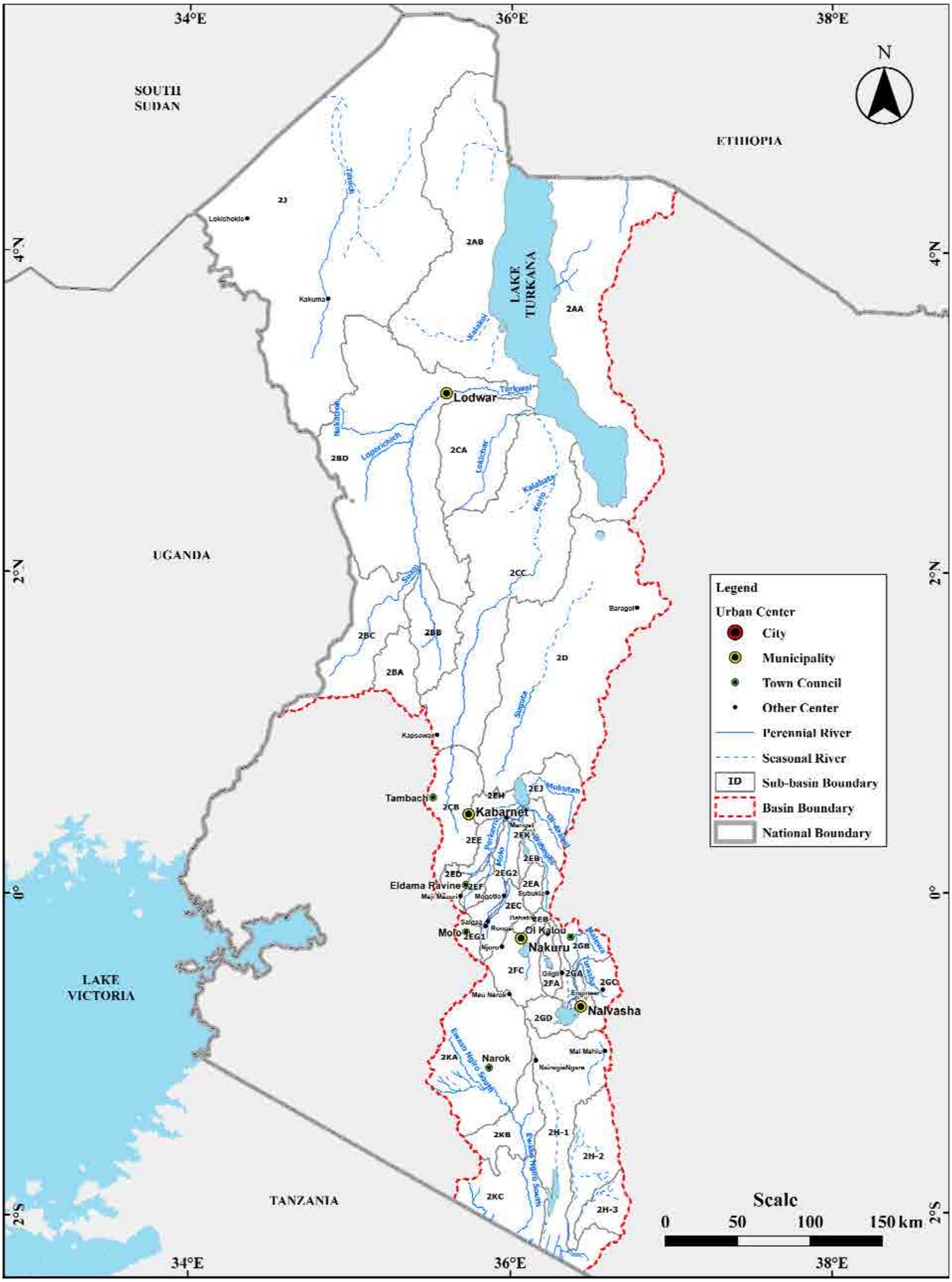

Source: JICA Study Team

| THE DEVELOPMENT OF<br>THE NATIONAL WATER MASTER PLAN 2030 | **Figure 4.6.1**<br>**Existing and Proposed Dams and Water Transfer Facilities (RVCA) (1/2)** |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | |




Source: JICA Study Team

| THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030 | **Figure 4.6.1 Existing and Proposed Dams and Water Transfer Facilities (RVCA) (2/2)** |
| --- | --- |
| JAPAN INTERNATIONAL COOPERATION AGENCY | |




Source: JICA Study Team

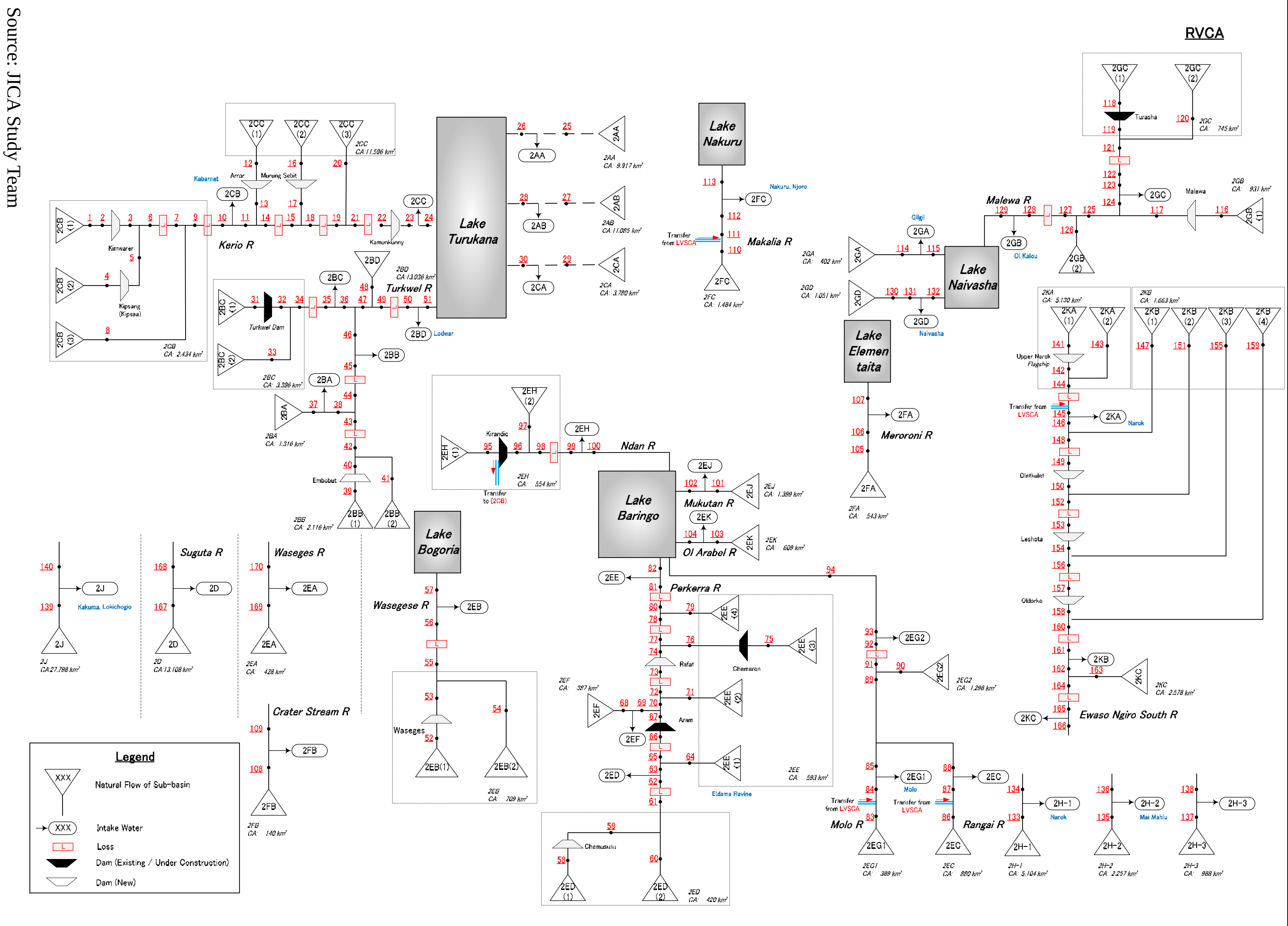
| THE DEVELOPMENT OF<br>THE NATIONAL WATER MASTER PLAN 2030 | **Figure 4.6.2**<br>**Sub-basin Division Map**<br>**(RVCA)** |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | |

