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

THE REPUBLIC OF KENYA

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

FINAL REPORT
VOLUME - I EXECUTIVE SUMMARY

OCTOBER 2013

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.

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FINAL REPORT

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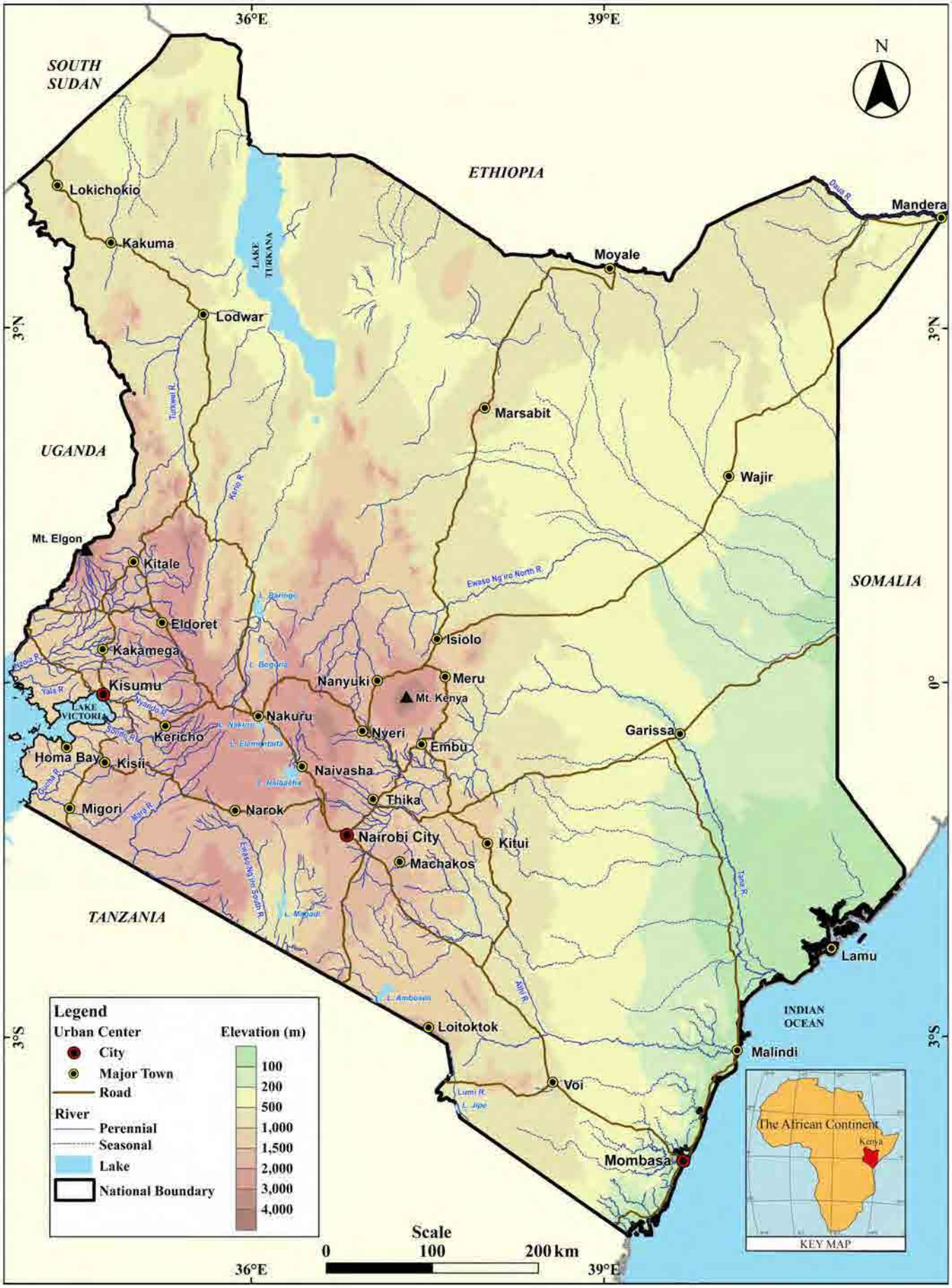
EXCHANGE RATE

US$1.00 = KSh 85.24 = ¥79.98

as of November 1, 2012

Executive Summary



Location Map

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

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List of Abbreviations and Acronyms

ACA	:	Athi Catchment Area
ASAL	:	Arid and Semi-arid Land
BOPA	:	Budget Outlook Paper
CAAC	:	Catchment Areas Advisory Committee
CBDM	:	Community-based disaster management
CDA	:	Coast Development Authority
CMIP3	:	Phase 3 of Coupled Model Intercomparison Project
CoK	:	Constitution of Kenya
CRC	:	Crisis Response Centre
D/D	:	Detailed Design
DIAS	:	Data Integration and Analysis System
DOC		Disaster Operation Center
EIRR	:	Economic Internal Rate of Return
ENN	:	Ewaso Ng'iro North
ENNCA	:	Ewaso Ng'iro North Catchment Area
ENNDA	:	Ewaso Ng'iro North Development Authority
ENSDA	:	Ewaso Ng'iro South Development Authority
FEWS	:	Flood Early Warning System
FFWS	:	Flood Forecasting and Warning System
GCM	:	General Circulation Model
GDP	:	Gross Domestic Product
GOK	:	Government of Kenya
ITCZ	:	Inter Tropical Convergence Zone
JICA	:	Japan International Cooperation Agency
KenGen	:	Kenya Electric Generating Company
KFS	:	Kenya Forest Service
KFSSG	:	Kenya Food Security Steering Group
KMD	:	Kenya Meteorological Department
KVDA	:	Kerio Valley Development Authority
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
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
MOE	:	Ministry of Energy
MORDA	:	Ministry of Regional Development Authority
MWI	:	Ministry of Water and Irrigation
MWL	:	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
NWP	:	National Policy on Water Resources Management and Development
NWRDP	:	National Policy on Water Resources Management and Development
O&M	:	Operation and Maintenance
RBO	:	River Basin Organization
RO	:	Regional Office
RV	:	Rift Valley
RVCA	:	Rift Valley Catchment Area
SHER	:	Similar Hydrologic Element Response
SRI		System of Rice Intennsification
SRO	:	Sub-regional Office
SSRWSS	:	Small Scale Water Supply System
TARDA	:	Tana and Athi River Development Authority
TCA	:	Tana Catchment Area
UC	:	Urban Centre
UN	:	United Nations
UWSS	:	Urban Water Supply System
WKCDD&FMP	:	Western Kenya community Driven Development & Flood Mitigation Project
WRMA	:	Water Resource Management Authority
WRUA	:	Water Resources Users Association
WSP	:	Water Service Provider
WSTF	:	Water Services Trust Fund
WWF	:	World Wide Fund for Nature
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

1, 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
lpcd	=	litter per capita 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

EXECUTIVE SUMMARY

1. INTRODUCTION

1.1 Background of the Project

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

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

The Kenya Vision 2030 was prepared in 2007 and the country's new development blueprint was presented. Water is defined as an essential resource to support the development activities planned under Vision 2030. In order to achieve Vision 2030, the proper implementation system and planning of water resources management are essential to be able to cope with the increasing water demands of domestic, irrigation, industries, etc. while conserving the catchments' sustainability.

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

The situation in the water sector has changed so much as mentioned above. This necessitates the renewal of NWMP (1992).

In response to an official request from the GOK, the Government of Japan decided to conduct technical cooperation on the Project for the Development of the National Water Master Plan 2030 in the Republic of Kenya (the Project). JICA was entrusted to undertake the Project jointly with the Ministry of Water and Irrigation (MWI) and in close cooperation with the authorities concerned.

1.2 Objectives of the Project

The objectives of the Project are:

a) To assess and evaluate the availability and vulnerability of country's water resources up to around 2050 taking climate change into consideration,
b) To formulate the National Water Master Plan towards the year 2030 for sustainable water resources development and management for six catchment areas,
c) To prepare action plan for activities of Water Resources Management Authority's regional offices up to the year 2022 to strengthen their water resource management capability, and
d) To transfer technology on water resources development and management through implementation of the Project.

1.3 Outline of the Project

1.3.1 Project Area and Target Year

The Project covers the entire area of Kenya. The project area consists of the following six catchments designated by the National Water Resources Management Strategies (2007-2009) as shown in Figure 1.3.1. These are the units for water resources management by the Water Resources Management Authority (WRMA).

a) Lake Victoria North Catchment Area (LVNCA): 18,374 km^2
b) Lake Victoria South Catchment Area (LVSCA): 31,734 km^2
c) Rift Valley Catchment Area (RVCA): 130,452 km^2
d) Athi Catchment Area (ACA): 58,639 km^2
e) Tana Catchment Area (TCA): 126,026 km^2
f) Ewaso Ng'iro North Catchment Area (ENNCA): 210,226 km^2

The catchment area figures mentioned above are those presented in the catchment management strategies of the six catchments of WRMA.

The target year for formulation of the National Water Master Plan is 2030 according to the objectives of the Project mentioned in Section 1.2.

1.3.2 Outputs of the Project

The Project was carried out in two phases, i.e. Phase 1: Basic Study and Phase 2: Formulation of Master Plan. The total period of the Project is 37 months. Phase 1 covers the period from October 2010 to December 2012 and Phase 2 covers the period from February 2012 to October 2013.

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

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

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

Executive Summary is a summary of the main reports.

2. PHYSICAL AND SOCIOECONOMIC CONDITIONS

2.1 Physical Conditions

Kenya is located on the east coast of Africa, with the equator running almost straight through the middle of the country as shown in the location map. Kenya borders with Somalia, Ethiopia, and South Sudan in the north, Uganda in the west, Tanzania in the south and the Indian Ocean in the east. Territorial area is 582,646 km^2 and it is divided into water area of 11,230 km^2 and land area of 571,416 km^2. The major part of the inland water surface area is covered by a portion of Lake Victoria and Lake Turkana. Of the land area, approximately 490,000 km^2 (more than 80% of the land area) is classified as arid and semi-arid land (ASAL). The remaining area of about 81,000 km^2 is classified as non-arid and profitably usable lands, sustaining a substantial portion of Kenyan economy and human population.

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

The climate in Kenya is primarily influenced by the movement of the Inter Tropical Convergence Zone (ITCZ) and by topographic relief, especially elevation. The rainfall in Kenya is affected by large water bodies like Lake Victoria, complex topography with the Great Rift Valley and high mountains like Mt. Kenya and Mt. Elgon. A relatively wet and narrow tropical belt lies along the Indian Ocean coast. Behind the coastline stretches large areas of semi-arid and arid lands. Kenya generally experiences two seasonal rainfall peaks of long rain (March – May) and short rain (October - December) in most places. Mean annual rainfall over the country is 680 mm. It varies from about 200 mm in the ASAL zone to about 1,800 mm in the humid zone.

2.2 Socioeconomic Conditions

Previously, administrative division comprised provinces, districts, divisions, locations, and sub-locations. With the New Constitution 2010, administrative division in Kenya has changed to the central government and a devolved county government for each county. There are now 47 county governments established under the New Constitution. Figure 2.2.1 shows the new county boundaries.

The number of persons in Kenya surveyed during the Population and Housing Census 2009 was 38.6 million representing an increase of about 35% from the Census 1999 at an average growth rate of 3.0% annually. The average population density in Kenya was calculated at 68 persons/km^2. As of 2009, 67.7% (26.1 million) are living in the rural areas and 32.3% (12.5 million) are living in the urban centres.

The economy of Kenya has been largely dependent on agriculture and tourism in the past. According to the 2012 Economic Survey, Kenya is steadily recovering from the multiple shocks that the country suffered since 2008. The World Bank's Kenya Economic Update for June 2012 projects a GDP growth rate of 5.0% for 2012. The agriculture sector contributes around 24% of the GDP of Kenya and the tourism sector is earning around 17% of the total exports.

According to the Economic Survey 2012, the central government revenue is expected to record a 15.1% increase for the preceding fiscal year, accounting for KSh 766.2 billion in 2011/12. On the other hand, the central government expenditure as a percentage of GDP is expected to rise a 35.2% from the previous year, accounting for KSh909.9 billion in 2011/12. The water sector's government grant is KSh24.8 billion and remains at 3.0% of the government's total budget of KSh838.2 billion, although it is on an upward trend. Within development expenditure, external resources makes up about 54% of the total in 2012/13 (KSh23.7 billion). In the water sector, irrigation received the majority of the sector's government grant, comprising about 39% of the development expenditure in 2012/13 (KSh8.0 billion), followed by water supply.

According to the Kenya Integrated Household Budget Survey (KIHBS) 2005/06, the monthly expenditure per adult in Kenya was KSh3,432 in 2005/06. There is a big difference as urban adults spent KSh6,673 per month while rural adults spent KSh2,331. Based on the above data, the monthly expenditure per adult in 2012 was estimated at around KSh175,000 for urban adults and around KSh61,000 for rural adults by taking into account the growth rate of real GDP and inflation rate. On average, around 47% of the population in Kenya were below the poverty line[1] in 2005/06.

3. NATIONAL WATER POLICY AND DEVELOPMENT TARGETS

3.1 National Water Policy

The National Water Policy of Kenya was developed in 1999 as the National Policy on Water Resources Management and Development (NWP 1999) and it is effective at present. Based on this NWP 1999, Water Act was established in 2002.

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

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

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

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

[1] According to the Kenya National Bureau of Statistics (KNBS), the poverty lines are set at KSh1,562 per month per person in rural areas, and KSh2,913 per person in urban areas (Sectoral Report (A), Socio-economy, Section 6.2 Poverty).

Through discussion with the Ministry of Water and Irrigation (MWI) as well as the Water Resources Management Authority (WRMA), it was agreed that NWMP 2030 would be formulated based on NWM 1999 and Water Act 2002. It should be noted that the national water policy is currently in the process of revision to align with the new Constitution of Kenya as National Water Policy 2012.

3.2 National Development Targets

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

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

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

a) Water and sanitation - to ensure that improved water and sanitation are available and accessible to all by 2030,
b) Agriculture - to increase the area under irrigation to 1.2 million ha by 2030 for increase of agricultural production,
c) Environment - to be a nation that has a clean, secure and sustainable environment by 2030, and
d) Energy - to generate more energy and increase efficiency in energy sector.

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

4. WATER RESOURCES OF KENYA

4.1 Projection on Effects of Future Climate Change

The water resources of Kenya will be affected by future climate change. In order to evaluate the effects of future climate change to water resources, future climate around 2050 was projected based on the output of 17 General Circulation Models (GCMs) of Phase 3 of Coupled Model Intercomparison Project (CMIP3) for the period from 2045 to 2065, which were obtained through the Data Integration and Analysis System with the cooperation of the University of Tokyo Earth Observation (DIAS). The emission scenario selected for the climate change projection was A1B scenario[3] because it is physically plausible and consistent, and the potential range of future regional climate change is

[2] Projects such as High Grand Falls Multipurpose Reservoir and Extension of Mzima Pipeline are proposed.
[3] Refer to Sectoral Report (B), Sections 4.1 to 4.5.

realistic. A flowchart for projection on effects of future climate change and formulation of water resources development plan is as shown in Figure 4.1.1.

Considering data availability for the adopted emission scenario A1B and evaluation of reproducibility of Kenya's climate characteristics, 11 out of 17 GCMs obtained were used for future climate projection for 2030 and 2050. The climate of 2030 was interpolated with the climates of 1990 and bias-corrected 2050.

According to the multi-model ensemble analysis of 11 GCMs, an increase of surface air temperature seems to be unavoidable in the future. Surface air temperature will increase around 1ºC by 2030 and 2 ºC by 2050 uniformly for the current climate. The mean annual rainfall and acutual evapotranspiration are expected to increase for 2030 and 2050 as shown below, but it should be noted that there are inherent uncertainties in any future climate change projection. As for estimation of the potential evapotranspiration[4], Hamon method which requires only temperature data for estimation was adopted taking into account insufficiency of available meteorological data. Further, it was tried to roughly estimate the evapotranspiration adjusted by FAO Penman-Monteith method based on statistical meteorological data.

Projection of Future Mean Annual Rainfall and Evapotranspiration

(Unit: mm/year)

Item	2010	2030	2050
Mean Annual Rainfall	679	750	801
Mean Annual Actual Evapotranspiration estimated by Hamon method	549	613	659
Mean Annual Actual Evapotranspiration adjusted by FAO Penman-Monteith method	608	675	723

Note: Figures are ensemble means of 11 GCMs and national average.
Source: JICA Study Team (Ref. Main Report Part A, Section 5.1)

4.2 Renewable Water Resources

Based on the projected future climates, the renewable water resources were calculated. The renewable water resources were calculated for the potential evapotranspirations estimated by two methods mentioned in the previous Section 4.1 by multiplying the difference of annual rainfall and annual actual evapotranspiration by land area. Then, surface water runoff and groundwater recharge were estimated by using Similar Hydrologic Element Response (SHER) model. The results are summarised as given below for the whole country and the years 2010, 2030 and 2050.

Annual Renewable Water Resources of Kenya

(Unit: MCM/year)

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

Source: JICA Study Team (Ref. Main Report Part A, Sub-section 5.2.1)

[4] Refer to Sectoral Report (B), section 5.5.

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

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

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

Annual Surface Water Runoff by Catchment Area

(Unit: MCM/year)

Catchment Area	Area (km^2)	2010	2030	2050
LVNCA	18,374	4,626	4,969	5,455
LVSCA	31,734	4,773	5,749	7,005
RVCA	130,452	2,457	3,045	3,794
ACA	58,639	1,198	1,334	1,711
TCA	126,026	5,858	7,261	7,383
ENNCA*	210,226	1,725	2,536	1,361
Total	575,451	20,637	24,894	26,709

Note: * The decrease of annual surface water runoff in ENNCA is supposed to be largely affected by the regional climate characteristics that 90% of the total precipitation evapotranspirates. Detailed explanation is given in Sectoral Report (B), Sub-section 5.4.1.
Source: JICA Study Team (Ref. Main Report Part A, Sub-section 5.2.1)

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

Annual Groundwater Recharge by Catchment Area

(Unit: MCM/year)

Catchment Area	Area (km^2)	2010	2030	2050
LVNCA	18,374	1,326	1,251	1,612
LVSCA	31,734	2,294	2,111	2,126
RVCA	130,452	1,126	1,126	1,209
ACA	58,639	3,345	3,303	3,649
TCA	126,026	7,719	6,520	5,840
ENNCA	210,226	5,660	5,095	4,851
Total	575,451	21,470	19,407	19,287

Note: The evapotarnspiration adjusted by FAO Penman-Monteith method was applied for groundwater recharge estimation.
Source: JICA Study Team (Ref. Main Report Part A, Sub-section 5.2.1)

4.3 Sustainable Yield of Groundwater

The renewable groundwater recharge estimated is not fully usable. It is quite difficult to estimate the sustainable yield of groundwater. According to the research studies of Ponce (2008) and U.S. Geological Survey Circulars 1186 and 1200 (1998 and 1999), the sustainable groundwater yield may be reasonably estimated at around 10% of groundwater recharge taking into consideration the aspects of hydrology, ecology, socio-economy, culture, etc. In this connection, this study also adopted 10%

of groundwater recharge as a sustainable yield, but the river and riparian areas with 1 km wide were excluded from the expected groundwater abstraction areas[5]. The exclusion of the river and riparian areas was decided to avoid potential influence of abstraction on river surface runoff, and therefore the abstraction will need to be restricted. As for the depth of groundwater, the deepest existing boreholes for water use purpose are at around 400 to 500 m at maximum. Therefore, this depth was regarded as the maximum for exploitation in the study. It was decided not to consider water use deeper than this, such as geothermal water. Then, estimated sustainable yields of groundwater by catchment area are given below.

Estimated Sustainable Yield of Groundwater by Catchment Area

(Unit: MCM/year)

Catchment Area	Area (km^2)	2010	2030	2050
LVNCA	18,374	116	108	140
LVSCA	31,734	203	188	190
RVCA	130,452	102	102	109
ACA	58,639	305	300	332
TCA	126,026	675	567	508
ENNCA	210,226	526	475	449
Total	575,451	1,927	1,740	1,728

Note: Estimated at around 10% of groundwater recharge amount (with an assumption that the river and riparian areas with 1 km wide were excluded from the expected groundwater abstraction area)

Source: JICA Study Team (Ref. Main Report Part A, Sub-section 5.2.2)

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

4.4 Available Water Resources

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

Available Water Resources by Catchment Area

(Unit: MCM/year)

Catchment Area	Area (km^2)	2010	2030	2050
LVNCA	18,374	4,742	5,077	5,595
LVSCA	31,734	4,976	5,937	7,195
RVCA	130,452	2,559	3,147	3,903
ACA	58,639	1,503	1,634	2,043
TCA	126,026	6,533	7,828	7,891
ENNCA	210,226	2,251	3,011	1,810
Total	575,451	22,564	26,634	28,437

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

[5] Expected groundwater abstraction area = catchment area – (river length x 1 km)

5. WATER DEMANDS AND WATER BALANCE

5.1 Basic Conditions for Water Demand Projection

(1) Categories and Years Subject for Projection

The water demand categories, subject for projection are domestic, industrial, irrigation, livestock, wildlife, and inland fisheries.

The water demands were estimated for the year 2010 and projected for the years 2030 and 2050. The projection for 2030 is used to formulate the NWMP 2030 and the projection for 2050 is used to assess vulnerability of water resources in the future considering climate change effect. The estimation for 2010 is used to grasp the current water use situation.

(2) Population

As mentioned in Section 2.2, the number of persons surveyed during the 2009 Population and Housing Census was 38.6 million, representing an increase of 35% from 28.7 million for the 1999 Census at an average rate of about 3.0% annually. Majority of the population still resides in rural areas. As of 2009, 67.7% of the population is living in rural areas and 32.3% in urban centres. Based on the 2009 Census data and the projection of the Kenya Vision 2030, the projected population for 2030 was estimated at 67.84 million, in which 67.8% of the population resides in urban areas.

The population in 2050 depended on the projection by United Nations in 2011 because population projection beyond 2030 is not available in Kenya and very difficult to predict. The ratio of urban and rural populations in 2050 was assumed to be the same as in 2030.

Projected Population

(Unit: million persons)

Year	2010		2030		2050	
Area	Population	%	Population	%	Population	%
Urban	13.08	33.9	46.02	67.8	65.69	67.8
Rural	25.45	66.1	21.82	32.2	31.20	32.2
Total	38.53	100.0	67.84	100.0	96.89*	100.0

Note: *UN World Urbanisation Prospects: The 2011 Revision
Source: JICA Study Team (Ref. Main Report Part A, Section 6.2 and Sectoral Report (A), Sub-section 3.2.3)

(3) GDP Growth Rate

The Budget Outlook Paper (BOPA) 2011 provides the basis of the GDP for the medium term projection. BOPA expects a moderate GDP growth rate of 6.1% in 2012 with the weaker global economy and tighter domestic macroeconomic conditions, but in the medium term the economy is expected to grow up to 7%. The Kenya Vision 2030 secretariat projects annual GDP growth rate up to 2030 as shown in the table below. The high economic growth envisaged in the Vision 2030 is expected to be achieved as key infrastructure development and oil export from Kenya are expected to be undertaken.

Projected Annual GDP Growth Rate up to 2030

(Unit: %)

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

Source: Kenya Vision 2030 Secretariat (Ref. Main Report Part A, Section 6.2 and Sectoral Report (A), Section 4.2)

For the projection of water demand in 2050, it was assumed that following the implementation of the Vision 2030 the Kenyan economy will have reached a level of relative maturity and an average annual GDP growth rate of 4% will be achieved for the period 2031 - 2050.

5.2 Water Demand

Based on the national development target in Kenya Vision 2030 and socioeconomic frameworks mentioned before, the water demand required for water resources development and management planning were estimated for the domestic, industrial, irrigation, livestock, wildlife and inland fisheries water use. The present and future water demands estimated and projected are given in the table below, but the future water demands are projected including irrigation water demand for new development area of 1.2 million ha targeted in Kenya Vision 2030 without benefit of any water balance study.

Present and Future Water Demand by Subsector

(Unit: MCM/year)

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

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

The water demands estimated are summarised by catchment area as shown below.

Present and Future Water Demands by Catchment Area

(Unit: MCM/year)

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

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

Source: JICA Study Team (Ref. Main Report Part A, Section 6.10)

The satisfiable water demands in 2030 after the water balance study based on the above water demands are presented in Table 7.2.1.

5.3 Balance of Water Demand and Available Water Resources

The ratio of present and future water demands to available water resources are presented in the table blow. The future irrigation water demands for 2030 and 2050 are water demands for new irrigation development area of 1.2 million ha targeted in Kenya Vision 2030 adding to the existing water demand.

Available Water Resources and Water Demands by Catchment Area

(Unit: MCM/year)

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

Source: JICA Study Team (Ref. Main Report Part A, Section 6.11)

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

In the target year 2030, water demand will increase in all catchment areas, and water balance is expected to be tight in all areas. The catchment areas except LVNCA will have large water deficits as predicted by the high water demand/water resource ratios[6] of more than 40%, and the irrigation water demands corresponding to the irrigation area proposed by Kenya Vision 2030 need to be reduced. On the contrary, LVNCA showing water demand/water resource ratios of less than 40% seems to be able to have a water balance for the predicted water demands by appropriate water resources developments.

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

The available water resources are a total of the renewable surface water resources and the sustainable yield of groundwater which are theoretically available quantities. As water resources are distributed unevenly in the country in terms of time and space, actual usable water resources are considered limited and less than the total of water resources.

Dividing each catchment area into sub-basins, the balance between the available water resources and water demands were examined for 2010 and 2030 with existing dams and inter-basin and intra-basin transfer facilities under the conditions shown in Section 6.7 (2). Figures 5.3.1 and 5.3.2 show the

[6] OECD defines the situation as “under severe water stress” in case the ratio exceeds 40%.

excess or deficit of water in each sub-basin for 2010 and 2030 respectively. As seen in the figures, most of sub-basins show water deficits in 2010, while all sub-basins will have deficits in 2030 due to drastic increase of water demands.

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

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

(Unit: MCM/year)

Catchment Area	2010			2030		
	Water Demand (a)	Water Deficit (b)	(b)/(a) (%)	Water Demand (c)	Water Deficit (d)	(d)/(c) (%)
LVNCA	228	27	12	1,337	371	28
LVSCA	385	150	39	2,953	1,304	44
RVCA	357	92	26	1,494	867	58
ACA	1,145	745	65	4,586	4,153	91
TCA	891	336	38	8,241	5,822	71
ENNCA	212	68	32	2,857	2,442	85
Total	3,218	1,418	44	21,468	14,959	70

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

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

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

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

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

6. OVERALL CONCEPTS AND FRAMEWORKS FOR PLANNING

6.1 Objectives and Components of National Water Master Plan 2030

(1) Objectives

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

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

Specific Objectives for Water Resources Development

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

Specific Objectives for Water Resources Management

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

(2) Components of NWMP 2030

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

NWMP 2030 will consist of the following nine component plans:

Development Plans

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

Management Plans

f) Water Resources Management Plan
g) Flood and Drought Disaster Management Plan
h) Environmental Management Plan

Institutional Plan

i) Institutional Strengthening Plan

The development plans and manage plans are prepared by catchment area, while the institutional strengthening plan requires a national-level action and therefore is not prepared by catchment area.

The chapter describes objectives and the five development plans are prepared to determine the future water demands and water uses of respective subsectors in the target year 2030 and the formulation of development plans is not the ultimate purpose of this study.

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

6.2 Water Allocation Policy

The currently effective "Guidelines for Water Allocation (WRMA, First Edition, March 2010)" conforming to the Water Act 2002 stipulate the requirements with regard to water allocation and prioritisation, as follows:

a) The water demands to be taken into account for water allocation are ecological needs, basic human needs[7] (BHNs), water for which commitments have been made in international treaties and inter basin water transfers, and water that can be allocated to individual uses by means of a permit.

   All users of water resources other than the reserve consisting of the ecological and basic human needs, international obligations and inter-basin transfers are authorised according to the criteria of equitable allocations.

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

c) The domestic water has a higher priority than other uses as stipulated in the Water Act 2002.

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

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

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

Prioritisation of Water Allocation for NWMP 2030

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, and results of discussions with MWI and WRMA

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

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

6.3 Water Supply Development Plan

(1) Development Target

Based on data of Census 2009, it is estimated that piped water supply systems cover only 28% of the population in Kenya, while boreholes, springs andwells provide water to 37% of the population. The boreholes, springs and wells also include unimproved drinking water sources. However, the percentage of unimproved sources is unknown.

It is known that existing the water supply system could provide only 36 L/p/d of water on average in Kenya, though the system is required to provide 60 L/p/d even for population in low class housing, according to the national standard. The ratio of Non-Revenue Water (NRW) is estimated to be quite high at 45% on the national average. For effective usage of water, it is required to improve the NRW ratio.

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

a) Increase coverage of improved water supply to 100% for both urban and rural areas,
b) Increase coverage of piped water supply by registered water service providers (WSPs) to 100% for urban population,
c) Increase unit water supply amount to suitable national standard level, and
d) Decrease NRW rate to 20% for efficient water use[8].

[8] There were opinions that the target rate of 20% seemed to be a high target considering the current NRW rate of 45%, however, through discussions with the Kenyan government side, it was decided to apply the target of 20%

To achieve the above target, the target water supply population and coverage ratio for 2030 was set as shown below.

Target Water Supply Population and Coverage Ratio for 2030

(Unit: million persons)

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

Note: The target water supply population by Spring/ Well/ Borehole was estimated by subtracting current piped water supply population from total rural population in the rural areas of districts based on Census 2009.