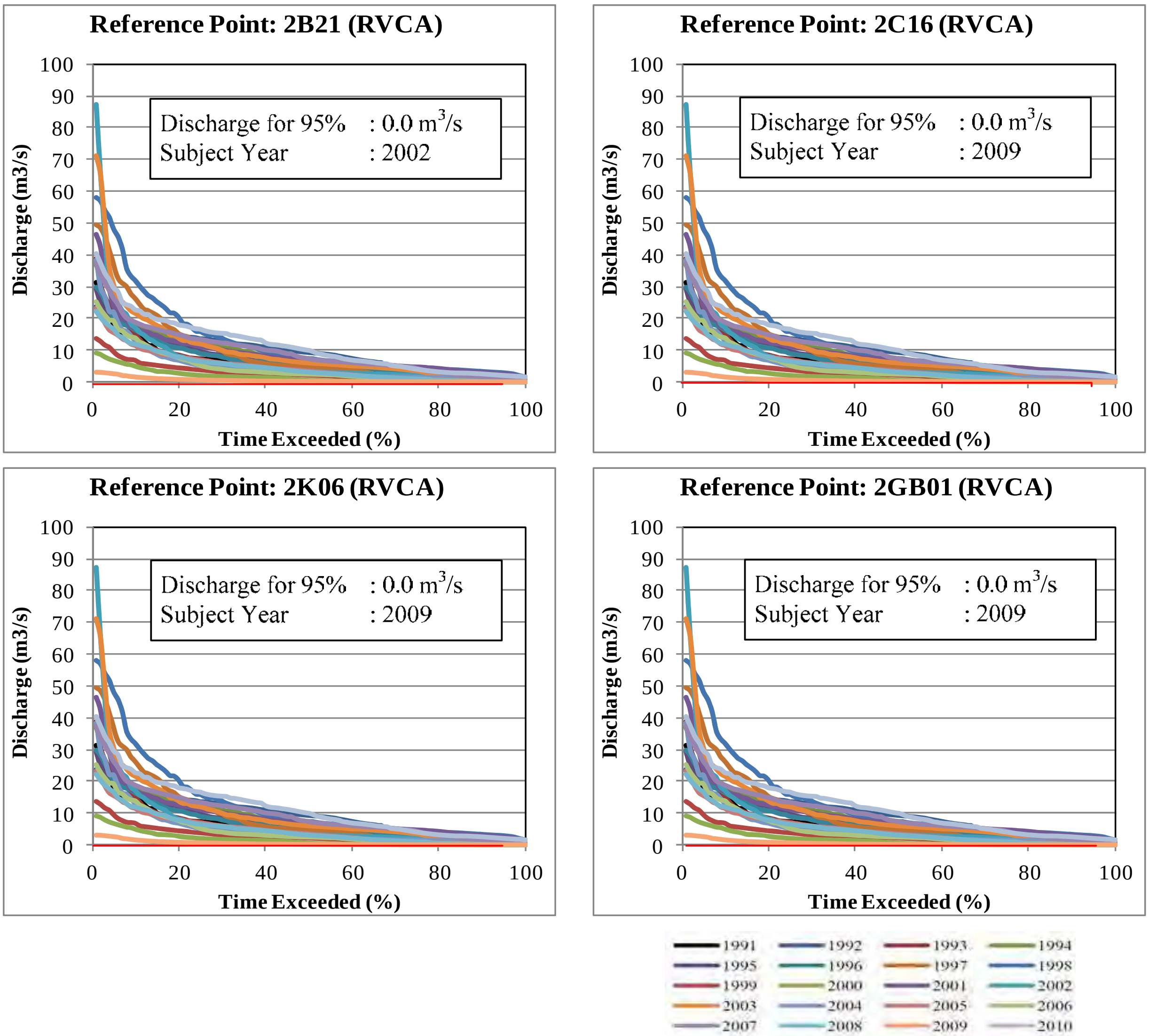
JAPAN INTERNATIONAL COOPERATION AGENCY

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030

**Figure 4.6.3 Surface Water Balance Calculation Model (RVCA)**

Source: JICA Study Team



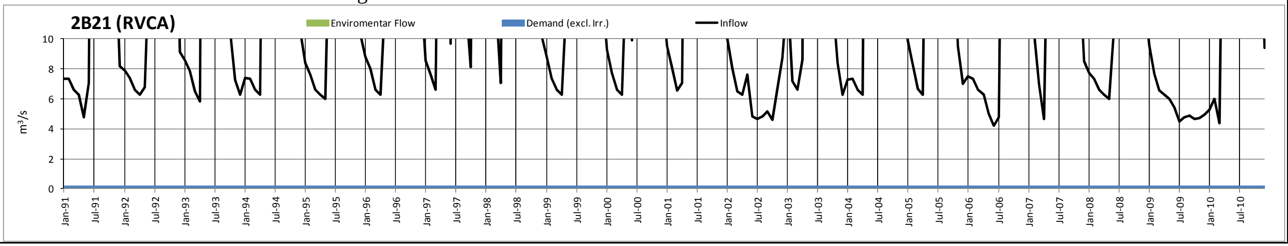



Source: JICA Study Team

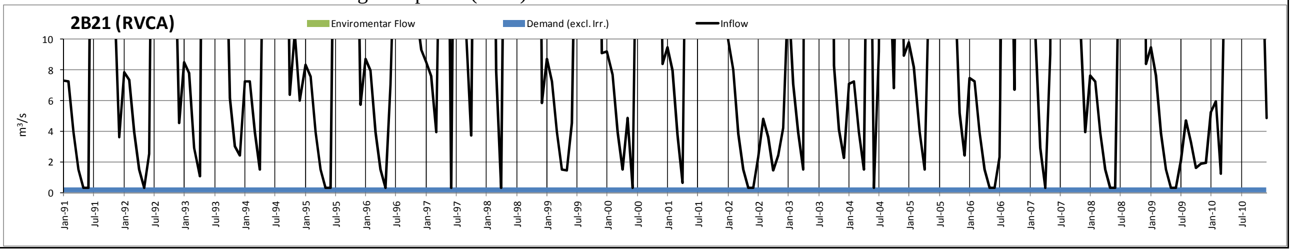
| THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030 | **Figure 4.6.4** **Simulated Flow Duration Curves for Estimate of Reserve at Reference Points (RVCA)** |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | |

River Name: Turkwel River (RVCA)
Reference Point: 2B21

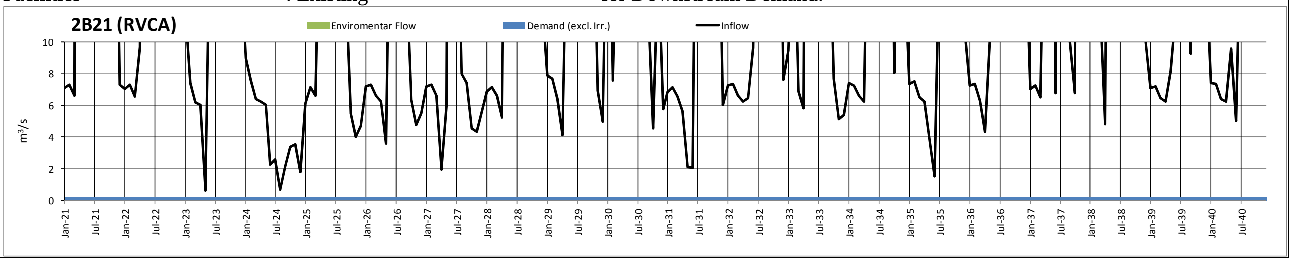
| | | | | |
|---|---|---|---|---|
| River Flow | : Present (1991-2010) | Reserve: | 0.0 | ($m^3$/s) |
| Water Demand | : 2010 | Required Discharge to be maintained | 0.3 | ($m^3$/s) |
| Facilities | : Existing | for Downstream Demand: | | |



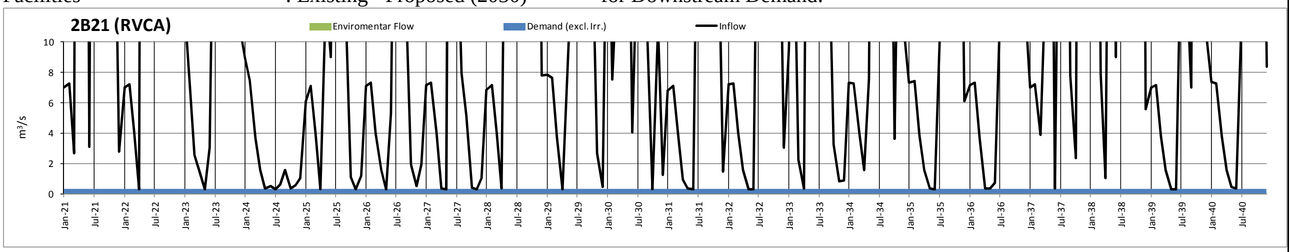

| | | | | |
|---|---|---|---|---|
| River Flow | : Present (1991-2010) | Reserve: | 0.0 | ($m^3$/s) |
| Water Demand | : 2030 | Required Discharge to be maintained | 0.3 | ($m^3$/s) |
| Facilities | : Existing +Proposed (2030) | for Downstream Demand: | | |




| | | | | |
|---|---|---|---|---|
| River Flow | : Future (2021-2040) | Reserve: | 0.0 | ($m^3$/s) |
| Water Demand | : 2010 | Required Discharge to be maintained | 0.3 | ($m^3$/s) |
| Facilities | : Existing | for Downstream Demand: | | |




| | | | | |
|---|---|---|---|---|
| River Flow | : Future (2021-2040) | Reserve: | 0.0 | ($m^3$/s) |
| Water Demand | : 2030 | Required Discharge to be maintained | 0.3 | ($m^3$/s) |
| Facilities | : Existing +Proposed (2030) | for Downstream Demand: | | |

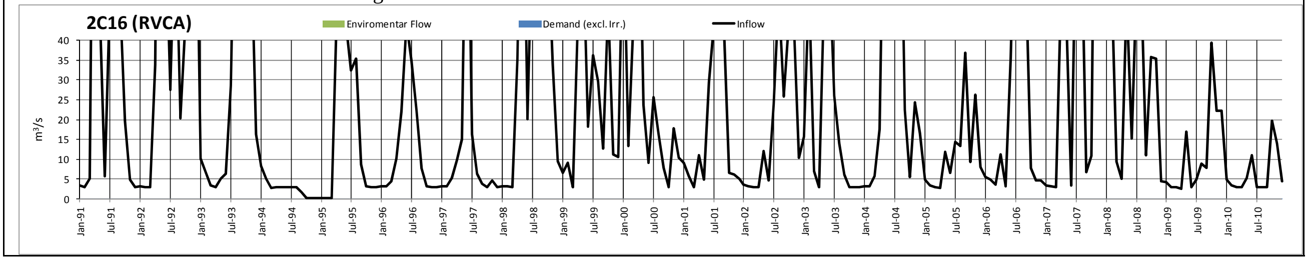



Source: JICA Study Team

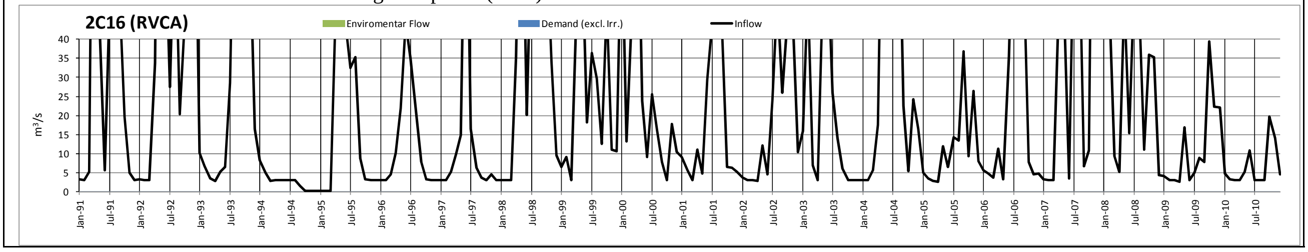
| THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030 | **Figure 4.6.5** |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | **River Flow at Reference Point 2B21 under Present and Future Water Demands and Facilities Conditions (RVCA) (1/4)** |