Source: JICA Study Team based on Kenya Vision 2030 and Water Service Strategic Plan in 2009 (Sectoral Report (C), Sub-section 3.4.3)

(2) Overall Concept and Framework for Planning

Based on the current situation and development targets of water supply mentioned above, the overall concept and framework for water supply development planning to be applied commonly to six catchment areas were set as follows:

a) The water supply development is composed of Urban Water Supply System (UWSS) and Large-scale Rural Water Supply System (LSRWSS) and Small-scale Water Supply System (SSRWSS).

b) UWSS is a piped water supply system for urban population in137 major urban centres[9] with population of more than 10,000 in 2009 Census. LSRWSS is a piped water supply system for the remaining urban population and around 30-50% of rural population in each catchment area. These piped water supply systems are managed by authorised water service providers (WSPs). SSRWSS is a water supply system for the remaining rural population, and it is managed by individuals, communities or institutions.

c) Access to unimproved water supply sources is to be switched to the abovementioned water supply systems.

d) Main water source for UWSS is surface water and around 5% of the total demand is to be met by groundwater, The water source allocation rate will be determined through water balance study.

e) In principle, UWSS is planned for each urban centre. In cases where several urban centres depend on the same water source, only one system will be considered for them.

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

as stipulated in " Water Service Strategic Plan 2009" to realise Kenya Vision 2030.

[9] Refer to Table 6.3.1

Proposed Unit Water Supply Amount in 2030

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

Source: JICA Study Team based on MWI Design Manual and "Guidelines for Water Allocation (WRMA, First Edition, March 2010)" (Ref. Main Report Part A, Sub-section 6.3.2 and Sectoral Report (C), Sub-section 3.4.3)

g) Water sources of LSRWSS are to be determined considering the availability of surface water and groundwater.

h) Water sources of SSRWSS are to be groundwater and spring water.

i) NRW ratio is to be reduced from the present 45% to 20% in 2030 through rehabilitation works and installation of suitable water meters.

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

6.4 Sanitation Development Plan

(1) Development Target

Based on data from Census 2009, it is estimated that sewerage system covers 18% of the urban population, which is only 6% of the total population in Kenya. As mentioned above, the Kenya Vision 2030 aims to ensure that improved water and sanitation are available to all. Based on the policy of the Kenya Vision 2030, Water Service Strategic Plan 2009 prepared by MWI, the target for sanitation development were set as follows:

a) Increase coverage rate of improved sanitation to 100% (Improve sanitation by sewerage system and on-site treatment facilities),

b) Increase coverage rate of sewerage system to 80% for urban population,

c) Install improved on-site treatment facilities for remaining population not covered by sewerage systems.

To achieve the above target, the target sanitation conditions for 2030 were set as shown below.

Target Sanitation Service Population and Coverage Ratio for 2030

(Unit: million persons)

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

Note: Figures in parenthesis show coverage ratio.

Source: JICA Study Team based on Kenya Vision 2030 and Water Service Strategic Plan in 2009 (Ref. Main Report Part A, Sub-section 7.4.1 and Sectoral Report (D), Section 3.1)

(2) Overall Concept and Framework for Planning

Based on the current situation and development targets of sanitation mentioned above, the overall concept and framework for water supply development planning to be applied uniformly to the six catchment areas were set as follows:

a) Sewerage system will cover 36.8 million service population by 2030 or 80% of urban population. In principle, sewerage system will be developed in each urban centre.
b) Sewerage system will be developed for 95 urban centers listed in Table 6.4.1, which have large populations, sewerage system development plans, and potential environmental problems.
c) Design capacity of wastewater treatment facilities is to be determined based on the unit water supply amount available for residential water use and wastewater generation factor given in the table below.

Proposed Unit Domestic Wastewater Generation Amount in 2030

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

Source: JICA Study Team based on MWI Design Manual (Ref. Main Report Part A, Sub-section 7.4.2 and Sectoral Report (D), Section 3.2)

d) Residents outside sewerage system service areas are to install and manage suitable on-site treatment facilities (improved sanitation) on individual and community basis.
e) For on-site treatment facilities, unsuitable facilities (unimproved sanitation) such as pit latrines without slab are to be changed to suitable facilities such as septic tanks.

6.5 Irrigation Development Plan

(1) Development Target

To strengthen agricultural sector in order to contribute to national economy, the Kenya Vision 2030 sets a national goal to increase new irrigation area by 1.2 million ha by 2030. This includes large scale (public), small scale (smallholders) and private irrigation schemes.

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

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

(Unit: ha)

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

Note: * Assumed values for target of Kenya Vision 2030 based on data on potential agricultural area proposed by MOA, before water balance study.
** Maximum possible area for new irrigation development based on water balance study.
Source: JICA Study Team (Ref. Main Report Part A, Sub-section 6.5.2 and Sectoral Report (E), Section 3.4）

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

(2) Overall Concept and Framework for Planning

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

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

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

The surface water irrigation is to be developed to the maximum by diversion weir and dam. The possible development area is to be determined through a water balance study between available river water and irrigation water demand by sub-basin. The existing irrigation development plans proposed by the government authorities listed in Table 6.5.1 are taken into account for planning.

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

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

For the arid and semi-arid lands (ASALs), the irrigation development is planned setting the cropping pattern for irrigated agriculture considering climate condition and the annual cropping intensity of 100%.

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

Proposed Area Ratio of Water Saving Irrigation and Irrigation Efficiency

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

Source: JICA Study Team (Ref. Sectoral Report (E), Section 4.2)

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

6.6 Hydropower Development Plan

(1) Development Target

A new National Energy Policy (Draft) was published in May 2012 (hereinafter called as “the draft policy”). The draft policy states that: i) the ratio of hydropower generation in the energy mixture is to be lowered at an appropriate level as the countermeasure for climate change; and ii) future hydropower projects should be developed as multipurpose type development from the viewpoint of effective use of limited water resources. Furthermore, it will be necessary to coordinate with other water users such as domestic and irrigation because of expected impending water demand increase and supply balance in the future.

In the draft policy, there is no target figure for hydropower development in the future at the national level. On the other hand, the total installed capacity of the existing individual development plan (as shown in Table 19.1.5 and expected to be implemented by 2030), which is prepared by the Ministry of Regional Development Authorities (MORDA) and the Kenya Electricity Generating Company (KenGen) etc., is 1,381 MW. The figure is similar to the hydropower development potential of 1,449 MW which is stated in the least cost power development plan 2011-2031. The total installed capacity of individual development plan (1,381 MW) is judged to be reasonable. Therefore, the development target of hydropower in NWMP 2030 is set at 1,381 MW.

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

(2) Overall Concept and Framework for Planning

The objective of hydropower development in this study is to develop maximum hydropower potential with the effective use of water resources. Based on the current situation and directions of National Energy Policy, the overall concept and framework for hydropower development plan formulation to be applied uniformly to the six catchment areas were set as follows:

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

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

6.7 Water Resources Development Plan

(1) Development Target

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

The domestic and industrial water supply is ensured for 10-year probable drought and the irrigation water supply for 5-year probable drought as mentioned in Section 6.1. These reliabilities follow the NWMP (1992) and are based on discussion results with MWI and WRMA.

(2) Overall Concept and Framework for Planning

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

a) Water resources is developed to the maximum to meet the water demands by allocating available surface water and groundwater;

b) By taking into account of the present water use and available water resources, water source of domestic use is firstly surface water and secondly groundwater where the surface water is not sufficiently available. For the industrial use, the surface water and groundwater is used fifty-fifty. In the coastal area, desalination is also proposed where the surface water and groundwater are not sufficiently available. The water source of irrigation is mainly surface water due to large water demand and the groundwater is used for small scale irrigation. The water source for livestock, wildlife and inland fisheries uses is surface water because of their small water demands.

c) Water resources is used effectively through multipurpose development, inter-basin transfer, intra-basin transfer, water saving, reuse of water, etc.;

d) Water resources is allocate based on the water allocation policy according to "Guidelines for Water Allocation (WRMA, First Edition, March 2010)" as stated in Section 6.2;

e) Climate change effect is considered by applying the available water resources estimated by the climate change analysis; and

f) Hydropower development plans are incorporated into multipurpose dam development plans in accordance with the concept and framework for hydropower development stated in Section 6.6.

The roof catchment and rock catchment is to be promoted in order to supplement the supply for domestic and livestock water demands, and to prepare for drought risks. Artificial groundwater recharge during flood is not considered in the master plan as there is not sufficient data for planning and there are many localised specific conditions. Further study will be required considering local specific hydrological and hydrogeological conditions. In the areas where the groundwater contains fluoride and/or salinity above an allowable level (more than 0.3 mg/L and 500 mg/L respectively), the groundwater is to be used for the domestic purpose other than drinking.

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

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

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

c) Water harvesting measures were planned mainly for rural domestic, small scale irrigation, livestock, wildlife and fisheries water demands, which are small in amount and scattered throughout the catchment area.

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

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

To allocate water resources to the respective demands, it is essential to follow the water allocation policy as stated in Section 6.2. In particular, the reserve needs to be strictly maintained in the rivers from ecological and basic human needs.

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

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

a) Allocation of surface water is to be based on the water allocation policy and priority mentioned in Section 6.2;
b) Reserve flow as river maintenance flow is to be 95% value (with 10-year probability) of the naturalised present daily flow duration curve for each river in accordance with "Guidelines for Water Allocation (WRMA, First Edition, March 2010)" and results of discussions with WRMA;
c) Return flow is to be 100% for hydropower, 25% for urban water supply[10], 5% for paddy irrigation;
d) The number of sub-basins divided for water balance calculation is to be 204; and
e) Interval of water balance calculation is to be a month.
f) The boreholes were not incorporated into the water balance computation model, but demands to be supplied from the groundwater were subtracted from the demands put into the computation model before calculation.

The water resources are national, and planning, development and management of the water resources should be basin-wise. The projects will be implemented, while managing the challenges through EIA implementation, which will address all issues including compensation and water management. It is noted that involvement of county governments in the implementation of the water resources development projects will be based on the relevant government regulations.

6.8 Water Resources Management Plan

(1) Objective of Water Resources Management

According to "the mission statement of WRMA", the objective of water resources management is to manage, regulate and conserve all water resources in an effective and efficient manner by involving

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

the stakeholders, guaranteeing sustained access to water and equitable allocation of water while ensuring environmental sustainability.

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

WRMA observes surface water, groundwater and rainfall for water resources monitoring. As shown in Table 6.8.1, WRMA observes a limited number of monitoring stations: 146 locations for surface water against the target of 223 locations; 92 locations for groundwater, against the target of 202; and 216 locations for rainfall against the target of 301. The reasons for the limited number of monitoring stations are lack of budget and human resources. There is an issue that water resources evaluation is not adequately conducted, and the monitored data is not fully utilised because of lack of human resources in charge of evaluation works, though the monitored data is adequately stored in the database[11].

As for issues on water permit issuance and control, the ratio of effective water permits against issued water permits is as low as 37% on average for the whole of Kenya though there are some differences in ratio among regional offices. It is necessary to maintain the latest version of the issued water permits.

As for watershed conservation, there are issues of forest degradation and resulting soil erosion increase and degradation of small water sources in local areas. According to the estimate in this study, rate of forest decrease between 1990 and 2010 is about 30%. On the other hand, although issues are recognised for soil erosion and degradation of small water sources, no concrete surveys are made and their current situations are not clarified.

(2) Overall Concept and Framework for Planning

Taking into account the current situation and objective of water resources management, the overall concept and framework for water resources management plan formulation which is common to six catchment areas were set below. Flood and drought aspects will be discussed in the flood and drought disaster management plan separate from the water resources management.

a) Establish more efficient monitoring networks for surface water, groundwater for amount and quality, as well as rainfall.
   - Surface water monitoring points is to be selected to cover representative locations of major rivers, lakes and springs.
   - Aiming at contribution to water resources development and management, reference points are to be established at points that can represent the flow conditions of major rivers.
   - At the reference point, a normal discharge value is set for monitoring, which value should be kept during drought periods. (The normal discharge value is calculated as reserve plus amount of water permits issued (water demand) downstream of a certain point. The normal

[11] Refer to Sectoral Report (H), Section 2.3.

discharge value is a discharge which ensures domestic and industrial water supply against 10-year probable drought and irrigation water supply against 5-year probable drought.)

- Groundwater level monitoring stations are to be selected at points where current and future groundwater uses are significant. In NWMP 2030, monitoring using dedicated boreholes is proposed in principle in urban centres that have both water supply development and sanitation development plans.
- Distributions of rainfall monitoring stations is to be reviewed considering the existing distribution and observation densities based on climatic zones of: i) one station per 500 to 1000 km^2 in humid areas; ii) one station per 3000 to 5000 km^2 in semi-arid areas; and iii) one station per 8000 to 10,000 km^2 in arid areas.
- At a surface water monitoring point, the water level is observed twice a day and the discharge is observed once a month. Water quality is observed and analysed quarterly (for important points[12]: once a month). At a groundwater monitoring point, the water level is observed once a month and water quality quarterly. At a rainfall monitoring station, the rainfall is observed once a day.

b) Enhance evaluation system of water resources in quantity and quality.

- A system is to be established in WRMA regional offices to gather the latest information on available water resources and water quality for the whole catchment area from observed data on surface water, groundwater and rainfall, water permit issuance data, and estimated water resources potential. Such a system is required to determine possible water volume for permit issuance from observed data, and to judge necessity of water resources development.
- The evaluation works of water resources quantity should include the following:
  - Estimation of river discharges in the catchment area based on the observed data,
  - Estimation of water use amount in the catchment area based on the water permits issued,
  - Estimation of the water resources amount of the catchment area for 10-year probable drought period, and
  - Rainfall-runoff analysis for estimation of the total amount of water resources of the catchment area based on the observed rainfall.

c) Improve water permit issuance and control system.

- Prior to increased water demand in the future, ensure the maintenance of the latest version of issued water permit data to enable accurate control of issued water permits by reflecting the current water use.
- To ensure adequate water permit issuance, revise the existing water allocation guidelines of WRMA ("Guidelines for Water Allocation (WRMA, First Edition, March 2010)"), considering future water demands and usable amount of water resources.
- Taking into account the actual situation of water permit issuance and control in WRMA regional offices, consider increase of water right officers for smooth execution of the works.

d) Implement watershed conservation activities such as forest recovery, conservation of small water sources, and soil erosion control.

- Aim at recovery of forest areas through reforestation of water source forests for conservation of water resources in the catchment area. The target of 10% forest cover in the Kenya Vision 2030 is used in the formulation of reforestation plans.

  The proposed forestation area of each catchment area was estimated by identifying the possible reforestation area based on the present forest area shown in Figure 6.8.1 and adjusted

[12] Refer to Sectoral Report (H), Subsection 3.3.2.

so as to meet the target of 10% forest cover in the Vision 2030. The target area of reforestation in each catchment area of WRMA is presented in the table below.

Target Forestation Area by Catchment Area

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

Source: JICA Study Team, based on Kenya Vision 2030 and satellite image analysis in this study. (Ref. Main Report Part A, Sub-section 7.8.2 and Sectoral Report (H), Section 3.2 (4))

- 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, major issues etc.
- The actual status of soil erosion control is not known. It is proposed to carry out a survey of devastated areas which includes location, scale, current situation, required countermeasures etc.

6.9 Flood and Drought Disaster Management Plan

(1) Objective of Flood and Drought Disaster Management

An adequate flood disaster management system has not been established because the frequency of widespread flooding was low especially prior to the 1997-1998 El Nino floods. Meanwhile, drought disaster management system has been generally established since the government has focused on drought disasters for a long time. Kenya Food Security Steering Group (KFSSG) and Crisis Response Centre (CRC) have been organised as a drought crisis response system in terms of food, water, energy, etc. Four WRMA Regional Offices, namely, RVCA, ACA, TCA and ENNCA implement water use restriction based on river water levels. Two other Regional Offices (LVNCA and LVSCA) do not implement water use restriction as there is no need for restriction. There are still issues to be tackled on mitigation of drought damages such as implementation of drought conciliation for reservoirs. Considering impacts by climate change, it is expected that damages caused by flood and drought disasters are expected to increase in the future, and therefore it is imperative to consider countermeasures against those disasters.

The flood and drought disaster management in this study aims to minimise human and economic damages caused by flood and drought focusing on "preparedness" as actions during the pre-disaster stage.

(2) Overall Concept and Framework for Flood Disaster Management Plan

Considering the current situation and objective of the flood disaster management plan, the overall concept and framework to be applied uniformly to the six catchment areas were set as follows:

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

b) Provide structural measures such as dykes, dams, retarding ponds, river training, urban drainage measures, etc. for densely populated areas;

c) Provide non-structural measures such as flood forecasting and warning systems, evacuation plan, flood mitigation plan, flood hazard map, community-based disaster management (CBDM), etc.;

d) Incorporate a concept of using the natural retarding effects of lands subject to frequent flooding such as pastures, paddies and dry fields;

e) Respecting the existing plans and strategies formulated by GOK and ensuring consistency with those official documents, areas subject to the flood disaster management plan were 21 basins/areas identified through Flood Mitigation Strategy (MWI, June 2009), NWCPC Strategic Plan 2010-2015, and NWMP (1992), as shown in the table below[13]; and

Proposed Areas Subject to Flood Disaster Management Plan

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

Source: JICA Study Team, based on Flood Mitigation Strategy (MWI, June 2009), NWCPC Strategic Plan 2010-2015, and NWMP (1992). (Ref. Main Report Part A, Sub-section 7.9.2 and Sectoral Report (J), Section 4.2)

f) Propose a basic idea to address insufficient flood data necessary for formulation of specific flood disaster management plan. It is proposed to carry out the flood surveys for the above 21 proposed areas as early as possible to collect the basic data and information necessary for planning such as location, depth, area and time of flooding, flood discharge, river conditions, topographic maps, etc.

(3) Overall Concept and Framework for Drought Disaster Management Plan

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

a) Prepare water use restriction rules for existing and proposed reservoirs to avoid water conflict during droughts and to aim at more efficient restriction instead of water use restriction rules by river water level, which are currently implemented in four regional offices of WRMA. The restriction rules shall be appropriately reviewed to cope with construction of new reservoirs and change of water demand in the future.

b) Monitor reference water levels which correspond to reserve or normal discharge (this work is to be implemented as a part of water resources management plan).

c) Establish Basin Drought Conciliation Council with a legal status to discuss water use restriction to minimise drought damage.

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

[13] Refer to Figure 6.9.1

6.10 Environmental Management Plan

(1) Objective of Environmental Management

Water resource development urgently needs to meet water demands due to rapid population and economic growth. However, water resource development projects should be implemented ensuring environmental sustainability. The water resources development projects will change river flow regime and may have undesirable impact on the ecosystems of rivers and lakes.

The objective of environmental management in NWMP 2030 is to minimise the negative impact of the water resource development activities on the natural environment[14].

(2) Overall Concept and Framework for Planning

The purpose of environmental management in the NWMP 2030 is to minimise impact caused by water resource developments and utilisations to natural environment. Currently, the river maintenance flow is defined as the flow value that exceeds 95% of the time as measured by naturalised flow duration curve by "Guidelines for Water Allocation (WRMA, First Edition, March 2010)." According to the Guidelines an environmental flow is defined as ecological needs and recognised as a part of the Reserve (river maintenance flow) together with basic human needs, however, the environmental flow rate is not mentioned in the Guidelines. The environmental flow largely affects the water resources development plan. It is important to set the environmental flow for each river and lake based on the basic information on river environment. It is proposed to set appropriate environmental flow and carry out the continuous environmental monitoring to confirm the maintenance and adequacy of the environmental flow set. Also, an environmental survey to set the environmental flow is proposed.

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

a) To set environmental flow rates at strategic points of major rivers and lakes through environmental surveys, namely:
   - Reference points of major rivers and lakes which are important for water resources development and management,
   - Confluence of mainstream and major tributaries where river discharges largely change, and
   - Locations where important or valuable ecosystems exist.
   - Items of environmental survey includes river discharge, water temperature, pH, DO, SS, BOD, and coliform, aquatic flora and fauna, important habitat, sediment, etc.

b) To implement environmental monitoring at strategic points of major rivers and lakes, namely:
   - Representative point to monitor the river ecosystem,
   - Points where rare or unique ecosystem exists (ex. estuary area, closed basin, etc.),
   - Points where a large city or town is located,
   - Points upstream from protected areas,

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

- Major lakes in the catchment area, and
- International rivers and lakes.

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

Proposed Items and Frequencies of Environmental Monitoring

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

Source: JICA Study Team (Ref. Main Report Part A, Sub-section 7.10.2 and Sectoral Report (K), Sub-section 3.2.2)

7. LAKE VICTORIA NORTH CATCHMENT AREA

7.1 Catchment Area Characteristics

LVNCA is located at the western part of the country as shown in Figure 1.3.1, and surrounded by Mt. Elgon in the north and Cherengani Hills and Mau Forest Complex in the east. The LVNCA borders on Uganda in the west and faces Lake Victoria in the south-west. Total area of LVNCA is 18,374 km^2, corresponding to 3.2% of the country's total land area. Based on the Census 2009, population of the area in 2010 is estimated at 6.97 million, or 18.1% of the total population of Kenya. Population density is as high as 379 persons/km^2. The topography of LVNCA varies, with Mt. Elgon peak at 4,321 m above mean sea level (amsl) to Lake Victoria at 1,134 m amsl. The whole area of the LVNCA lies in the highland having elevations greater than 1,000 m amsl.

Major rivers are the 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 the LVNCA while Yala River is the second largest 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 to 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 fresh water lake in the world and strides the borders of Kenya, Tanzania and Uganda.

LVNCA is classified as a humid land (non-ASAL). The mean annual rainfall ranges between 1,200 mm to 1,800 mm and the catchment area average mean annual rainfall is 1,420 mm. The renewable water resources, which is defined as precipitation minus evapotranspiration, is estimated at 5.95 BCM/year in 2010 for LVNCA and the per capita renewable water resources is calculated at 855 m^3/year/capita.

7.2 Water Resources, Water Demands and Water Allocation

The available water resources were estimated in LVNCA for the years of 2010 (present) and 2030 (future) as explained in Section 4.4 and summarised below. The estimate for 2030 includes impacts of climate change.

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
Ratio of 2030 to 2010	107%	93%	107%

Source: JICA Study Team (Ref. Main Report Part B, Section 3.2)

The annual water demands were estimated for the year 2010 and projected for 2030 in LVNCA as described in Section 5.2 and summarised below. The projection for 2030 followed the national development targets of Kenya Vision 2030 and socioeconomic framework, but without considering the available water resources.

Water Demands by Subsector (LVNCA)

Year	Water Demands (MCM/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 B, Section 3.3)

In order to assess severity of water balance, ratios of available water resources and water demands presented above and those of water demands and water deficits discussed in Section 5.3 are tabulated for both 2010 and 2030 as follows:

Ratios of Water Demands/Available Water Resources and Water Deficits/Water Demands (LVNCA)

Description	2010	2030
Available Water Resources (MCM/year)	4,742	5,077
Water Demands (MCM/year)	228	1,337
Water Demands/Available Water Resources	5%	26%
Water Deficits (MCM/year)	27	371
Water Deficits/Water Demands	12%	28%

Source: JICA Study Team (Ref. Main Report Part B, Section 3.4 (1) and Sectoral Report (G), Sub-section 3.4.2)

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 sharply increase to 26% of the available water resources in 2030. This ratio is known as a water stress ratio, and the ratio of more than 40% is regarded to indicate the severe water stress. LVNCA is not in the severe water stress in general. It can be said therefore that there is a potential to increase the irrigation water demand for 2030 mentioned above through appropriate water resources development to utilise the water resources as much as possible.

The above table also shows the estimated water deficits of 27 MCM/year in 2010 and increased deficits of 371 MCM/year in 2030. The appropriate water resources development is inevitable for satisfying the demands.

The water balance study was carried out based on the proposed water resources development plans of the related subsectors described in the following sections. The water demands that can be covered by the available water resources are presented in Table 7.2.1. The allocated amounts of surface water and groundwater to satisfy the 2030 water demands are as follows:

Water Resources Allocation Plan for Water Demands in 2030 after Water Balance Study (LVNCA)

(Unit: MCM/year)

Subsector	Water Demand (2030)	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. Main Report Part B, Section 3.4 (3) and Sectoral Report (G), Sub-section 4.4.3 (2))

It was concluded that the provisional target of new irrigation development area of 90,786 ha for 2030 can be extended to 168,913 ha from the viewpoint of the available water resources as stated in Sections 6.5 and 7.5.

The above mentioned water resources allocation plan should be the base data for future water resources management plan of the LVNCA.

7.3 Water Supply Development Plan

(1) Current Situation of Water Supply

Current population of LVNCA in 2010 is estimated to be 6.96 million, including an urban population 1.53 million and a rural population of 5.43 million. The LVNCA has the highest population density among the six catchment areas. The 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 population in 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, ponds without proper treatment are categorised as an unimproved drinking water source. Around 23% of the population gets drinking water from such unimproved drinking water sources. Also, around 66% of the population gets water from springs, wells or 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 ones is not known.

It is projected that urban population will increase by 6.18 million, the rural population will decrease by 0.78 million and the total population will be 12.36 million in 2030. Currently, piped water supply covers 31% of the urban population of LVNCA, of which the target coverage ratio for 2030 is 100%. It is therefore required to implement a large-scale urban water supply system development to cope with rapid growth of the urban population and achieve the target coverage ratio of 100%.

(2) Development Strategy

A large percentage of the population is using groundwater and spring water in LVNCA. In addition, the surface water resources originating from Mt. Elgon and Cherngani Hills were abandoned in this area. The urban water supply systems (UWSS) are primarily designed to get surface water, and the rural water supply systems are planned to use groundwater with priority.

Based on the overall concept mentioned in Section 6.3, UWSS are planned for 32 urban centres (UC) in LVNCA. The water supply capacity required for UWSS in LNVCA in 2030 is 782,000 m^3/day against the current water supply capacity (including capacity under construction) of 135,000 m^3/day. Therefore, additional capacity of 647,000 m^3/day is to be developed by 2030. It is to be developed through the following three types of projects.

a) Rehabilitation of existing UWSS: In order to achieve 20% of NRW ratio, water meters are to be installed for all households and old pipes of existing UWSS of the 20 UCs, which has a water supply capacity of 135,000 m^3/day, are to be replaced. In addition, the rehabilitation will include 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 above 20 UCs to meet the water demand in 2030. The total capacity of expansion is 556,000 m^3/day.
c) Construction of new UWSS: The construction of new UWSS is planned for the 12 UCs which have no UWSS. The total capacity of new construction is 91,000 m^3/day.
d) According to data from WSBs, there are 12 plans of urban water supply development projects to cover nine UCs and surrounding areas in LVNCA[15], which have 45,000 m^3/day of total water supply capacity. These plans are to be taken into account for planning.

Based on the overall concept mentioned in Section 6.3, rural water supply systems are planned to be developed by LSRWSS and SSRWSS.

a) Development of LSRWSS: LSRWSS is proposed mainly for areas with high population density or areas with difficulties in groundwater use on a personal or community basis. LSRWSS is to be developed for 1.78 million residents in the 11 counties of LVNCA.
b) Development of SSRWSS: SSRWSS is proposed for 4.01 million residents in 11 counties of LVNCA, and it includes construction and improvement of boreholes, wells, and springs on a personal and community basis. As this type of works is to be implemented on a personal and community basis, only the water demand projection is carried out for SSRWSS in the master plan.

[15] Refer to Sectoral Report (C), Section 2.4

(3) Proposed Water Supply Development Plan

In accordance with the development strategy above, the proposed UWSS is presented in Table 7.3.1, and the proposed LSRWSS and SSRWSS are shown in Tables 7.3.2 and 7.3.3, respectively. Figure 7.3.1 shows urban centers subject to urban water supply system development.

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

Proposed Water Supply Development Plan (LVNCA)

Type of Project		Target Area	Total Capacity (m^3/day)	Service 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 (Prepared based on Tables 7.3.1 to 7.3.3)

By the above water supply development plan, the water supply situation of LVNCA in 2030 will be improved 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		32 UC	11 Counties		--

Source: JICA Study Team (Figures for 2010 were prepared by reference to Sectoral Report (C), Section 2.3. Figures for 2030 were prepared based on Tables 7.3.1 to 7.3.3.)

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 presented in Tables 7.7.1 and 7.7.2, as the result of the water balance study.

7.4 Sanitation Development Plan

(1) Current Situation of Sanitation Development

Based on the Census 2009 data, 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, Cesspool (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 limited areas in LVNCA and current sewerage coverage ratio is only 2%. There are eight small-scale waste water treatment plants with a total treatment capacity of about 21,000 m^3/day. Around 94% of the population use on-site treatment facilities such as septic tanks, etc. The on-site treatment facilities include unimproved ones, but the ratio of the unimproved facilities is not known. Around 4% of the population does not have any treatment facilities and resort to unsanitary waste disposal.

(2) Development Strategy

Based on the overall concept described in Section 6.4, sewerage system development is planned for 19 UCs in LVNCA. The sewerage system development is conducted through the following three types of projects:

a) Rehabilitation of existing sewerage system: Rehabilitation includes the repair and replacement of mechanical and electrical equipment of wastewater treatment plants (WWTPs) and pumping stations, and replacement of corroded sewer pipes in 7 UCs, which have sewerage systems with a total capacity of 21,000 m^3/day.
b) Expansion of sewerage system: In order to cover the demand in 2030, capacities of existing sewerage systems of 7 UCs are to be expanded. This includes expansion and/or new construction of sewerage pipes, pumping stations, and WWTPs. The total capacity of expansion is 230,000 m^3/day.
c) Construction of New Sewerage System: There are no sewerage systems in 12 UCs. New sewerage systems are to be constructed in those 12 UCs with total capacity of 209,000 m^3/day.
d) 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[16]. These plans are to be taken into account for planning.

Following the development strategy above, for outside the sewerage service area, improved on-site treatment facilities will be available for the remaining 6.33 million residents in 2030. Currently, 6.64 million residents (94% of the entire population) are using existing on-site treatment facilities, but unimproved ones are to be improved with new housing construction. Development of on-site treatment facilities is planned for 11 counties in LVNCA.