River Name: Kerio River (RVCA)
Reference Point: 2C16

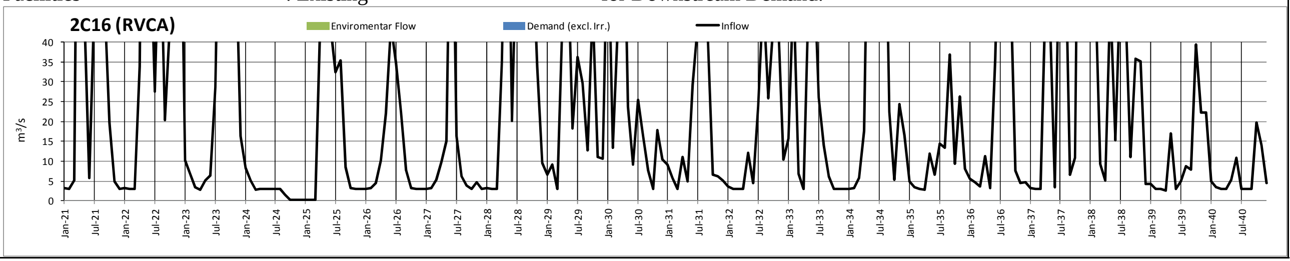
| | | | | |
|---|---|---|---|---|
| River Flow | : Present (1991-2010) | Reserve: | 0.0 | ($m^3/s$) |
| Water Demand | : 2010 | Required Discharge to be maintained | 0.1 | ($m^3/s$) |
| Facilities | : Existing | for Downstream Demand: | | |



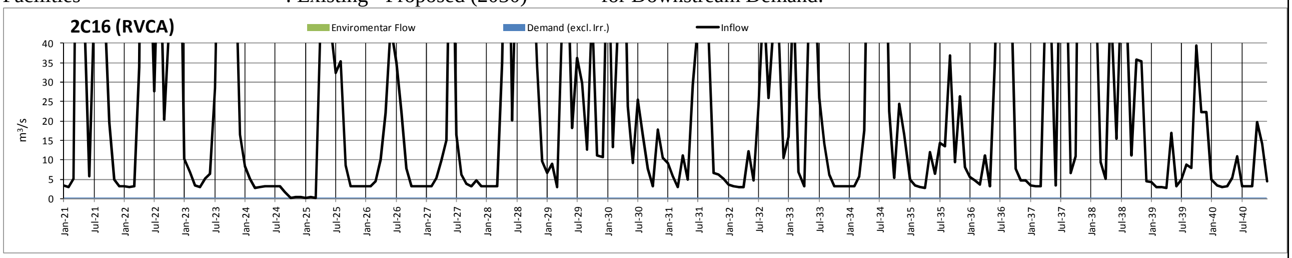

| | | | | |
|---|---|---|---|---|
| River Flow | : Present (1991-2010) | Reserve: | 0.0 | ($m^3/s$) |
| Water Demand | : 2030 | Required Discharge to be maintained | 0.1 | ($m^3/s$) |
| Facilities | : Existing +Proposed (2030) | for Downstream Demand: | | |




| | | | | |
|---|---|---|---|---|
| River Flow | : Future (2021-2040) | Reserve: | 0.0 | ($m^3/s$) |
| Water Demand | : 2010 | Required Discharge to be maintained | 0.1 | ($m^3/s$) |
| Facilities | : Existing | for Downstream Demand: | | |




| | | | | |
|---|---|---|---|---|
| River Flow | : Future (2021-2040) | Reserve: | 0.0 | ($m^3/s$) |
| Water Demand | : 2030 | Required Discharge to be maintained | 0.1 | ($m^3/s$) |
| Facilities | : Existing +Proposed (2030) | for Downstream Demand: | | |




Source: JICA Study Team

THE DEVELOPMENT OF
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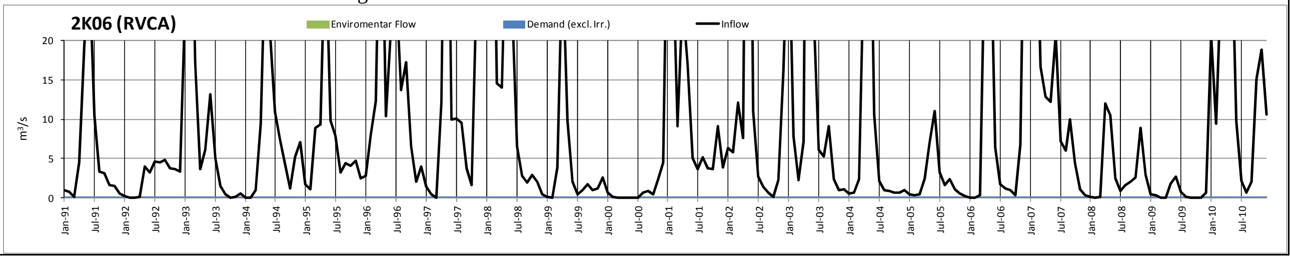
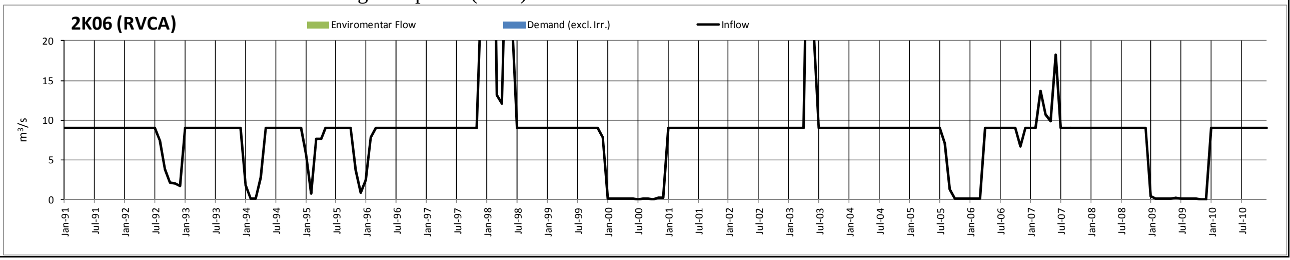
**Figure 4.6.5**
**River Flow at Reference Point 2C16 under Present and Future Water Demands and Facilities Conditions (RVCA) (2/4)**

River Name: Ewaso Ng'iro South River (RVCA)
Reference Point: 2K06

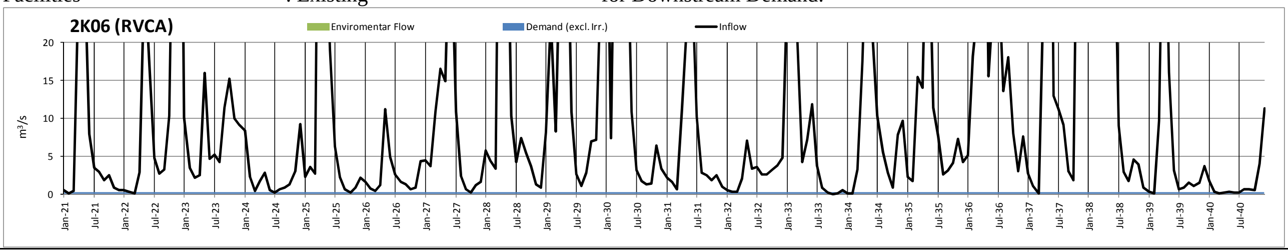
| | | | | |
|---|---|---|---|---|
| River Flow | : Present (1991-2010) | Reserve: | 0.0 | ($m^3/s$) |
| Water Demand | : 2010 | Required Discharge to be maintained | | |
| Facilities | : Existing | for Downstream Demand: | 0.1 | ($m^3/s$) |



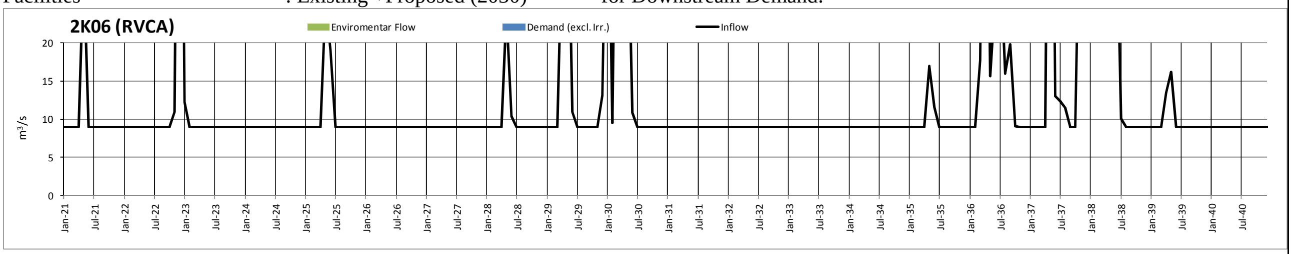

| | | | | |
|---|---|---|---|---|
| River Flow | : Present (1991-2010) | Reserve: | 0.0 | ($m^3/s$) |
| Water Demand | : 2030 | Required Discharge to be maintained | | |
| Facilities | : Existing +Proposed (2030) | for Downstream Demand: | 0.1 | ($m^3/s$) |




| | | | | |
|---|---|---|---|---|
| River Flow | : Future (2021-2040) | Reserve: | 0.0 | ($m^3/s$) |
| Water Demand | : 2010 | Required Discharge to be maintained | | |
| Facilities | : Existing | for Downstream Demand: | 0.1 | ($m^3/s$) |




| | | | | |
|---|---|---|---|---|
| River Flow | : Future (2021-2040) | Reserve: | 0.0 | ($m^3/s$) |
| Water Demand | : 2030 | Required Discharge to be maintained | | |
| Facilities | : Existing +Proposed (2030) | for Downstream Demand: | 0.1 | ($m^3/s$) |



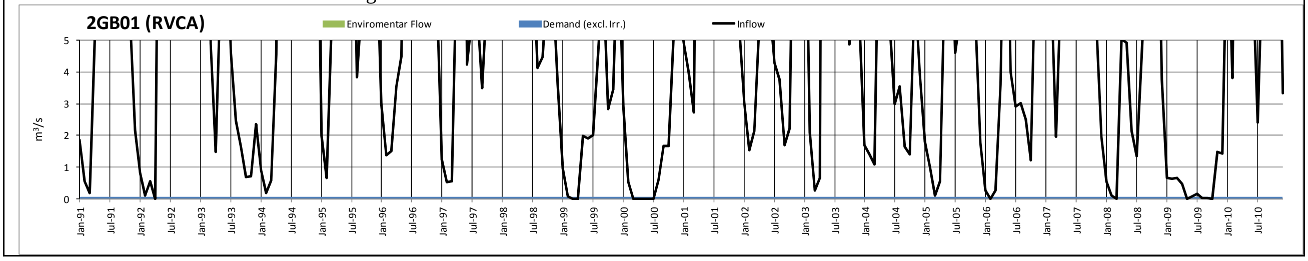

Note: Hydropower discharge is constant from the proposed Oletukat Dam.