[16] Refer to Sectoral Report (D), Section 2.4

(3) Proposed Sanitation Development Plan

The sewerage development plan is shown in Table 7.4.1 and the on-site treatment development plan is shown in Table 7.4.2. Figure 7.3.1 shows urban centers subject to sewerage system development. 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 (Prepared based on Tables 7.4.1 and 7.4.2)

Out of 7.77 million of the urban population in LVNCA, 78% is expected to be covered by the sewerage system. It is almost equal to 80% of the national target of sewerage coverage ratio. By the above sanitation development, the sanitation situation of LVNCA in 2030 will be improved for 2010 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 UC	11 Counties

Source: JICA Study Team (Figures for 2010 were prepared by reference to Sectoral Report (D), Section 2.3. Figures for 2030 were prepared based on Tables 7.4.1 and 7.4.2.)

7.5 Irrigation Development Plan

(1) Current Situation of Irrigation Development

LVNCA receives the highest annual rainfall in Kenya and blessed with ample water resources for irrigation. The cropping area in 2011 was 776,811 ha, and mostly falls under rainfed agricultural areas with lower crop productivity. The existing irrigation area in LVNCA in 2010 was only 1876 ha, consisting of 363 ha (19%) of public irrigation schemes, 1,327 ha (71%) of smallholder irrigation schemes, and 186 ha (10%) of private schemes. The share of irrigation area against cropping area is only 0.2%. Existing large and small-scale irrigation systems need repair and rehabilitation of deteriorated facilities due to insufficient maintenance.

(2) Development Strategy

Following the overall concept and frameworks for irrigation development mentioned in section 6.5, strategy for irrigation development in LVNCA was set as follows:

a) Owing to ample river water resources available for irrigation in LVNCA, priority should be given to weir irrigation to use river water to maximise irrigation area, and then to dam irrigation and groundwater irrigation as long as water resources are available.

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

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

(3) Proposed Irrigation Development Plan

As a result of the water balance study by sub-basins in LVNCA, possible irrigation development areas under application of the water-saving irrigation methods were estimated as summarised below.

Possible Irrigation Area in 2030 (LVNCA)

(Unit: ha)

Type of Irrigation	Existing Irrigation Area in 2010	New Irrigation Area in 2030						Total Irrigation Area in 2030
		Surface Water Irrigation			Groundwater Irrigation	Water Harvesting Irrigation	New Irrigation Total	
		River Water	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. Main Report Part B, Sub-section 4.4.3)

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 6.5, the possible new irrigation development area comes to 168,913 ha (increase of 78,127 ha) with maximum water resources development presented in Section 7.7. Table 7.5.1 shows the maximum irrigation area by catchment area in 2030.

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 6.5.1 were taken up for the water balance study, and six projects listed in Table 7.5.2 (78,370 ha in total) were selected as the possible projects in LVNCA from a viewpoint of surface water resources availability for irrigation. The locations of the selected projects are shown in Figure 7.5.1. Among them, the large scale irrigation projects more than 5,000 ha are as follows.

a) Lower Nzoia Irrigation Project (10,470 ha, weir and Nzoia 42A multipurpose dam)
b) Lower Sio Irrigation Project (6,600 ha, Weir)
c) Upper Nzoia Irrigation Project (24,000 ha, Nzoia 34B multipurpose dam)
d) Moi's Bridge Irrigation Project (19,800 ha, Moi's Bridge multipurpose dam)
e) Kibolo Irrigation Project (11,500 ha, Kibolo multipurpose dam)

The irrigation water demand for the above new irrigation development and existing irrigation was estimated at 1,359 MCM/year as given in Table 7.2.1.

7.6 Hydropower Development Plan

(1) Current Situation of Hydropower Development

In LVNCA, there is only one existing hydropower station, the Sosiani Small Hydropower Station (400 kW) in Sosiani River, in upstream area of the tributary of Nzoia River. There are no large hydropower stations with more than 10 MW installed capacity in LVNCA. Although the amount of water resources in the catchment area is abundant, there have been no sufficient studies conducted for hydropower development since 1990. Since the catchment area is a densely populated area, it is necessary to take care of social and environmental aspects when formulating hydropower development plans.

(2) Development Strategy

As there is no plan taken up in the Least Cost Power Development Plan (LCPDP) in LVNCA, the hydropower component of multipurpose-type development scheme is to be taken up based on the overall concept and frameworks as mentioned in Section 6.6. Hydropower components of multipurpose dam development plans in the major rivers of Nzoia and Yala are to be taken up as hydropower development plan of LVNCA.

(3) Proposed Hydropower Development Plan

Based on the above development strategy, the proposed hydropower development plan consists of the following three plans which are the hydropower components of multipurpose dam development projects in LVNCA. The locations of the proposed hydropower development sites are shown in Figure 7.6.1.

Proposed Hydropower Development Plan (LVNCA)

Plan	River	Installed Capacity	Purpose
Nzoia (34B) Multipurpose Dam Development Plan	Nzoia River	16 MW	Water Supply, Irrigation, Flood Control, Hydropower
Nzoia (42A) Multipurpose Dam Development Plan	Nzoia River	25 MW	Flood Control, Hydropower
Nandi Forest Multipurpose Dam Development Plan	Yala River	50 MW	Water Supply, Irrigation, Hydropower
Total		91 MW	

Source: JICA Study Team, based on information from MORDA and LBDA. (Ref. Main Report Part B, Sub-section 4.5.3)

Of the above proposed plans, the levels of the studies for Nzoia (34B) and Nzoia (42A) seem to be low. Additional studies are required to confirm the planned installed capacity and amount of power generation.

7.7 Water Resources Development Plan

(1) Current Situation of Water Resources Development

LVNCA has a total catchment area of 18,374 km^2 (3.2% of the county), and an annual average rainfall of 1,420 mm which is the largest among the six WRMA catchment areas. The available water resources estimated in LVNCA for 2010 (present) are 4,626 MCM/year for surface water and 708 MCM/year for groundwater. The available surface water resources for 2030 were estimated to

increase to 4,969 MCM/year considering the effect of climate change, while the available groundwater resources is 704 MCM/year which is almost same as the amount of 2010.

The present (2010) water demands in LVNCA were estimated to be 228 MCM/year, which consist mainly of domestic water demands for the population of 6.96 million (18.1% of national population) distributed over the catchment area. Among 32 urban centres situated in the catchment area, 20 centres have water supply systems. About 66% of the population are supplied with groundwater. Rainfed agriculture has been developed because of abundant rainfall, and the existing irrigation area is only 1,876 ha.

The existing water resource structures/facilities except for direct intake facilities from the rivers to satisfy the present water demands are: i) five dams (all for domestic water supply, with total storage volume of 24 MCM); ii) an intra-basin and an inter-basin water transfer facility; iii) 270 small dams/water pans (for domestic and livestock water supply, with total storage volume of 8 MCM); and iv) 1,776 boreholes (mainly for domestic water supply, with total abstraction volume of 41 MCM/year). There is no dam under construction. The values of present water supply reliability in LVNCA were estimated by the water balance study to be 1/7 at the reference point of Webuye (1DA02) in Nzoia River and 1/7 at Bondo (1FG01) in Yala River under the condition of existing water resource structures/ facilities mentioned above.

(2) Development Strategy

As mentioned in Sections 7.3 and 7.5, the projected 2030 water demand of 2,048 MCM/year shows a large increase of about 9.0 times compared to the present demand due to considerable increase in population to 12.36 million and irrigation areas to 193,551 ha expected by the year 2030 in LVNCA. Judging from the estimated 2030 water deficits discussed in Section 7.2, it is certain that the existing water resource structures/facilities will not be able to satisfy the greatly increased 2030 water demand because of the uneven distribution of water resources both spatially and temporally. Therefore, new water resource structures/facilities are required to be developed.

Strategies for the water resources development in LVNCA were enumerated below to formulate the well balanced development plan between water resources and demands, based on the overall concept and framework for the planning as stated in Section 6.7 and the current situation of the catchment area and future water demands.

a) Since surface water is abundant over the catchment area, the development plan focuses on the maximum exploitation of surface water.
b) The existing intra-basin water transfer facility from Moiben Dam to Eldoret/Iten is to be included in the development plan to satisfy future domestic water demands in the area. Also, the plan of inter-basin transfer from the Nandi Forest multipurpose dam in LVNCA to LVSCA is taken into account 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 Section 8.2 for LVSCA.
c) Dam development is essential and to be promoted over the catchment area to satisfy large future water demands such as domestic, industrial and irrigation water demands in the entire catchment area. Candidates for dam development for maximum surface water exploitation

include, in principle: i) dams proposed by the NWMP (1992), and ii) dams under the design and/or planning stage by the government including the Kenya Vision 2030 flagship projects.

d) Small dams and/or water pans are to be constructed in small rivers throughout 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 possible for large dams but where surface water is available.

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

(3) Proposed Water Resources Development Plan

The water balance study was carried out for 2030 between the available water resources and water demands in LVNCA based on the overall concept and framework for the planning and development strategy. As a result of the water balance study, the required new water resource structures/facilities in addition to direct intake facilities from rivers are as follows:

Existing Structures/Facilities and Proposed Water Resources Development Plan (LVNCA)

Structure		No.	Purpose	Dimension/ Capacity	Remarks
Dam	Existing	5	Domestic	Total storage volume of 24 MCM	
	Proposed	7	Domestic, industrial, irrigation, hydropower and flood control	Total storage volume of 1,080 MCM	
Intra-basin Water Transfer	Existing	1	Domestic	Transfer volume of 5 MCM/year from Moiben Dam to Eldoret/ Iten (including existing inter-basin)	
	Proposed	1	Domestic	Transfer volume of 5 MCM/year from Moiben Dam to Eldoret/ Iten	Expansion
Inter-basin Water Transfer	Existing	1	Domestic	Moiben Dam to Tambach	
	Proposed	1	Domestic, irrigation and hydropower	Transfer volume of 189 MCM/year from Nandi Forest Dam to LVSCA	
Small Dam/ Water Pan	Existing	270	Domestic and livestock	Total storage volume of 8 MCM	
	Proposed	3,620	Rural domestic, livestock, irrigation, wildlife and fisheries	Total storage volume of 181 MCM	
Borehole	Existing	1,776	Domestic	Total abstraction of 41 MCM/year	
	Proposed	560	Domestic, industrial and irrigation	Total abstraction of 56 MCM/year	

Note: The water supply reliability applied in the plan is 1/10 for domestic and industrial use and 1/5 for irrigation use.
Source: JICA Study Team (Main Report Part B, Sub-sections 4.6.1 and 4.6.3)

A list of the proposed dams is represented in Table 7.7.1 and a list of the proposed water transfer facilities is shown in Table 7.7.2. Figure 7.7.1 illustrates locations of the dams and water transfer facilities.

The water demand and supply balance for 2030 in LVNCA under the condition of proposed water resources development structures mentioned above is summarised in Table 7.7.3.

The water supply reliabilities for 2010 and 2030 at the reference points proposed for water resources management in LVNCA are estimated as below:

Water Supply Reliability at Reference Point (LVNCA)

Reference Point	Present Water Supply Reliability (2010) (with Existing Facilities)	Future Water Supply Reliability (2030) (with Existing and Proposed Facilities)
Nzoia River (1DA02), Webuye	1/7	1/5
Yala River (1FG01), Bondo	1/7	1/10

Source: JICA Study Team (Ref. Sectoral Report (G), Section 4.4)

The future water supply reliability in 2030 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, while that of Bondo in Yala River is 1/10 as the 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 6.1 (1). Appropriate water resources development and management will be required to maintain the target reliability.

The naturalised flows, reserves, water demands, yields and water supply reliabilities at the reference points are presented in Table 7.7.4. Estimated river flows for 2010 and 2030 are illustrated in Figure 7.7.2 for the reference points in LVNCA.

The proposed water resources development plan listed above is a basis of the proposed water resources allocation plan for 2030 water demands stated in Section 7.2.

7.8 Water Resources Management Plan

(1) Current Situation of Water Resources Management

Water resources monitoring systems in LVNCA are established, covering the major rivers of Nzoia and Yala. As for the current monitoring situation, the ratio of actual monitoring stations against the WRMA's target is 75% (21 stations) for surface water level, 69% (9 stations) for groundwater level and 80% (52 stations) for rainfall as presented in Table 6.8.1. The current monitoring is relatively well executed.

Water resources evaluation is not being properly done using the above monitored data, therefore it is necessary to establish a system to evaluate water resources in the catchment area.

Water permit issuance and control is relatively well managed as the ratio of effective water permit/issued permit is 71% (surface water 67%, groundwater 79%), however further improvement is necessary.

For watershed conservation, Mt. Elgon, Cherangani Hills and Mau Forest Complex of the Five Water Towers, are major water sources of Nzoia and Yala rivers. Decrease in forest areas is significant in these water source forests. According to the analysis conducted in this study[17], about 30% of forest area has disappeared in LVNCA since 1990. In addition, soil erosion control due to deforestation is an issue in this catchment area.

(2) Management Strategy

Based on the overall concept and frameworks mentioned in Section 6.8, strategy for water resources management in LVNCA is to be considered for four major aspects of: a) monitoring, b) water resources evaluation, c) water permit issuance and control, and d) watershed conservation as described hereunder:

[17] Refer to Sectoral Report (B), Section 8.3.

1) Monitoring

Monitoring items are surface water, groundwater and rainfall. For the surface water and groundwater, water quantity and quality are monitored. To make the current monitoring system more effective, review is to be made on surface water monitoring stations of major rivers of Nzoia and Yala and major tributaries. 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.

Rainfall monitoring stations are to be reviewed considering the climate division (humid area) of the catchment area and corresponding rainfall station density to establish proper monitoring system.

Groundwater monitoring stations are to be set at areas where groundwater demand will increase in the future, namely, areas that have both water supply development plan and sewerage development plan. In such areas, groundwater is to be monitored using dedicated boreholes for monitoring.

2) Evaluation of Water Resources

As mentioned in the overall concept and frameworks in Section 6.8, regional offices should enhance the capacity for evaluation of water resources in both quantity and quality so as to determine available water resources for water permit issuance based on the monitored data, and to judge necessity of water resources development.

3) Water Permit Issuance and Control

Based on the overall concept mentioned in Section 6.8, in preparation of increased water demand in the future, the latest version of the issued water permits is to be maintained to enable accurate control of issued water permits that reflect the current water use. In addition, revision of standards such as "Guidelines for Water Allocation (WRMA, First Edition, March 2010)" is to be considered to enable issuance of water permits that reflect the current water use and available water resources. Furthermore, in view of the current working conditions in the issuance of water permits in regional offices, water rights officers in charge of water permit issuance and control are to be increased for regional/subregional offices for smooth work.

4) Watershed Conservation

Based on the overall concept and frameworks mentioned in Section 6.8, forest recovery is to be implemented through reforestation focusing on Mt. Elgon, Cherangani Hills, and the Mau Forest Complex. Furthermore, preventive measures for soil erosion caused by deforestation in this catchment area are to be considered.

(3) Proposed Water Resources Management Plan

Based on the management strategy mentioned above, the water resources management plan proposed for LVNCA is as follows:

1) Monitoring

Proposed layout of monitoring stations for surface water, groundwater, rainfall and reference point is shown in Figures 7.8.1 and 19.1.2. Water quantity and quality are monitored at surface water monitoring and groundwater monitoring stations, while rainfall amount is monitored at rainfall monitoring stations. WRMA's target number and the proposed number of monitoring stations are shown in Table 6.8.1.

In view of covering representative locations of major rivers, lakes and springs, current layout of the surface water monitoring stations were reviewed. Proposed surface water monitoring stations are 15 stations in Nzoia River and six stations in Yala River as major rivers in the catchment area, and one station each in the Sio, Malaba, and Malakisi international rivers. In total, 24 stations are proposed against WRMA's target number of 28 for surface water monitoring network in LVNCA. In addition, the reference points representing the flow conditions of major rivers were set at two representative surface water monitoring stations, one each for the Nzoia and Yala rivers as shown in Figure 19.1.2.

Based on the overall concept described in Section 6.8 (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 of Nzoia and Yala rivers.

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. Sectoral Report (H), Sub-section 3.3.2)

The above normal discharges are to be reviewed and revised as necessary in the "Evaluation of Water Resources" 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.

As a result of the review based on the overall concept mentioned in Section 6.8 (2), 42 rainfall monitoring stations are proposed against WRMA's target number of 65.

As for groundwater monitoring stations, 19 locations which are 19 urban centers having both a water supply development plan and a sewerage development plan in this study are proposed for monitoring against WRMA's target number of 13 considering increase of groundwater demand toward future. Groundwater monitoring is to be conducted using dedicated boreholes.

2) Evaluation of Water Resources

As for the enhancement of water resource quantity evaluation system, an evaluation team is to be formed by assigning a chief hydrologist from LVNCA regional office in Kakamega as the leader and assistant hydrologists from each subregional office of Kitale, Eldoret, and Siaya as members. The evaluation team will target the whole area of LVNCA to evaluate water resources of the catchment area once a year on the items mentioned in Section 6.8 (2) b).

For water resource quality evaluation, the existing water quality testing laboratory in Kakamega is to be maintained with adequate number of water quality experts and a system for proper evaluation of qualities of surface water and groundwater at a monitoring time should be established.

3) Water Permit Issuance and Control

As for water permit issuance and control, the following activities are proposed:

a) To maintain the latest version of the issued water permits through periodic updating of the water permit database and establishment of a notification system for permit expiry;
b) To revise standards of WRMA such as "Guidelines for Water Allocation (WRMA, First Edition, March 2010)" based on future water demands and available water resources; and
c) To enable smooth water permit issuance and control, it is proposed to increase water rights officers of LVNCA regional office in Kakamega and Kitale, Eldoret, and Siaya subregional offices from the current five to seven by adding two additional officers, one additional water right officer each in Eldoret and Siaya subregional offices.

4) Watershed Conservation

For reforestation for forest recovery, about 230,000 ha of reforestation is proposed for LVNCA to achieve the target of the Kenya Vision 2030. Of the target, gazetted forest is supposed to be implemented by Kenya Forest Service (KFS). Figure 6.8.1 shows the existing forested area and potential reforestation areas.

As for control of soil erosion, it is proposed to conduct surveys for target locations first to formulate plans.

7.9 Flood and Drought Disaster Management Plan

(1) Current Situation of Flood Disaster Management

LVNCA as well as LVSCA has been the most vulnerable area to flood disasters in Kenya. Due to this historical background, Western Kenya Community Driven Development & Flood Mitigation Project (WKCDD&FMP) has been implemented since 2007. The project is implemented based on the concept of integrated flood disaster management consisting of various components including construction of multipurpose dam, construction and rehabilitation of dykes, river improvement works, establishment of FEWS, etc. It is therefore expected that flood damages will be mitigated by those structural and non-structural measures in the future once the project has been completed.

Although the project is still on-going, there have already been some issues on operation and maintenance such as theft or failure of monitoring equipment. In addition, although FEWS has been developed through cooperation among WRMA LVNCA Regional Office, Kenya Meteorological Department (KMD), and National Disaster Operation Centre (NDOC), a post-project operation plan has not been determined yet.

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 of the Nzoia River, and 9 km on the right bank of the Yala River. They have contributed to flood control against normal floods. However, it was recorded that those dykes were breached by the large-scale flood in 2008. At the time, it is even said that inadequate flood fighting activities have resulted in the expansion of inundated areas.

(2) Current Situation of Drought Disaster Management

Drought damages have not been reported in LVNCA. There are five existing dams for domestic water supply purposes. A drought disaster management program, including water use restriction of the reservoirs, has not been implemented.

(3) Flood Disaster Management Strategy

As explained in the overall concept e) mentioned in Section 6.9, the proposed examination area in LVNCA is Yala Swamp only. It is expected that the critical areas in Yala Swamp will be protected by structural measures to be constructed through on-going WKCDD&FMP. Also, CBDM is being established through the project as measures to mitigate damage caused by floods exceeding a design level.

Therefore, the flood disaster management strategy for Yala Swamp is to incorporate the structural measures planned by WKCDD&FMP into NWMP 2030 and non-structural measures to focus on operation and maintenance issues for the existing and on-going flood disaster management measures.

(4) Drought Disaster Management Strategy

Based on the overall concept mentioned in Section 6.9, drought disaster management strategy for LVNCA includes: i) preparation of water use restriction rules for existing and proposed reservoir, ii) establishment of Basin Drought Conciliation councils, and iii) establishment of drought early warning system.

(5) Proposed Flood and Drought Disaster Management Plans

Based on the management strategy mentioned above, the flood disaster management plan for LVNCA is proposed as follows:

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 WRMA LVN Regional Office in collaboration with KMD;
c) Preparation of flood fighting plan for both the existing and planned dykes along the lower reaches of the Nzoia and Yala Rivers.

Based on the management strategy mentioned above, the drought disaster management plan for LVNCA is proposed as follows:

a) Preparation of water use restriction rules for reservoirs of five existing and seven proposed dams including setting of reference reservoir water level, and determination of reduction rate,
b) Monitoring of reference water levels which correspond to reserve or normal discharge (this work is to be implemented as a part of water resources management plan),
c) Establishment of two Basin Drought Conciliation Councils with legal status on the basis of a river basin unit, and
d) Establishment of drought early forecast system specialised for water use restriction, that are linked to expected fluctuation of water storage of 12 reservoirs mentioned above.

Figure 7.9.1 shows the proposed flood disaster management plan and drought disaster management plan.

7.10 Environmental Management Plan

(1) Current Status of Environmental Management

Major rivers of LVNCA are the Nzoia and Yala rivers. They flow into Lake Victoria which is the largest freshwater lake in Africa. WRMA has monitoring points for river flow rate and water quality for the rivers. However, the current data is not enough to confirm the time-dependent change of the water environment.

In Lake Victoria, which is one of the main water resources for LVNCA, destruction of ecosystems by invasive alien species, water pollution and eutrophication caused by inflow of sewage, and drawdown due to rainfall decrease are observed. Water resource development projects such as Yala swamp irrigation project might affect the eutrophication of Lake Victoria and fish species upstream in rivers. It is necessary to monitor the situation through environmental monitoring.

Mt. Elagon and Cherangani Hills, which are water resources of the Nzoia River and a part of Mau Forest Complex, which is a water resource of the Yala River, are located in the northern part of LVNCA. These three forests are included in the Five Water Towers, regarded as the most important water resource forests of Kenya, but they have been destroyed by illegal logging and encroachment due to population growth. The deforestation has affected water resource conservation.

For formulation of the water resources development plans in LVNCA, the careful considerations on social and environmental impacts by the development are required as the population density in the catchment area is high.

(2) Management Strategy

Based on the overall concept mentioned in Section 6.10, it is proposed to set environmental flow rate and to carry out environmental monitoring in main rivers and lakes in LVNCA.

The water resource development projects in NWMP 2030 are mostly proposed on the Nzoia and Yala rivers as main rivers of LVNCA. Therefore, setting of environmental flow rate and environmental

monitoring are proposed for these two rivers. In addition, environmental monitoring is also proposed for Lake Victoria which is facing water environment degradation.

(3) Proposed Environmental Management Plan

Based on the management strategy mentioned above and selection criteria of environmental flow rate setting point and environmental monitoring point mentioned in the overall concept, the proposed environmental flow rate setting and environmental monitoring of environmental management plan for LVNCA are shown in the following table. Locations of the proposed points are shown Figure 7.10.1.

Environmental Flow Rate Setting Points and Environmental Monitoring Points (LVNCA)

Target	Setting Point			Proposed Major Development Projects
Nzoia River	Environmental flow rate	1	Lower reach in the Nzoia River : LVN-F1	Nzoia (42A) and Teremi dams
		2	Reference point (Webuye Town) : LVN-F2	Nzoia (34B) and Kibolo dams
		3	Moi's Bridge Town : LVN-M3	Siyoi and Moi's Bridge dams
	Environmental monitoring	4	Lower reach in the Nzoia River : LVN-M1	Nzoia (42A) and Teremi dams
		5	Reference point (Webuye Town) : LVN-M2	Nzoia (34B) and Kibolo dams
Yala River	Environmental flow rate	1	Reference point (Yala Town) : LVN-F4	Nandi Forest Dam, Yala Swamp irrigation
		2	Lower reaches of the Nandi Forest Dam: LVN-F5	
	Environmental monitoring	3	Yala swamp : LVN-M3	
Lake Victoria	Environmental monitoring	1	Nearly inflow point of the Nzoia River : LVN-M4	-
		2	Nearly inflow point of the Yala River : LVN-M5	

Source: JICA Study Team (Ref. Main Report Part B, Sub-section 4.9.3)

In addition, environmental survey for setting of environmental flow rate (river discharge, water quality and river ecosystem) should be conducted for Nzoia and the Yala rivers.

8. LAKE VICTORIA SOUTH CATCHMENT AREA

8.1 Catchment Area Characteristics

LVSCA is located at the south-western part of the country as shown in Figure 1.3.1. LVSCA borders on the LVNCA in the north, RVCA in the east, Tanzania in the south and Lake Victoria in the west. The Mau Forest Complex of Five Water Towers[18] lies in the north-eastern part of the area. Total area of LVS is 31,734 km^2, corresponding to 5.5% of the country's land area. Based on the Census 2009, 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, with Mt. Londiani Peak in the Mau Forest at 3,009 m amsl to Lake Victoria at 1,134 m amsl. The whole area of LVSCA lies in the highland at elevations greater 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 6843 km^2, respectively. The total drainage area of these three rivers accounts for 43.9% of LVSCA. The Mara River flows through Masai Mara National Reserve across the border with

[18] The 'Five Water Towers' of Kenya, namely, the Mt. Kenya, the Aberdare Range, the Mau Forest Complex, the Mt. Elgon, and the Cherangani Hills- are montage forests and the five largest forest blocks in the country. They are situated in the upper catchments of all the main rivers in Kenya except the Tsavo River. Refer to Sectoral Report (K), Sub-section 2.3.1 (5).

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 fresh water lake in the world and strides the borders of Kenya, Tanzania, and Uganda.

The LVSCA is classified as non-ASAL. The mean annual rainfall ranges between 1,200 mm to 1,800 mm and the catchment area average mean annual rainfall is 1,280 mm. The renewable water resources, which is defined as precipitation minus evapotranspiration, is estimated at 7.07 BCM/year in 2010 for LVSCA and the per capita renewable water resources of LVSCA is calculated at 959 m^3/year/capita.

8.2 Water Resources, Water Demands and Water Allocation

The available water resources were estimated in LVSCA for the years of 2010 (present) and 2030 (future) as explained in Section 4.4 and summarised below. The estimate for 2030 includes impacts of climate change.

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
Ratio of 2030 to 2010	120%	93%	119%

Source: JICA Study Team (Ref. Main Report Part C, Section 3.2)

The annual water demands were estimated for the year 2010 and projected for 2030 in LVSCA as described in Section 5.2 and summarised below. The projection for 2030 followed the national development targets of Kenya Vision 2030 and socioeconomic framework, but without considering the available water resources.

Water Demands by Subsector (LVSCA)

Year	Water Demands (MCM/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 C, Section 3.3)

In order to assess severity of water balance, ratios of available water resources and water demands presented above and those of water demands and water deficits discussed in Section 5.3 are tabulated for both 2010 and 2030 as follows:

Ratios of Water Demands/Available Water Resources and Water Deficits/Water Demands (LVSCA)

Description	2010	2030
Available Water Resources (MCM/year)	4,976	5,937
Water Demands (MCM/year)	385	2,953
Water Demands/Available Water Resources	8%	50%
Water Deficits (MCM/year)	150	1,304
Water Deficits/Water Demands	39%	44%

Source: JICA Study Team (Ref. Main Report Part C, Section 3.4 (1) and Sectoral Report (G), Sub-section 3.4.2)

Although the present water demands in 2010 are estimated to be 8% of the available water resources (water stress ratio), the water demands for 2030 are expected to increase drastically, going up to 50% of the 2030 available water resources. As the water stress ratio in 2030 is over 40%, LVSCA will be in the severe water stress in the future. The above table also shows the estimated water deficits of 150 MCM/year in 2010 and increased deficits of 1,304 MCM/year in 2030. The irrigation water demand, representing about 79% of the total demand, needs to be reduced to attain the appropriate water balance as well as proper water resources development.

The water balance study was carried out based on the proposed water resources development plans of the related subsectors described in the following sections. The water demands that can be covered by the available water resources are presented in Table 7.2.1. The allocated amounts of surface water and groundwater to satisfy the 2030 water demands are as follows:

Water Resources Allocation Plan for Water Demands in 2030 after Water Balance Study (LVSCA)

(Unit: MCM/year)

Subsector	Water Demand (2030)	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 (Ref. Main Report Part C, Section 3.4 (3) and Sectoral Report (G), Sub-section 4.5.3 (2))

Because of limited water resources, it was concluded that interim target of new irrigation development area of 186,978 ha for 2030 needed to be reduced to 113,206 ha as stated in Sections 6.5 and 8.5.

The abovementioned water resources allocation plan should be used as a base data for the future water resources management plan of the LVSCA.

8.3 Water Supply Development Plan

(1) Current Situation of Water Supply

The current population of LVSCA in 2010 is estimated at 7.37 million including an urban population of 1.85 million and a rural population of 5.52 million. The population is concentrated in Kisumu, Kisii and their surrounding areas. Based on the 2009 census data, the current situation of water connection of population in 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 taken from streams, lakes and ponds without proper treatment are categorised as unimproved drinking water sources. Around 48% of the

population get drinking water from such unimproved drinking water sources. Also, around 41% of the population get water from springs, wells or boreholes. On the other hand, unprotected wells and springs are also categorised as an unimproved drinking water sources, but the utilisation ratio of unprotected ones is not known.

It is projected that the urban population will increase by 6.14 million, the rural population will decrease by 0.79 million and the total population will be 12.72 million in 2030. Currently, piped water supply covers 26% of the urban population of LVSCA, 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 rapid growth of the urban population and achieve the target coverage ratio of 100%.

(2) Development Strategy

LVSCA is divided into three areas such as Kisumu, Kisii and the surrounding area for UWSS planning considering the characteristics of the three areas.