Source: JICA Study Team

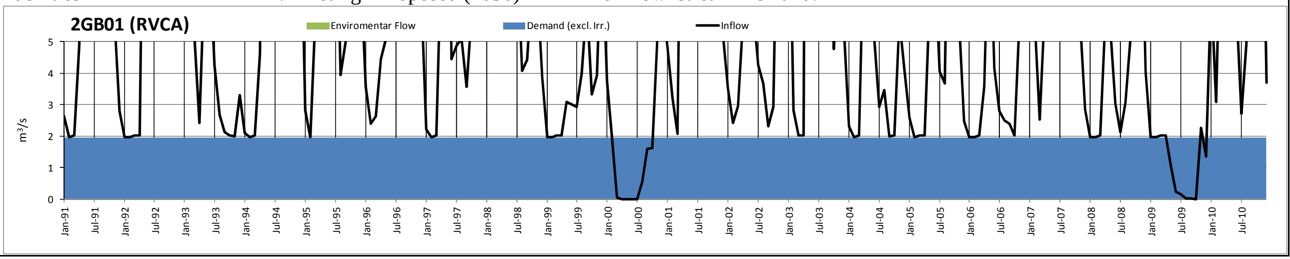
| | |
|---|---|
| **THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030** | **Figure 4.6.5** **River Flow at Reference Point 2K06 under Present and Future Water Demands and Facilities Conditions (RVCA) (3/4)** |
| **JAPAN INTERNATIONAL COOPERATION AGENCY** | |

River Name: Malewa River (RVCA)
Reference Point: 2GB01

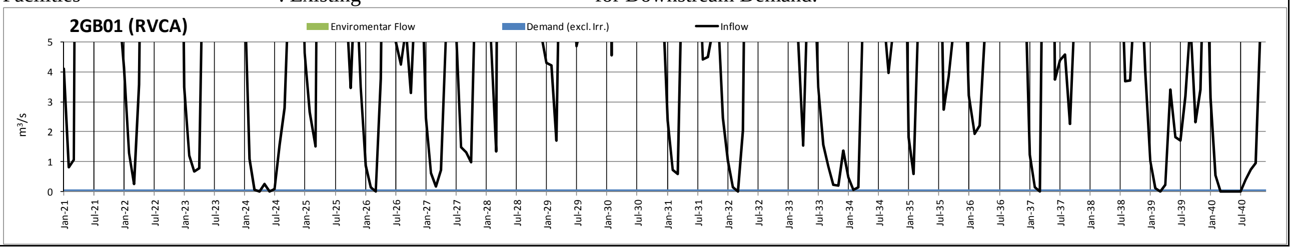
| | | | | |
|---|---|---|---|---|
| River Flow | : Present (1991-2010) | Reserve: | 0.0 | ($m^3$/s) |
| Water Demand | : 2010 | Required Discharge to be maintained | | |
| Facilities | : Existing | for Downstream Demand: | 0.1 | ($m^3$/s) |



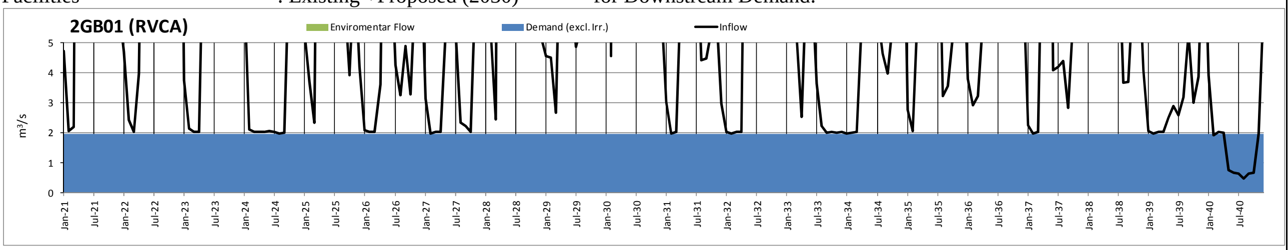

| | | | | |
|---|---|---|---|---|
| River Flow | : Present (1991-2010) | Reserve: | 0.0 | ($m^3$/s) |
| Water Demand | : 2030 | Required Discharge to be maintained | | |
| Facilities | : Existing +Proposed (2030) | for Downstream Demand: | 2.0 | ($m^3$/s) |




| | | | | |
|---|---|---|---|---|
| River Flow | : Future (2021-2040) | Reserve: | 0.0 | ($m^3$/s) |
| Water Demand | : 2010 | Required Discharge to be maintained | | |
| Facilities | : Existing | for Downstream Demand: | 0.1 | ($m^3$/s) |

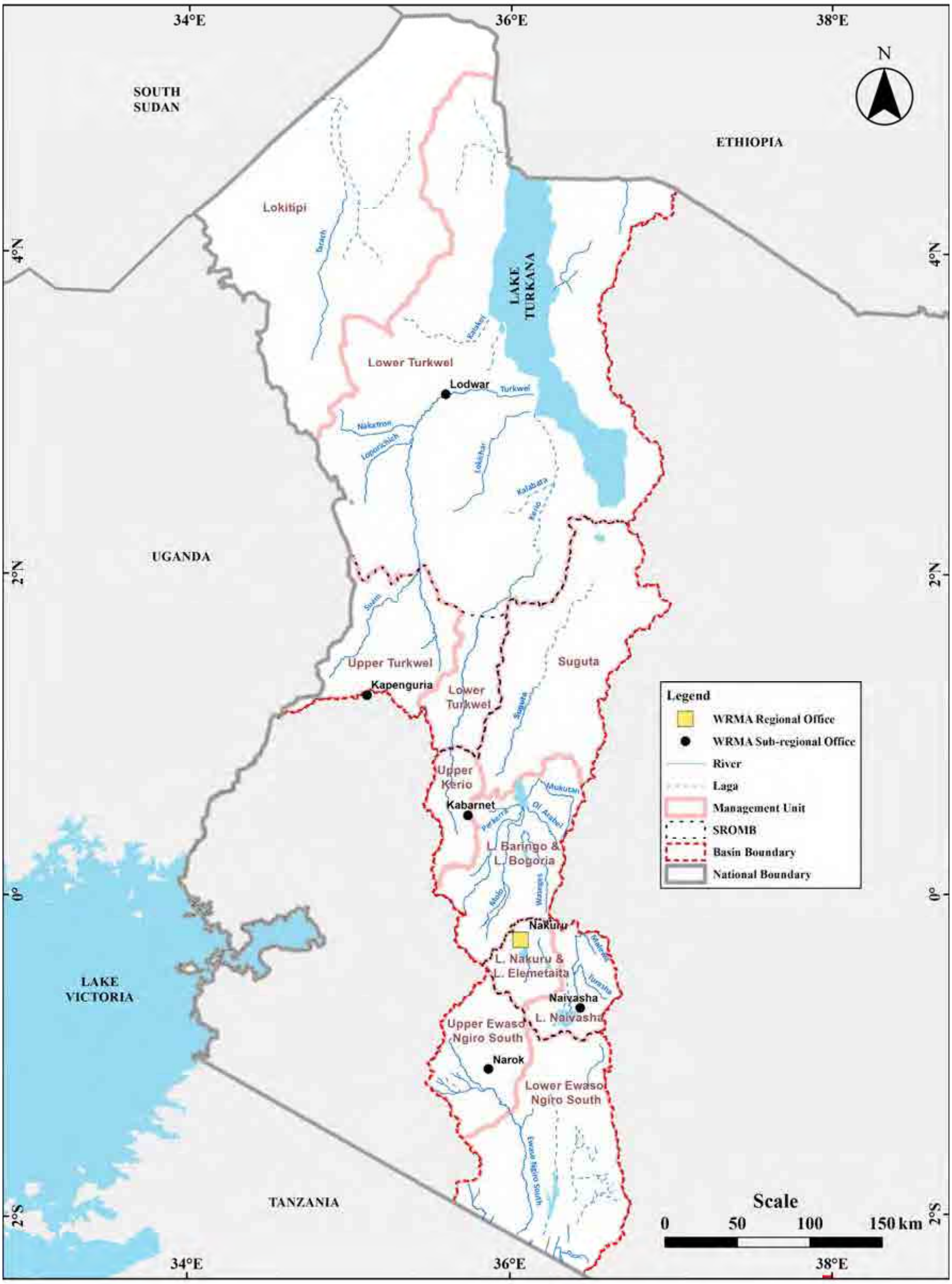



| | | | | |
|---|---|---|---|---|
| River Flow | : Future (2021-2040) | Reserve: | 0.0 | ($m^3$/s) |
| Water Demand | : 2030 | Required Discharge to be maintained | | |
| Facilities | : Existing +Proposed (2030) | for Downstream Demand: | 2.0 | ($m^3$/s) |