Based on the overall concept mentioned in Section 6.3, UWSS are planned for 25 urban centres (UC) in LVSCA. As for six UCs in Kisumu and its surrounding area and seven UCs in Kisii and its surrounding area, one water supply system is planned to cover several UCs. The remaining 12 UCs are planned to have independent water supply systems.

The water supply capacity required for UWSS in LNSCA is 785,000 m^3/day in 2030 against the current water supply capacity (including capacity under construction) of 120,000 m^3/day, so an additional capacity of 664,000 m^3/day needs be developed by 2030. It is to be developed through the following three types of projects:

a) Rehabilitation of existing UWSS: In order to achieve 20% NRW ratio, water meters are to be installed for all households and old pipes of existing UWSS of 21 UCs, which have 120,000 m^3/day of water supply capacity, are 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 21 UCs to meet the water demand in 2030. The total capacity of expansion is 570,000 m^3/day.
c) Construction of new UWSS: The construction of new UWSS are planned for 4 UCs which have no UWSS. The total capacity of new construction is 94,000 m^3/day.
d) According to data from WSBs, there are 27 plans of water supply development projects to cover 21 UCs and surrounding areas in LVSCA[19], which have 301,000 m^3/day of total water supply capacity. These plans are to be taken into account for planning.

Based on the overall concept mentioned in Section 6.3, the rural water supply systems are planned to be developed using LSRWSS and SSRWSS.

a) Development of LSRWSS: LSRWSS is proposed mainly for areas with high population density or areas with difficulties of groundwater use on a personal or community basis. LSRWSS is to be developed for 2.67 million residents in 14 counties of LVSCA.

[19] Refer to Sectoral Report (C). Section 2.4.

b) Development of SSRWSS: SSRWSS is proposed for 3.79 million residents in one county of LVSCA, and it includes construction and improvement of boreholes, wells, and springs on a personal and community basis. As this type of works is to be implemented on a personal and community basis, only the water demand projection is carried out for SSRWSS in the master plan.

(3) Proposed Water Supply Development Plan

Based on the development strategy mentioned above, the proposed UWSS is estimated as shown in Table 8.3.1, and the proposed LSRWSS and SSRWSS are in Tables 8.3.2 and 8.3.3, respectively. Figure 7.3.1 shows urban centers subject to urban water supply system development.

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

Proposed Water Supply Development Plan (LVSCA)

Type of Project		Target Area	Total Capacity (m^3/day)	Service 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 (Prepared based on Tables 8.3.1 to 8.3.3.)

Based on the above water supply development, the water supply situation of LVSCA in 2030 will be improved 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 prepared by reference to Sectoral Report (C), Section 2.3. Figures for 2030 were prepared based on Tables 8.3.1 to 8.3.3.)

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 presented in Tables 7.7.1 and 7.7.2, as the result of the water balance study.

8.4 Sanitation Development Plan

(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 limited areas in LVSCA and current sewerage coverage ratio is only 1%. There are four small-scale wastewater treatment plants, with total treatment capacity of about 20,531 m^3/day. Around 82% of the population use on-site treatment facilities such as septic tanks, etc. The on-site treatment facilities include unimproved ones, but the ratio of the unimproved facilities is not known. Around 17% of the population does not have any treatment facilities, and resort to unsanitary waste disposal.

(2) Development Strategy

Based on the overall concept and framework mentioned in Section 6.4, sewerage system development is planned for 19 UCs in LVSCA. Sewerage system development is conducted through 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, and replacement of corroded sewer pipes in three UCs, which have sewerage systems with a total capacity of 22,000 m^3/day.
b) Expansion of sewerage system: In order to cover the demand in 2030, capacities of existing sewerage systems of three UCs are to be expanded. This includes expansion and/or new construction of sewerage pipes, pumping stations, and WWTPs. The total expansion capacity is 171,000 m^3/day.
c) Construction of New Sewerage System: There is no sewerage system in 16 UCs. New sewerage systems are to be constructed in those UCs with a total capacity of 292,000 m^3/day.
d) According to data from WSBs, there are seven plans of sewerage development projects to cover seven urban centres in LVSCA, which have 53,000 m^3/day of total treatment capacity[20]. These plans are to be taken into account for planning.

Outside the sewerage service area, improved on-site treatment facilities will be available for the remaining 6.70 million residents in 2030. Currently, 6.09 million residents, (82% of the entire population) are using existing on-site treatment facilities, but unimproved ones are to be improved with new housing construction. Development of on-site treatment facilities is planned for 14 counties in LVSCA.

[20] Refer to Sectoral Report (D), Section 2.4.

(3) Proposed Sanitation Development Plan

Based on the development strategy mentioned above, the sewerage development plan is shown in Table 8.4.1, and the on-site treatment development plan is in Table 8.4.2. The proposed sanitation development plan for LVSCA is outlined below.

Proposed Sanitation Development Plan (LVSCA)

Type of Project		Target Area	Total Capacity (m^3/day)	Service Population (million persons)
Sewerage System	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		14 Counties	--	6.70

Source: JICA Study Team (Prepared based on Tables 8.4.1 and 8.4.2.)

Out of 7.99 million of the urban population in LVSCA, 75% (8.15 million) is expected to be covered by the sewerage system. The ratio of LVSCA is a little lower than the national target of 80% because there are only a few large-scale UCs which have priority of sewerage system development. Considering the above sanitation development, 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 were prepared by reference to Sectoral Report (D), Section 2.3. Figures for 2030 were prepared based on Tables 8.4.1 and 8.4.2.)

8.5 Irrigation Development Plan

(1) Current Situation of Irrigation Development

The northern half of LVSCA has ample annual rainfall (1,000~1,600 mm) and is wet, but the southern half has less rainfall. The cropping area in 2011 was 553,655 ha in total and mostly under the rainfed condition. Major crop cultivated are horticultural crops and food crops such as maize. Rice cultivation is active at the low lying area nearby Lake Victoria. The 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 1,193 ha (9%) of private schemes. The share of irrigation area against cropping area is only 2.4%. Most of all the existing irrigation systems need rehabilitation of deteriorated facilities due to insufficient maintenance.

(2) Development Strategy

Following the overall concept and frameworks for irrigation development mentioned in section 6.5, strategy for irrigation development in LVSCA was set as follows:

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

b) 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 ample land and water resources available for irrigation in LVSCA, priority should be given to both dam irrigation and weir irrigation to maximise irrigation area, and then to small-scale dam irrigation and groundwater irrigation as long as water resources are available.

(3) Proposed Irrigation Development Plan

As a result of the water balance study by sub-basins in LVSCA, possible irrigation development areas under application of the water-saving irrigation methods were estimated as summarised below.

Possible Irrigation Area in 2030 (LVSCA)

(Unit: ha)

Type of Irrigation	Existing Irrigation Area in 2010	New Irrigation Area in 2030						Total Irrigation Area in 2030
		Surface Irrigation Area			Groundwater Irrigation	Water Harvesting Irrigation	New Irrigation Total	
		River Water	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. Main Report Part C, Sub-section 4.4.3.)

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 6.5, 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 8.7 as given in Table 7.5.1 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 6.5.1 were taken up for the water balance study, and eight projects listed in Table 7.5.2 (75,572 ha in total) were selected as the possible projects in LVSCA from a viewpoint of surface water resources availability for irrigation. The locations of the selected projects are shown in Figure 7.5.1. Among them, the large scale irrigation projects more than 5,000 ha are as follows.

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) Nandi Irrigation Project (7,272 ha, Nandi Forest multipurpose dam)

d) Amala Irrigation Project (5,000 ha, Amala multipurpose dam)

The irrigation water demand for the above new irrigation development and existing irrigation was estimated at 1,158 MCM/year as given in Table 7.2.1.

8.6 Hydropower Development Plan

(1) Current Situation of Hydropower Development

In LVSCA, there are existing hydropower stations of Sondu/Miriu Hydropower Station (60 MW) and Sangoro Hydropower Station (21 MW) in the Sondu River, and Gogo Falls Hydropower Station (2 MW) in the Gucha-Migori River. These 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. As the catchment area is a densely populated area, it is necessary to take care of social and environmental aspects when formulating hydropower development plans.

(2) Development Target

As there is no plan taken up in the Least Cost Power Development Plan (LCPDP) in LVSCA, hydropower component of multipurpose-type development scheme on the Sondu River is to be taken up for the hydropower development plan for LVSCA based on the overall concept mentioned in Section 6.6.

(3) Proposed Hydropower Development Plan

Based on the development strategy mentioned above, the proposed hydropower development plan consists of the following plan, which is the hydropower components of a multipurpose dam development project in LVSCA[21]. Locations of the proposed hydropower development sites are shown in Figure 8.6.1.

Proposed Hydropower Development Plan (LVSCA)

Name of the plan	River	Installed Capacity	Purpose
Magwagwa Multipurpose Dam Development Plan	Sondu River	115 MW	Water Supply, Irrigation, Hydropower
Total		115 MW	

Source: JICA Study Team, based on information from MORDA and LBDA. (Ref. Main Report Part C, Sub-section 4.5.3.)

Magwagwa Multipurpose Dam Development Plan is located in the upstream area of the existing Sondu/Miriu and Sangoro hydropower stations. Magwagwa Dam is expected to increase the power generation amount of Sondu/Miriu and Sangoro hydropower stations through the storage effect of the dam.

8.7 Water Resources Development Plan

(1) Current Situation of Water Resources Development

LVSCA has a total catchment area of 31,734 km^2 (5.5% of the county), and an annual average rainfall of 1,280 mm which is the second largest among the six WRMA catchment areas. The available water

[21] An expansion plan for the existing Gucha dam is considered by NIB, however, the plan in not taken up in the study as there is no coordination made between NIB and KenGen (the owner of the dam).

resources estimated in LVSCA for the year 2010 (present) are 4,773 MCM/year for surface water and 874 MCM/year for groundwater. The available water resources in 2030 were estimated to be 5,749 MCM/year considering the effect of climate change, while the available groundwater resources is 868 MCM/year which is almost same as the amount of 2010.

The present (2010) water demands in LVSCA were estimated to be 385 MCM/year which consist mainly of domestic water demands for the population of 7.37 million (19.1% of national population) and irrigation water demands for the irrigation area of 13,218 ha. The population is distributed over the catchment area, although some concentration in Kisumu and Kisii is seen. Among 25 urban centres situated in the catchment area, 21 centres have water supply systems. About 41% of the population are supplied with groundwater.

The existing water resource structures/facilities except for the direct intake facilities from the rivers to satisfy the present water demands are: i) two dams (all for the hydropower generation purpose, with total storage volume of 1 MCM); ii) no intra-basin and/or inter-basin water transfer facility; iii) 544 small dams/water pans (for domestic and livestock water supply, with total storage volume of 5 MCM); and iv) 489 boreholes (mainly for domestic water supply purposes, with total abstraction volume of 36 MCM/year). There is no dam under construction. 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.

It is observed that the water balance is tight in the areas of Kisumu and Kisii since there are no domestic water supply dams near the areas.

(2) Development Strategy

As mentioned in Sections 8.3 and 8.5, the projected 2030 water demand of 2,016 MCM/year show the large increase of about 5.2 times compared to the present demand due to considerable increase in population to 12.72 million and irrigation areas to 156,797 ha, expected by the year 2030 in LVSCA. Judging from the estimated 2030 water deficits discussed in Section 8.2, it is certain that the existing water resource structures/facilities will not be able to satisfy the greatly increased 2030 water demand because of the uneven distribution of water resources both spatially and temporally. Therefore, new water resource structures/facilities are required to be developed.

It is noted that the LVSCA needs to play an important role to transfer part of its water resources to the Greater Nakuru area in RVCA where large domestic water demands are expected in the future but the available water resources are scarce.

Based on the overall concept and framework mentioned in Section 6.7, strategies for the water resources development in LVSCA were enumerated below to formulate the well balanced development plan between water resources and demands, based on the current situation of the catchment area and future water demands.

a) The surface water is abundant over the catchment area. Therefore, the development plan focuses on the maximum exploitation of the surface water.

b) The inter-basin water transfer facility from Itare and Londiani dams to the neighbouring RVCA is to be developed to supply domestic water to the Greater Nakuru area where heavily concentrated domestic water demands are expected in 2030 but both the 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 Section 9.2 for RVCA. The volume of water transferred from Nandi Forest Dam to LVSCA is included in the water demands mentioned in Section 8.2 for LVSCA.

c) Dam development is essential and to be promoted over the catchment area to satisfy large future water demands such as domestic, industrial and irrigation water demands in the entire 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 the design and/or planning stage by the government including the Kenya Vision 2030 flagship projects.

d) Small dams and/or water pans are to be constructed in small rivers throughout 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 possible for large dams but where surface water is available.

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

(3) Proposed Water Resources Development Plan

The water balance study was carried out for 2030 between the available water resources and water demands in LVSCA based on the overall concept and framework for the planning and development strategy. As a result of the water balance study, the required new water resource structures/facilities in addition to direct intake facilities from rivers are as follows:

Existing Structures/Facilities and Proposed Water Resources Development Plan (LVSCA)

Structure		No.	Purpose	Dimension/ Capacity	Remarks
Dam	Existing	2	Hydropower	Total storage volume of 1 MCM	
	Proposed	10	Domestic, industrial, irrigation, hydropower, and flood control	Total storage volume of 1,000 MCM	
Inter-basin Water Transfer	Existing	0			
	Proposed	1	Domestic	Transfer volume of 41 MCM/year from Itare and Londiani dams to RVCA	
	Proposed	1	Domestic, irrigation, and hydropower	Transfer volume of 82 MCM/year from Amala Dam to RVCA	
	Proposed	1	Domestic, irrigation and hydropower	Transfer volume of 189 MCM/year from Nandi Forest Dam in LVNCA to LVSCA	
Small Dam/ Water Pan	Existing	544	Domestic and livestock	Total storage volume of 5 MCM	
	Proposed	3,880	Rural domestic, livestock, irrigation, wildlife, and fisheries	Total storage volume of 194 MCM	
Borehole	Existing	489	Domestic	Total abstraction of 36 MCM/year	
	Proposed	1,250	Domestic, industrial, and irrigation	Total abstraction of 125 MCM/year	

Note: The water supply reliability applied in the plan is 1/10 for domestic and industrial use and 1/5 for irrigation use.
Source: JICA Study Team (Ref. Main Report Part C, Sub-sections 4.6.1 and 4.6.3.)

A list of the proposed dams is shown in Table 7.7.1 and a list of the proposed water transfer facilities is shown in Table 7.7.2. Figure 7.7.1 illustrates locations of the dams and water transfer facilities.

The water demand and supply balance for 2030 in LVSCA under the condition of proposed water resources development structures mentioned above is summarised in Table 8.7.1.