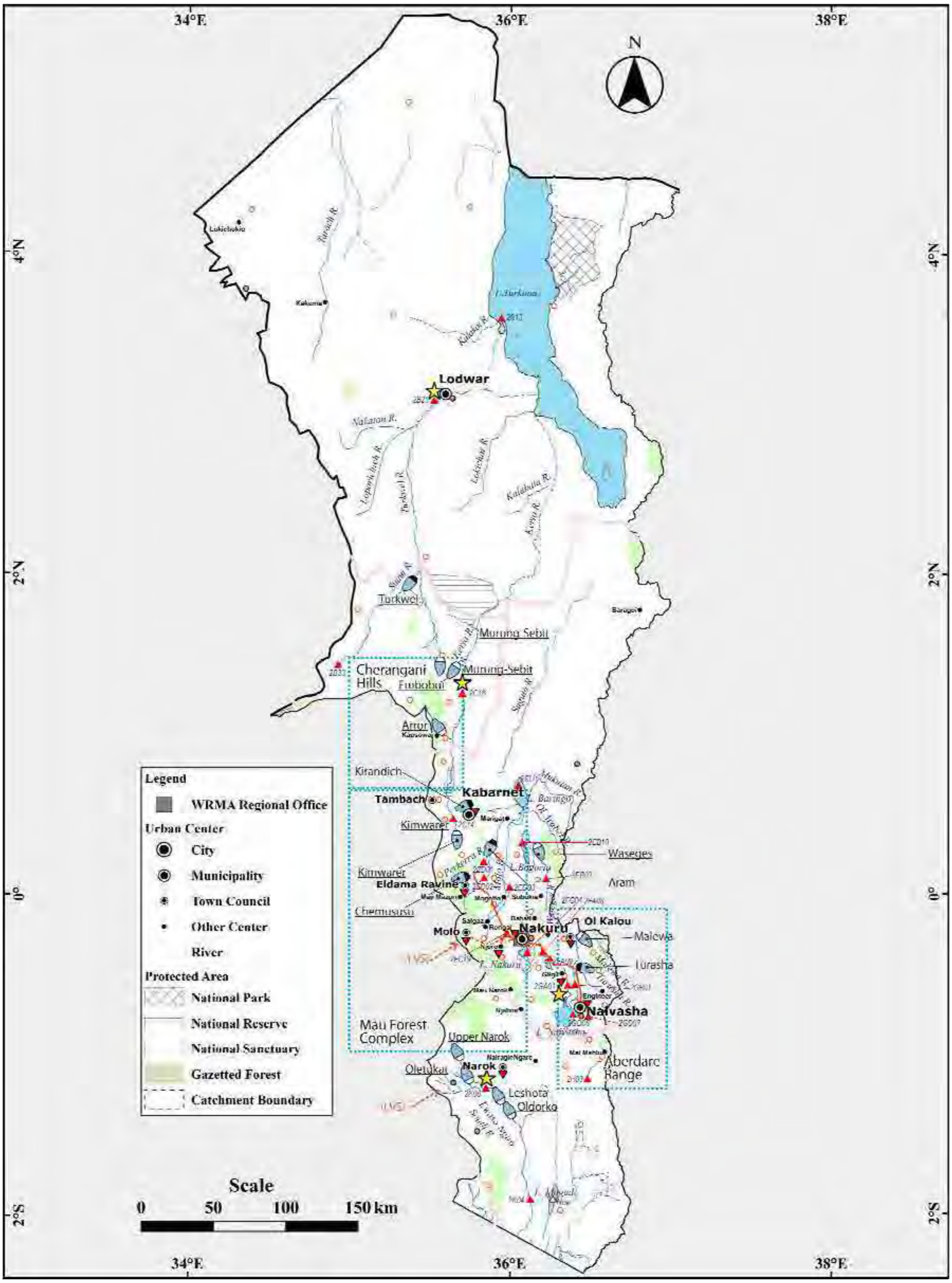

Source: JICA Study Team

| | |
|---|---|
| **THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030** | **Figure 4.6.5** |
| **JAPAN INTERNATIONAL COOPERATION AGENCY** | **River Flow at Reference Point 2GB01 under Present and Future Water Demands and Facilities Conditions (RVCA) (4/4)** |




Source: JICA Study Team

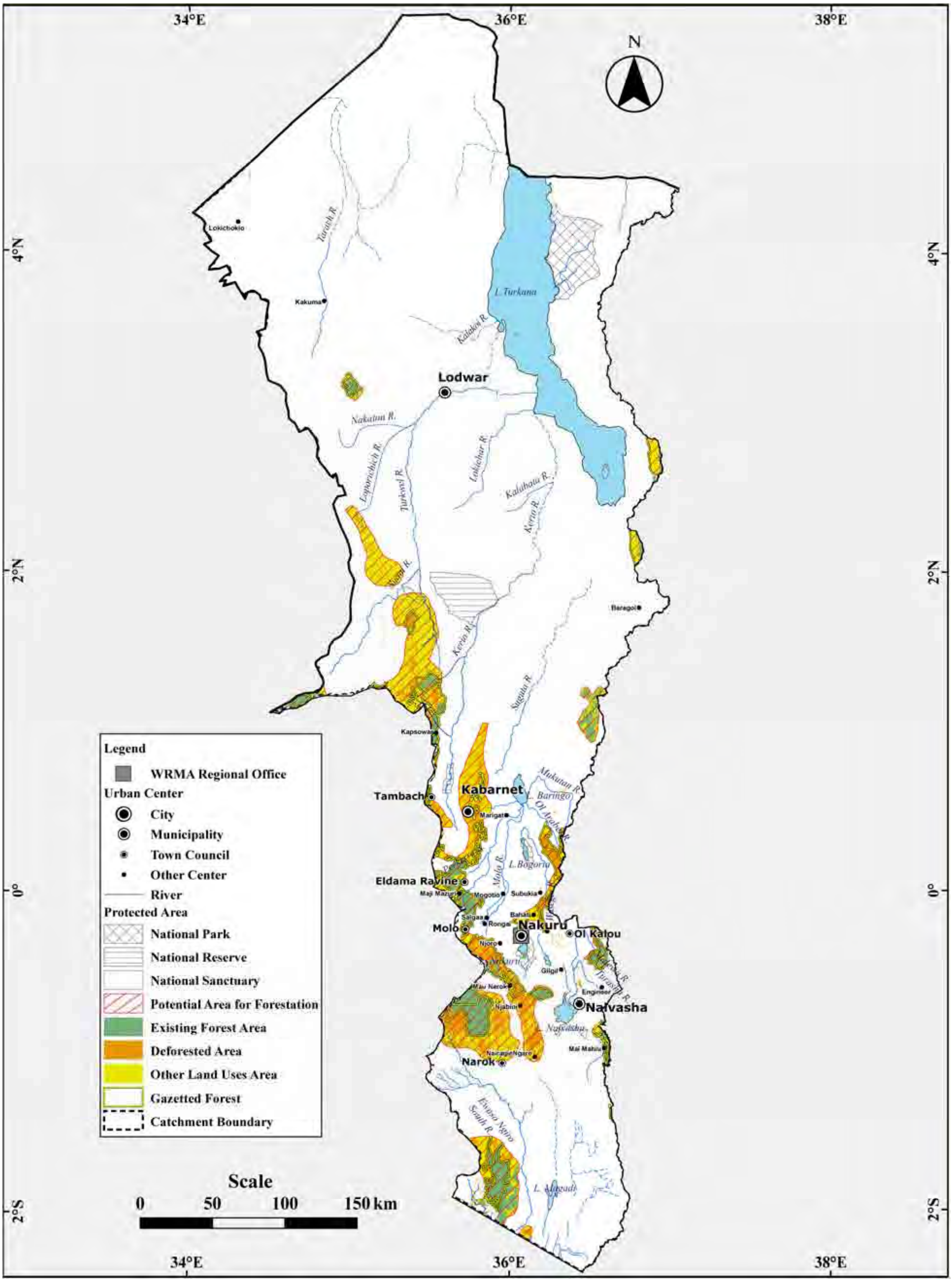
| THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030 | **Figure 4.7.1** **Rivers and Boundaries for Administration (RVCA)** |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | |




| LEGEND | Surface Water Monitoring Station<br>Existing / Newly Proposed | 23 locations | Groundwater Monitoring Station<br>Proposed Monitoring Station | 10 locations |
|---|---|---|---|---|
| | Rainfall Monitoring Station<br>Existing / Newly Proposed | 47 locations | Reference Point<br>Proposed Reference Point | 4 locations |

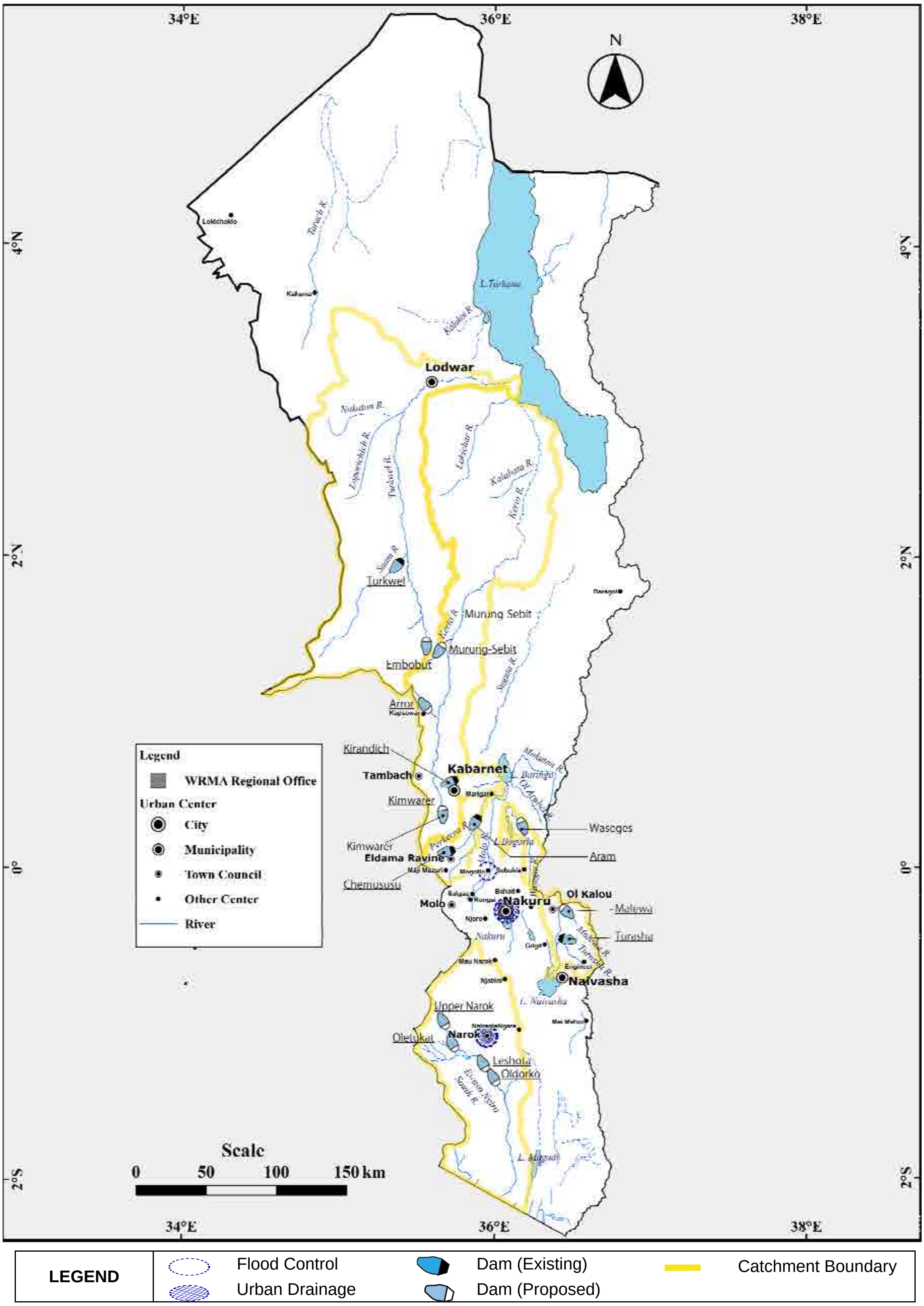
Source: JICA Study Team

| THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030 | **Figure 4.7.2 Proposed Monitoring Stations for Water Resources Management (RVCA)** |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | |




Source: JICA Study Team, based on satellite images

| THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030 | **Figure 4.7.3 Current Situation of Forest Areas and Potential Forestation Areas (RVCA)** |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | |



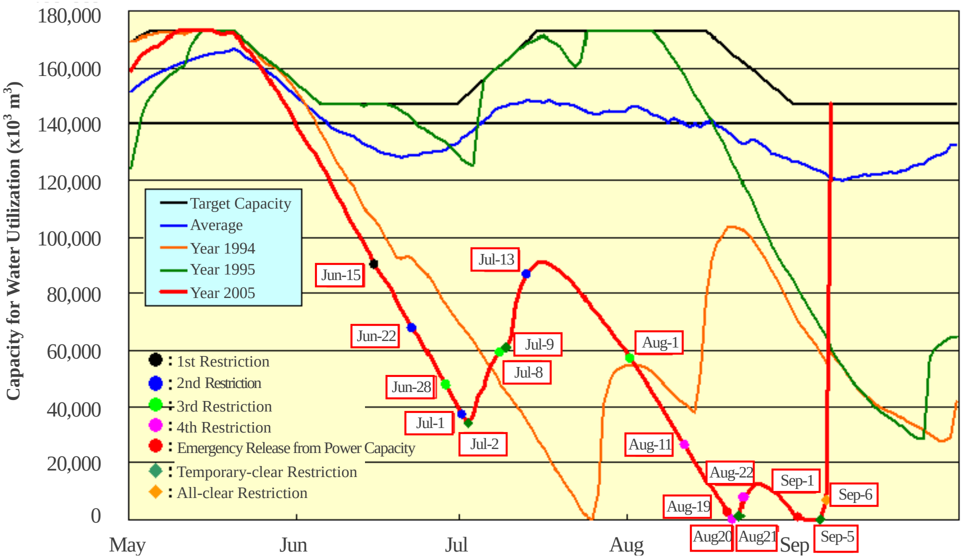

Note: The yellow line shows the boundaries of river basin unit for establishment of Basin Drought Conciliation Council in drought disaster management plan.

Source: JICA Study Team

| THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030 | **Figure 4.8.1** **Proposed Flood and Drought Disaster Management Plan (RVCA)** |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | |

## Flow of Water Use Restriction of the Sameura Dam in 2005 Drought

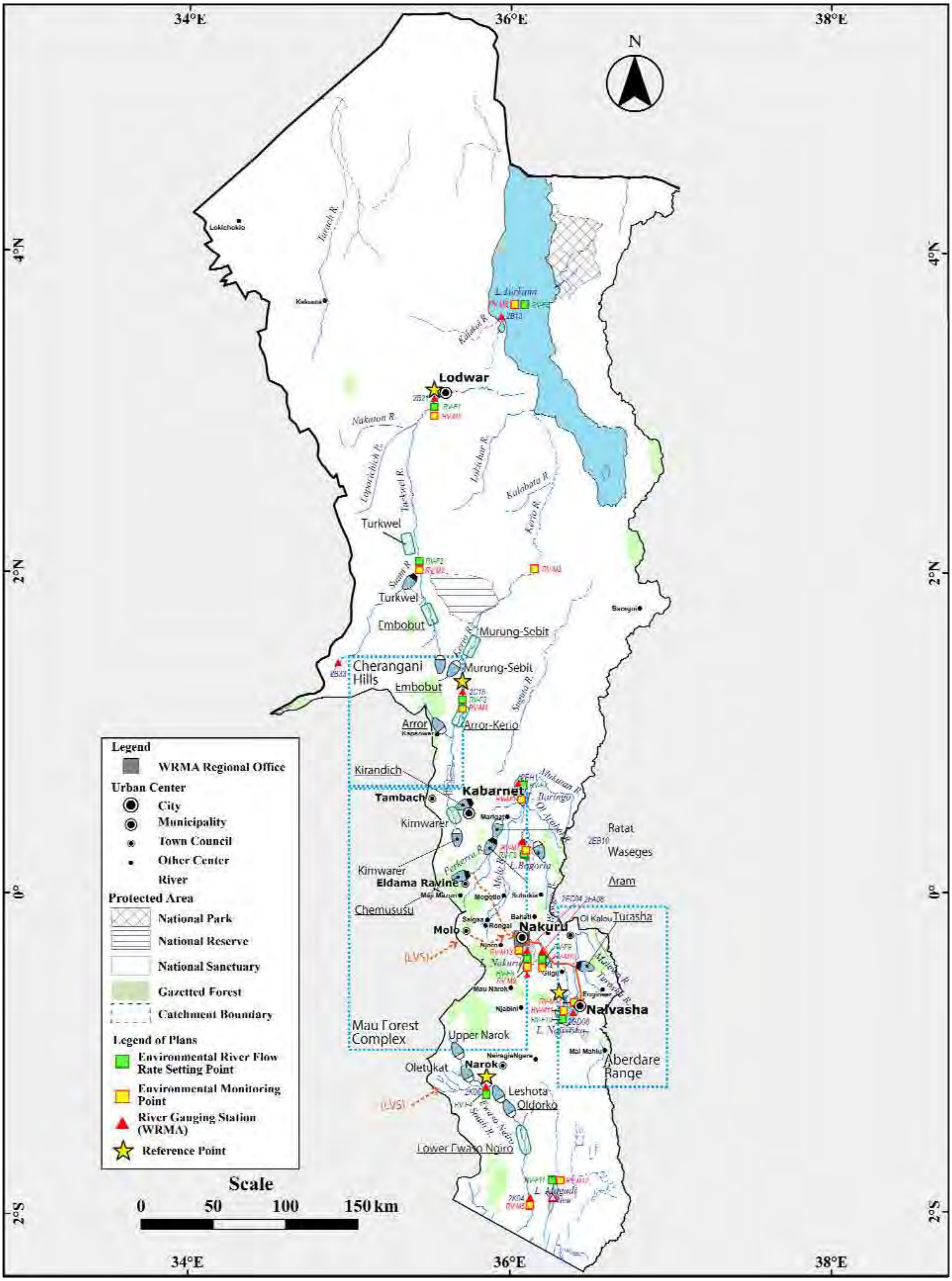
| Date | Reserve | Water Use Restriction | Organizational Arrangement |
|---|---|---|---|
| May 26 | 96.40% | | 15:00 Setting up a head office of special task force for water restriction in Shikoku Regional Development Bureau (a)<br>15:00 Setting up a branch office of special task force for water restriction 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<br>[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<br>[Tokushima 15.9% (new 35%), Kagawa 35%] | |
| Jun 28 | 32.40% | 9:00 The third water restriction<br>[Tokushima 17.6% (new 50%), Kagawa 50%] | |
| Jul 1 | 25.10% | 22:00 Ease the second water restriction<br>[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<br>[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<br>[Tokushima 17.2% (new 35%), Kagawa 35%] | |
| Aug 1 | 32.90% | 9:00 The third water restriction<br>[Tokushima 19.0% (new 50%), Kagawa 50%] | |
| Aug 11 | 15.10% | 9:00 The forth water restriction<br>[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<br>[Tokushima 1.85 $m^3/s$, Kagawa 1.81 $m^3/s$] | |
| Aug 20 | 0.00% | 22:00 Temporary ease the forth water restriction<br>[Tokushima 22.0% (new 75%), Kagawa 75%]<br>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<br>[Tokushima 22.4% (new 75%), Kagawa 75%] | |
| Sep 1 (8:00) | 0.5% (0.0%) | 8:00 Start emergency release from power generation capacity<br>[Tokushima 1.85$m^3/s$, Kagawa 1.81$m^3/s$] | |
| Sep 5 | 0.00% | 5:00 Stop emergency release from power generation capacity<br>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)<br>18:00 Breaking up the office (d)<br>18:00 Breaking up the office (c)<br>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 4.8.2**<br>**Example for Water Use Restriction of Sameura Dam in 2005 Drought** |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | |




Source: JICA Study Team

| THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030 | **Figure 4.9.1 Proposed Environmental Management Plan (RVCA)** |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | |

| WRMA Catchment | No. | Name of Project | Project Status | Capacity to be developed ($m^3$/day) Total | Initial Develop. | Ratio | Implementation Schedule: Short Term (2013–2017; 13/14–17/18) | Medium Term (2018–2022; 18/19–22/23) | Long Term (2023–2030; 23/24–30/31) |
|---|---|---|---|---|---|---|---|---|---|
| RV | 1 | Greater Nakuru Area | | | | | Itare Dam | Londiani Dam; Transmission from Itare Dam and Londiani Dam | Malewa Dam (for Naivasha) |
| | | Nakuru, Naivasha, Molo, Gilgil, Njoro, Eldama Ravine (6UC) | WSB, F/S | 192,374 | 100,000 | 52% | | | |
| | 2 | Kabarnet | WSB, F/S | 1,221 | 1,221 | 100% | | | |
| | 3 | Ol Kalou | WSB, MTP | 34,858 | 10,000 | 29% | | | |
| | 4 | Narok | WSB, MTP | 21,274 | 4,600 | 22% | Upper Narok Dam | | |
| | 5 | Lodwar | MTP | 4,018 | 1,205 | 30% | | | |
| | 6 | Mai Mahiu | - | 6,984 | 2,095 | 30% | | | |
| | 7 | Kakuma | - | 5,408 | 1,622 | 30% | | | |
| | 8 | Lokichogio | - | 2,595 | 779 | 30% | | | |
| | Rehabilitation for 11 Urban Centres | | | | | | | | |
| | Total Urban Water Supply Projects | | | 268,732 | 121,522 | 45% | 322.6 | 435.6 | 420.8 |
| | Water Resources Development for Rural Water Supply | | | | | | | Arror Dam; Oletukat Dam; Leshota Dam; Kimwarer Dam; Embobut Dam | Oldorko Dam; Waseges Dam |
| | Rural Water Supply Projects in RVCA | | | | | | | | |

Note: As for “Project Status”, “WSB” means a project proposed by WSB, “MTP” means a flagship project proposed in the First Medium Term Plan (2008 – 2019) of Kenya Vision 2030, and “F/S” means a project proposed in completed F/S.

Source: JICA Study Team

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**Figure 7.3.1**
**Implementation Schedule of Proposed Water Supply System Development Plan (RVCA)**

| WRMA Catchment | No. | Urban Centre | F/S Status | Capacity to be developed ($m^3$/day) | | | Implementation Schedule | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Short Term | | | | | Medium Term | | | | | Long Term | | | | | | | |
| | | | | Total | Initial Develop. | Ratio | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
| | | | | | | | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 | 19/20 | 20/21 | 21/22 | 22/23 | 23/24 | 24/25 | 25/26 | 26/27 | 27/28 | 28/29 | 29/30 | 30/31 |
| RV | 1 | Kabarnet | WSB, D/D (additional) | 2,380 | 2,380 | 100% | | ■ | ■ | ■ | | | | | | | | | | | | | | |
| RV | 2 | Nakuru | WSB, F/S | 71,871 | 70,000 | 97% | | | | ■ | ■ | ■ | | | | | | ■ | ■ | ■ | | | | |
| RV | 3 | Eldama Ravine | WSB, F/S (additional) | 6,855 | 6,855 | 100% | | | | ■ | ■ | ■ | | | | | | | | | | | | |
| RV | 4 | Naivasha | WSB | 63,946 | 12,000 | 19% | | | | | | ■ | ■ | ■ | | | | | | ■ | ■ | ■ | | |
| RV | 5 | Ol Kalou | WSB, MTP | 25,322 | 7,000 | 28% | | | | | | | ■ | ■ | ■ | | | | | | ■ | ■ | ■ | |
| RV | 6 | Molo | WSB | 14,333 | 4,300 | 30% | | | | | | | ■ | ■ | ■ | | | | | | ■ | ■ | ■ | |
| RV | 7 | Narok | WSB, MTP | 14,826 | 3,220 | 22% | | | | | ■ | ■ | ■ | | | | | | | | | ■ | ■ | ■ |
| RV | 8 | Gilgil | _ | 13,538 | 4,061 | 30% | | | | | | | | ■ | ■ | ■ | | | | | | ■ | ■ | ■ |
| RV | 9 | Njoro | _ | 9,034 | 9,034 | 100% | | | | | | | | ■ | ■ | ■ | | | | | | | | |
| RV | Rehabilitation Works for 3 Urban Centres | | | | | | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | | |
| RV | Total | | | 222,105 | 118,850 | 54% | | | | | | | | | | | | | | | | | | |

Note: As for "Project Status", "WSB" means a project proposed by WSB, "MTP" means a flagship project proposed in the First Medium Term Plan (2008 – 2019) of Kenya Vision 2030, and "F/S" means a project proposed in completed F/S.

Source: JICA Study Team

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**Figure 7.3.2**
**Implementation Schedule of Proposed Sewerage System Development Plan (RVCA)**

| No | Name of Project | County | Irrigation Area (ha) | Multi-purpose Dam | Short Term (2013–2017; 13/14–17/18) | Medium Term (2018–2022; 18/19–22/23) | Long Term (2023–2030; 23/24–30/31) |
|---|---|---|---|---|---|---|---|
| **A. Large Scale Irrigation Project (New)** | | | | | | | |
| 1 | Perkera Irrigation Extention | Baringo | 3,000 | - | P | | |
| 2 | Turkwel Irrigation | West Pokot | 5,000 | Turkwel | *Dam (Existing)* P | | |
| 3 | Arror Irrigation | Elgeyo Marakwet | 10,850 | Arror | P | *Dam* | |
| 4 | Norera Irrigation | Narok | 2,000 | Upper Narok | P | *Dam* | |
| 5 | Lower Ewaso Ng'iro Irrigation | Kajiado | 15,000 | Oldorko/ Oletukat | | P | *Dam* |
| 6 | Todonyang-Omo Irrigation | Turkana | 35,000 | Gibe 3 Ethiopia | *Dam (in Ethiopia)* | P | |
| 7 | Kimwarer Irrigation | Baringo | 2,000 | Kimwarer | | | P *Dam* |
| 8 | Oldekesi Irrigation | Narok | 2,000 | - | | | P |
| 9 | Embobut Irrigation | Elgeyo Marakwet | 2,000 | Embobut | | | P *Dam* |
| | On-going Weir Irrigation | | 2,000 | | | | |
| | Total | | 78,850 | | 2,000 | 17,850 | 59,000 |
| **B. Small Scale Irrigation Project (New)** | | | | | | | |
| 1 | Weir Irrigation | | 5,335 | | 1,067 | 1,601 | 2,667 |
| 2 | Dam Irrigation | | 0 | | 0 | 0 | 0 |
| 3 | Small Dam/Pond/Water Pan Irrigation | | 2,890 | | 578 | 867 | 1,445 |
| 4 | Groundwater Irrigation | | 1,046 | | 209 | 314 | 523 |
| | **Total for B** | | 9,271 | | 1,854 | 2,782 | 4,635 |
| **C. Private Irrigation Project (New)** | | | | | | | |
| 1 | Weir Irrigation | | 3,000 | | 600 | 900 | 1,500 |
| 2 | Groundwater Irrigation | | 1,045 | | 209 | 314 | 522 |
| | **Total for C** | | 4,045 | | 809 | 1,214 | 2,022 |
| | **Total for RVCA** | | 92,166 | | 4,663 | 21,846 | 65,657 |

Note:
- F/S and/or D/D
- P Procurement
- Construction of Irrigation System
- Construction of Multipurpose Dam

Source: JICA Study Team

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**Figure 7.3.3 Implementation Schedule of Proposed Irrigation Development Plan (RVCA)**

| WRMA Catchment | No | Name of Project | Purpose | Installed Capacity (MW) | Project Status | Implementation Schedule | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Short Term | | | | | Medium Term | | | | | Long Term | | | | | | | |
| | | | | | | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
| | | | | | | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 | 19/20 | 20/21 | 21/22 | 22/23 | 23/24 | 24/25 | 25/26 | 26/27 | 27/28 | 28/29 | 29/30 | 30/31 |
| RV | 5 | Arror Dam | W, I, P, F | 80 | D/D done | | P | | | | | | | | | | | | | | | | |
| | 6 | Oletukat Dam | W, P | 36 | D/D ongoing | | | | P | | | | | | | | | | | | | | |
| | 7 | Leshota Dam | W, P | 54 | D/D ongoing | | | | | P | | | | | | | | | | | | | |
| | 8 | Oldorko Dam | W, I, P | 90 | D/D ongoing | | | | | | P | | | | | | | | | | | | |
| | 9 | Kimwarer Dam | W, I, P | 20 | F/S done | | | | | | | | | | P | | | | | | | | |
| | 10 | Embobut Dam | W, I, P | 45 | Pre-F/S done | | | | | | | | | | P | | | | | | | | |

F/S and/or D/D

P Procurement

Construction

W=Domestic and industrial water supply, I=Irrigation, P=Hydropower, F-Flood control

D/D=Detailed Design, F/S=Feasibility Study, Pre-F/S=Pre-Feasibility Study

Source: JICA Study Team

| THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030 | Figure 7.3.4 Implementation Schedule of Proposed Hydropower Development Plan (RVCA) |
|---|---|
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| WRMA Catchment | No. | Name of Project | Purpose | Effective Storage Volume (MCM) | Project Status | Implementation Schedule | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Short Term | | | | | Medium Term | | | | | Long Term | | | | | | | |
| | | | | | | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
| | | | | | | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 | 19/20 | 20/21 | 21/22 | 22/23 | 23/24 | 24/25 | 25/26 | 26/27 | 27/28 | 28/29 | 29/30 | 30/31 |
| RV | 1 | Upper Narok Dam | W, I, F | 29 | Flagship | | | P | | | | | | | | | | | | | | | |
| | 2 | Arror Dam | W, I, P, F | 62 | D/D done | | P | | | | | | | | | | | | | | | | |
| | 3 | Oletukat Dam | W, P | 300 | D/D ongoing | | | | P | | | | | | | | | | | | | | |
| | 4 | Leshota Dam | W, P | 33 | D/D ongoing | | | | | P | | | | | | | | | | | | | |
| | 5 | Oldorko Dam | W, I, P | 20 | D/D ongoing | | | | | | P | | | | | | | | | | | | |
| | 6 | Kimwarer Dam | W, I, P | 107 | Pre-F/S done | | | | | | | | | | P | | | | | | | | |
| | 7 | Embobut Dam | W, I, P | 30 | Pre-F/S done | | | | | | | | | | P | | | | | | | | |
| | 8 | Malewa Dam | W | 34 | | | | | | | | | | | | | P | | | | | | |
| | 9 | Waseges Dam | W | 4 | | | | | | | | | | | | | | P | | | | | |
| | 10 | Murung-Sebit Dam | I, F | 40 | | | | | | | | | | | | | | | P | | | | |

F/S and/or D/D
P Procurement
Construction
W=Domestic and industrial water supply, I=Irrigation, P=Hydropower, F-Flood control
D/D=Detailed Design, F/S=Feasibility Study, Pre-F/S=Pre-Feasibility Study

Source: JICA Study Team

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**Figure 7.3.5**
**Implementation Schedule of Proposed Water Resources Development Plan (RVCA)**

| No. | Description | Implementation Schedule | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Short Term | | | | | Medium Term | | | | | Long Term | | | | | | | |
| | | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
| | | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 | 19/20 | 20/21 | 21/22 | 22/23 | 23/24 | 24/25 | 25/26 | 26/27 | 27/28 | 28/29 | 29/30 | 30/31 |
| *Development Activities* | | | | | | | | | | | | | | | | | | | |
| (1) | Monitoring | | | | | | | | | | | | | | | | | | |
| M1 | Replacement of iron post for river gauge to concrete post | ■ | ■ | ■ | | | | | | | | | | | | | | | |
| M2 | Upgrade manual gauge to automatic (surface water level) | | | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | |
| M3 | Upgrade manual gauge to automatic (groundwater level) | | | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | |
| M4 | Upgrade manual gauge to automatic (rainfall) | | | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | |
| M5 | Installation of Dedicated Boreholes for Groundwater Monitoring | ■ | ■ | ■ | | | | | | | | | | | | | | | |
| M6 | Installation/Rehabilitation of River Gauging Stations | ■ | ■ | | | | ■ | ■ | | | | ■ | ■ | | | | | | |
| M7 | Installation/Rehabilitation of Rainfall Gauging Stations | ■ | ■ | | | | ■ | ■ | | | | ■ | ■ | | | | | | |
| M8 | Flood Discharge Measurement Equipment (Each SRO) | | ■ | ■ | ■ | | | | | | | | ■ | ■ | ■ | | | | |
| (2) | Evaluation | | | | | | | | | | | | | | | | | | |
| E1 | Hydromet DB Upgrade (Software + Hardware) | | | ■ | ■ | | | | ■ | ■ | | | | ■ | ■ | | | | |
| E2 | Establishment of additional Water Quality Test Laboratory in Lodwar and Kapenguria | ■ | ■ | | | | | | | | | | | | | | | | |
| (3) | Permitting | | | | | | | | | | | | | | | | | | |
| P1 | PDB Upgrade (Software + Hardware) | | | ■ | ■ | | | | ■ | ■ | | | | ■ | ■ | | | | |
| (4) | Watershed Conservation | | | | | | ■ | ■ | ■ | ■ | | | | | | | | | |
| W1 | Forestation (Gazetted Forest Area) | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | | |
| W2 | Forestation (Non-gazetted Forest Area) | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| *Recurrent Activities* | | | | | | | | | | | | | | | | | | | |
| (1) | Monitoring | | | | | | | | | | | | | | | | | | |
| M1 | Surface Water Level Monitoring | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| M2 | River Discharge Measurement | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| M3 | Groundwaer Level Monitoring | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| M4 | Rainfall Monitoring | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| M5 | Flood Discharge Measurement | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| M6 | Surface Water Quality Monitoring | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| M7 | Groundwater Quality Monitoring | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| (2) | Others | | | | | | | | | | | | | | | | | | |
| O1 | Catchment Forum Operation (Venue and Allownce to WURAs) | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |

Source: JICA Study Team

| THE DEVELOPMENT OF<br>THE NATIONAL WATER MASTER PLAN 2030 | **Figure 7.3.6**<br>**Implementation Schedule of Proposed Water Resources Management Plan (RVCA)** |
|---|---|
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*Flood Disaster Management Plan*

| WRMA Catchment | No. | Description | Implementation Schedule | | | | | | | | | | | | | | | | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Short Term | | | | | Medium Term | | | | | Long Term | | | | | | | | |
| | | | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | |
| | | | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 | 19/20 | 20/21 | 21/22 | 22/23 | 23/24 | 24/25 | 25/26 | 26/27 | 27/28 | 28/29 | 29/30 | 30/31 | |
| RV | R1 | Nakuru | | | | | | | | | | | | | | | | | | | |
| | | R1.1 Implementation of Urban Drainage Measures | | | | | | | | | | | | | | | | | | | |
| | R2 | Narok | | | | | | | | | | | | | | | | | | | |
| | | R2.1 Construction of Multipurpose Dam | | | | | | | | | | | | | | | | | | | Upper Narok Dam |
| | | R2.2 River Training Works | F/S | | | | | | | | | | | | | | | | | | |
| | | R2.3 Preparation of Hazard Map | | | | | | | | | | | | | | | | | | | |
| | | R2.4 Formulation of Evacuation Plan | | | | | | | | | | | | | | | | | | | |
| | | R2.5 Implementation of Urban Drainage Measures | | | | | | | | | | | | | | | | | | | |
| | R3 | Mogotio | | | | | | | | | | | | | | | | | | | |
| | | R3.1 River Training Works | | | F/S | | | | | | | | | | | | | | | | |
| | | R3.2 Preparation of Hazard Map | | | | | | | | | | | | | | | | | | | |

Note: Construction Schedule for River Training Works (to be determined in the Feasibility Study)

*Drought Disaster Management Plan*

| No. | Description | Implementation Schedule | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Short Term | | | | | Medium Term | | | | | Long Term | | | | | | | |
| | | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
| | | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 | 19/20 | 20/21 | 21/22 | 22/23 | 23/24 | 24/25 | 25/26 | 26/27 | 27/28 | 28/29 | 29/30 | 30/31 |
| 1 | Preparation of Water Use Restriction Rule for Reservoirs | | | | | | | | | | | | | | | | | | |
| 2 | Establishment of Basin Drought Conciliation Councils | | | | | | | | | | | | | | | | | | |
| 3 | Development of Drought Early Forecast System | | | | | | | | | | | | | | | | | | |

Legend: Establishment Update / Expansion

Source: JICA Study Team

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**Figure 7.3.7**
**Implementation Schedule of Proposed Flood and Drought Disaster Management Plan (RVCA)**

| No | Name of Project | County | Irrigation Area (ha) | Multi-purpose Dam | Short Term | | | | | Medium Term | | | | | Long Term | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
| | | | | | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 | 19/20 | 20/21 | 21/22 | 22/23 | 23/24 | 24/25 | 25/26 | 26/27 | 27/28 | 28/29 | 29/30 | 30/31 |
| **A. Large Scale Irrigation Project (New)** | | | | | | | | | | | | | | | | | | | | | | |
| 1 | Perkera Irrigation Extention | Baringo | 3,000 | - | | P | | | | | | | | | | | | | | | | |
| 2 | Turkwel Irrigation | West Pokot | 5,000 | Turkwel | Dam (Existing) | | P | | | | | | | | | | | | | | | |
| 3 | Arror Irrigation | Elgeyo Marakwet | 10,850 | Arror | | | | P | | | Dam | | | | | | | | | | | |
| 4 | Norera Irrigation | Narok | 2,000 | Upper Narok | | | | | P | | | Dam | | | | | | | | | | |
| 5 | Lower Ewaso Ng'iro Irrigation | Kajiado | 15,000 | Oldorko/ Oletukat | | | | | | | P | | | | Dam | | | | | | | |
| 6 | Todonyang-Omo Irrigation | Turkana | 35,000 | Gibe 3 Ethiopia | | | | | | Dam (in Ethiopia) | | P | | | | | | | | | | |
| 7 | Kimwarer Irrigation | Baringo | 2,000 | Kimwarer | | | | | | | | | | | P | | | | Dam | | | |
| 8 | Oldekesi Irrigation | Narok | 2,000 | - | | | | | | | | | | | | P | | | | | | |
| 9 | Embobut Irrigation | Elgeyo Marakwet | 2,000 | Embobut | | | | | | | | | | | | | P | | Dam | | | |
| | On-going Weir Irrigation | | 2,000 | | | | | | | | | | | | | | | | | | | |
| Total | | | 78,850 | | 2,000 | | | | | 17,850 | | | | | 59,000 | | | | | | | |
| **B. Small Scale Irrigation Project (New)** | | | | | | | | | | | | | | | | | | | | | | |
| 1 | Weir Irrigation | | 5,335 | | 1,067 | | | | | 1,601 | | | | | 2,667 | | | | | | | |
| 2 | Dam Irrigation | | 0 | | 0 | | | | | 0 | | | | | 0 | | | | | | | |
| 3 | Small Dam/Pond/Water Pan Irrigation | | 2,890 | | 578 | | | | | 867 | | | | | 1,445 | | | | | | | |
| 4 | Groundwater Irrigation | | 1,046 | | 209 | | | | | 314 | | | | | 523 | | | | | | | |
| **Total for B** | | | 9,271 | | 1,854 | | | | | 2,782 | | | | | 4,635 | | | | | | | |
| **C. Private Irrigation Project (New)** | | | | | | | | | | | | | | | | | | | | | | |
| 1 | Weir Irrigation | | 3,000 | | 600 | | | | | 900 | | | | | 1,500 | | | | | | | |
| 2 | Groundwater Irrigation | | 1,045 | | 209 | | | | | 314 | | | | | 522 | | | | | | | |
| **Total for C** | | | 4,045 | | 809 | | | | | 1,214 | | | | | 2,022 | | | | | | | |
| **Total for RVCA** | | | 92,166 | | 4,663 | | | | | 21,846 | | | | | 65,657 | | | | | | | |

Note:
- F/S and/or D/D
- P Procurement
- Construction of Irrigation System
- Construction of Multipurpose Dam

Source: JICA Study Team

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**Figure 7.3.8**
**Implementation Schedule of Proposed Environmental Management Plan (RVCA)**