The water supply reliabilities for 2010 and 2030 at the reference points proposed for water resources management in LVSCA are estimated as below:

Water Supply Reliability at Reference Point (LVSCA)

Reference Point	Present (2010) Water Supply Reliability (with Existing Facilities)	Future (2030) Water Supply Reliability (with Existing and Proposed Facilities)
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. Sectoral Report (G), Section 4.5)

The future water supply reliabilities in 2030 at the reference points of Ahero in Nyando River and Migori in Migori River are estimated at 1/5, since water demand downstream of the reference points is mainly irrigation use. The future water supply reliabilities at Rongo in Gucha River and Masai-Mara in Mara River are estimated at 1/10, since water demand downstream of the reference points is domestic use only. The future water supply reliability at Sondu in Sondu River comes to 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 6.1 (1). Appropriate water resources development and management will be required to maintain the target reliability.

The naturalised flows, reserves, water demands, yields and water supply reliabilities at the reference points are presented in Table 7.7.4. Estimated river flows for 2010 and 2030 are illustrated in Figure 8.7.1 for the reference points in LVSCA.

The proposed water resources development plan listed above is a basis of the proposed water resources allocation plan for 2030 water demands stated in Section 8.2.

8.8 Water Resources Management Plan

(1) Current Situation of Water Resources Management

Water resources monitoring systems in LVSCA were established, covering the major rivers of Nyando, Sondu, Gucha-Mgori, and Mara. As for the current monitoring situation, the ratio of actual monitoring stations against the WRMA's target is 79% (30 stations) for surface water level, 50% (15 stations) for groundwater level and 82% (53 stations) for rainfall as presented in Table 6.8.1. The ratio of groundwater monitoring against the target is relatively low.

Water resources evaluation is not properly done using the above monitored data. Therefore, it is necessary to establish a system to evaluate water resources in the catchment area.

Water permit issuance and control is relatively well-managed as the ratio of effective water permit/issued permit is as high as 82% (surface water 80%, groundwater 97%). However, further improvement is necessary.

As for watershed conservation, the Mau Forest Complex of the Five Water Towers is a major water source of Nyando, Sondu, and Mara rivers. Decrease of forested areas is significant in the water source forest. According to the analysis conducted in this study[22], about 40% of the forested area has disappeared in LVSCA since 1990. In addition, degradation of small water sources and soil erosion control caused by deforestation are issues in this catchment area.

(2) Management Strategy

Based on the overall concept and frameworks as mentioned in Section 6.8, strategies for water resources management in LVSCA is to be considered for four major aspects of: a) monitoring, b) water resources evaluation, c) water permit issuance and control, and d) watershed conservation, as described hereunder:

1) Monitoring

Monitoring items are surface water, groundwater and rainfall. For the surface water and groundwater, water quantity and quality are monitored. To make the current monitoring system more effective, a review is to be made on surface water monitoring stations of major rivers namely, Nyando, Sondu, Gucha-Migori, and Mara and major tributaries. 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.

Rainfall monitoring stations are to be reviewed considering the climate division (humid area that covers most of the catchment area and semi-arid areas in the south-eastern part of the catchment area) of the catchment area and corresponding rainfall station densities to establish proper monitoring system.

Groundwater monitoring stations are to be set at areas where groundwater demand will increase in the future, namely, the areas that have both water supply development plan and sewerage development plan. In such areas, groundwater is to be monitored with dedicated boreholes for monitoring.

2) Evaluation of Water Resources

As mentioned in the overall concept and frameworks in Section 6.8, regional offices should enhance the capacity for evaluation of water resources in both quantity and quality so as to determine available water resources for water permit issuance based on the monitored data, and to judge necessity of water resources development.

[22] Refer to Sectoral Report (B), Section 8.3.

3) Water Permit Issuance and Control

Based on the overall concept mentioned in Section 6.8, in preparation of increased water demand in the future, the latest version of the issued water permits is to be maintained to enable accurate control of issued water permits that reflect the current water use. In addition, revision of standards such as "Guidelines for Water Allocation (WRMA, First Edition, March 2010)" is to be considered to enable issuance of water permits that reflect the current water use and available water resources. Furthermore, in view of the current working conditions in the issuance of water permits in regional offices, water rights officers in charge of water permit issuance and control are to be increased for regional/subregional offices for smooth work.

4) Watershed Conservation

Based on the overall concept and frameworks mentioned in Section 6.8, forest recovery is to be implemented through reforestation focusing on the Mau Forest Complex. Furthermore, conservation of small water sources and preventive measures for soil erosion caused by deforestation in this catchment area are to be considered.

(3) Proposed Water Resources Management Plan

Based on the management strategy mentioned above, the water resources management plan proposed for LVSCA is as follows:

1) Monitoring

Proposed layout of monitoring stations for surface water, groundwater, rainfall and reference point is shown in Figures 7.8.1 and 19.1.4. Water quantity and quality are monitored at surface water monitoring and groundwater monitoring stations, while rainfall amount is monitored at rainfall monitoring stations. WRMA's target number and the proposed number of monitoring stations are shown in Table 6.8.1.

In view of covering representative locations of major rivers, lakes and springs, current layout of the surface water monitoring stations were reviewed. Proposed surface water monitoring stations are five stations in Nyando River, five stations in Sondu River, four stations in Gucha-Migori River, three stations in Mara River as major rivers in the catchment area, one station for water level of Lake Victoria near Kisumu City and five stations in the small basins along the Winam Gulf of Lake Victoria. In total, 23 stations are proposed against WRMA's target number of 38 for surface water monitoring network in LVSCA.

In addition, the reference points representing the flow conditions of major rivers were set at five representative surface water monitoring stations, one each for the Nyando, Sondu, Gucha, Migori and Mara rivers as shown in Figure 19.1.4.

Based on the overall concept described in Section 6.8 (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 of the respective rivers.

Normal Discharge at Reference Point (LVSCA)

(Unit: m^3/sec)

Reference Point	Normal Discharge (Reserve + Water Demand for the Downstream of Reference Point)	
	2010	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. Sectoral Report (H), Sub-section 3.4.2)

The above normal discharges are to be reviewed and revised as necessary in the "Evaluation of Water Resources" 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.

As a result of the review based on the overall concept mentioned in Section 6.8 (2), 50 rainfall monitoring stations are proposed against WRMA's target number of 65.

As for groundwater monitoring stations, 19 locations which are 19 urban centers having both a water supply development plan and a sewerage development plan in this study are proposed against WRMA's target number of 30 considering increase of groundwater demand toward future. Groundwater monitoring is to be conducted using dedicated boreholes.

2) Evaluation of Water Resources

As for the enhancement of water resource quantity evaluation system, an evaluation team is formed by assigning a chief hydrologist from LVSCA Regional Office in Kisumu as the leader and assistant hydrologists from each subregional office of Kisumu, Kericho and Kisii as members. The evaluation team will target the whole area of LVSCA to evaluate water resources of the catchment area once a year on the items mentioned in Section 6.8 (2) b).

For water resource quality evaluation, the existing water quality testing laboratory in Kisumu is to be maintained with adequate number of water quality experts and a system for proper evaluation of qualities of surface water and groundwater at a monitoring time should be established.

3) Water Permit Issuance and Control

As for water permit issuance and control, the following activities are proposed:

a) To maintain the latest version of the issued water permits through periodic updating of the water permit database and establishment of a notification system for permit expiry;

b) To revise standards of WRMA such as "Guidelines for Water Allocation (WRMA, First Edition, March 2010)" based on future water demands and available water resources; and

c) To enable smooth water permit issuance and control, it is proposed to increase water right officers of LVSCA Regional Office in Kisumu, Kericho, and Kisii subregional offices from the current four to seven by adding three additional officers, one additional water right officer each in LVSCA Regional Office, Kisumu, and Kericho subregional offices.

4) Watershed Conservation

For reforestation for forest recovery, about 410,000 ha of reforestation is proposed for LVSCA to achieve the target of the Kenya Vision 2030. Of the target, gazetted forest is supposed to be implemented by KFS. Figure 6.8.1 shows the existing forested areas and potential reforestation areas.

As for conservation of small water sources and control of soil erosion caused by deforestation in the catchment area, it is proposed to conduct surveys for target locations first to formulate plans.

8.9 Flood and Drought Disaster Management Plan

(1) Current Situation of Flood Disaster Management

LVSCA has suffered from severe flood damages over the years. Due to this historical background, Integrated Flood Disaster Management Plan for Nyando River Basin was formulated in 2009. Following this, CBDM has been developed in the Nyando River basin though the JICA programme. The system included small-scale structural measures as well as non-structural measures. However, in the current system, while occurrence of flood is identified based on visual judgment of river water level, the issue is that enough lead time for evacuation activities has not been secured because propagation time of flood in LVSCA is relatively short.

WRMA's flood disaster management is implemented only in the Nyando River basin. No particular flood disaster management has been done in other flood prone areas such as the Sondu and Kuja river mouth areas.

Dikes have so far been constructed with a total length of 15.1 km on both banks along the Nyando River. They have contributed to flood control against normal floods. However, it was recorded that those dykes were breached and overtopped by the large-scale flood in 2006. At the time, it is even said that inadequate flood fighting activities have resulted in the expansion of inundated areas.

(2) Current Situation of Drought Disaster Management

Drought damages have not been reported in LVSCA. There are two existing dams for hydropower purposes. A drought disaster management program, including water use restriction of the reservoirs, has not been implemented.

(3) Flood Development Management Strategy

As explained in the overall concept e) mentioned in Section 6.9, the proposed examination areas in LVSCA are Kano Plain, Sondu River mouth, Kuja River mouth, and Kisumu.

In Kano Plain/Nyando River basin, an integrated flood disaster management plan was formulated in 2009. As proposed in the plan, this area shall be protected by structural flood control measures including multipurpose dams. In addition, to minimise inundation area by avoiding dike breaching or overtopping, a flood fighting plan shall be prepared for the existing dykes. Meanwhile, the existing CBDM system shall be improved by installing telemetric equipment in order to provide enough lead time for evacuation.

In the Sondu River mouth and Kuja River mouth, flood control measures will not be required because there are only a small number of densely-populated areas. Therefore, the flood disaster management strategy for Sondu and Kuja is to develop CBDM system by installing a simplified flood forecasting system based on water level observation in the upper reaches.

The type of floods that occurred in Kisumu are not river-induced floods, but rather floods caused by urban drainage issues. In consideration of the high population density in Kisumu, the drainage system should be improved.

(4) Drought Disaster Management Strategy

Based on the overall concepts mentioned in Section 6.9, drought disaster management strategy for LVSCA includes: i) preparation of water use restriction rules for existing and proposed reservoir, ii) establishment of Basin Drought Conciliation councils and iii) establishment of drought early warning system.

(5) Proposed Flood and Drought Disaster Management Plan

Based on the management strategy mentioned above, the flood disaster management plan for LVSCA is proposed as follows:

a) Implementation of flood control measures, which were planned in the Nyando master plan;
b) Establishment of flood forecasting and warning system in the Nyando River basin;
c) Preparation of flood fighting plan for the existing dykes along the lower reaches of the Nyando River;
d) Establishment of CBDM system in Sondu River mouth and Kuja River mouth; and
e) Implementation of urban drainage measures in Kisumu.

Based on the management strategy mentioned above, the drought disaster management plan for LVSCA is proposed as follows:

a) Preparation of water use restriction rules for reservoirs in the two existing and ten proposed dams including setting of reference reservoir water level, and determination of reduction rate,
b) Monitoring of reference water levels which correspond to reserve or normal discharge (this work is to be implemented as a part of water resources management plan),

c) Establishment of five Basin Drought Conciliation Councils with legal status on the basis of a river basin unit, and

d) Establishment of specialised drought early forecast system for water use restriction, that are linked to expected fluctuation of the above 12 reservoirs.

Figure 7.9.1 shows the flood disaster management plan and drought disaster management plans.

8.10 Environmental Management Plan

(1) Current Status of Environmental Management

LVSCA faces the Winam Gulf of Lake Victoria and six rivers in LVSCA are flowing into the gulf. Water pollution and eutrophication of the gulf are caused by hazardous substances in sewage and industrial wastewater from the rivers and Kisumu City and from nutrients from agricultural land of upper reaches. In particular, inflows of the Nyando and Sondu rivers, regarded as main rivers of LVSCA, contribute a large load to the gulf. WRMA has monitoring points of river flow and water quality for the rivers. However, the current data is not enough to confirm the secular change of water environment.

The Masai-Mara National Reserve is located in LVSCA. The reserve is noted as an important natural resource in an international basis. The Mara River is the main water source for the reserve and is a solitary example of environmental river flow study by World Wide Fund for Nature (WWF). However, conflicts between rural people and Kenya Wildlife Service (KWS) caused by water shortage and excessive grasslands affected by drought are becoming problems in recent years.

The Mau Forest Complex, which has the largest forest area among the Five Water Towers, is located in the northern part of LVSCA. The forest has lost the largest forested area among the Five Water Towers because of illegal logging and encroachment. The deforestation has become a major factor for water resource degradation.

For formulation of the water resources development plans in LVSCA, the careful considerations on social and environmental impacts by the development are required as the population density in the catchment area is high.

(2) Management Strategy

Based on the overall concept mentioned in Chapter 6.10, it is proposed to set environmental flow rate and to carry out environmental monitoring in main rivers and lakes in LVSCA.

The water resource development projects in NWMP 2030 are mostly proposed for the Nyando, Sondu, and Gucha-Migori rivers as main rivers of LVNCA. Therefore, setting of environmental flow rate and environmental monitoring are proposed for these three rivers. In addition, setting of environmental flow rate and environmental monitoring are also proposed for the Mara River because Masai-Mara National Reserve has a biological importance.

In addition, the environmental monitoring is proposed for Winam Gulf of Lake Victoria. Kisumu City and Homa Bay Town facing with Lake Victoria are targeted for environmental monitoring because sewage and industrial wastewater from their future population growth will increase.

(3) Proposed Environmental Management Plan

Based on the management strategy mentioned above and selection criteria of environmental flow rate setting point and environmental monitoring point mentioned in the overall concept and framework, the proposed environmental flow rate setting and environmental monitoring of environmental management plan for LVSCA are shown in the following table. Locations of the proposed points are shown Figure 7.10.1.

Environmental Flow Rate Setting Points and Environmental Monitoring Points (LVSCA)

Target	Setting Point			Proposed Major Development Projects
Nyando River	Environmental flow rate	1	Reference point (Ahero Town) : LVS-F1	Nyando(Koru) and Londiani dams, Kano Plain Irrigation
		2	Surrounding Muhoroni Town : LVS-F2	
	Environmental monitoring	3	Reference point (Ahero Town): LVS-FM1	
		4	Surrounding Muhoroni Town : LVS-M2	
Sondu River	Environmental flow rate	1	Reference point (Upper reaches of the Sondu Dam) : LVS-F3	Magwagwa and Itare dams
		2	Upper reaches (Confluence point of the Itare River) : LVS-F4	
	Environmental monitoring	3	Reference point (Upper reaches of the Sondu Dam) : LVS-M3	
		4	Upper reaches (Confluence point of the Itare River) : LVS-M4	
Gucha - Migori River	Environmental flow rate	1	Confluence point of both rivers : LVS-F5	Bunyunyu, Ilooiterre and Katieno dams, Lower Kuja irrigation
		2	Reference point (Gucha River) : LVS-F6	
		3	Reference point (Migori River) : LVS-F7	
	Environmental monitoring	4	Confluence point of both rivers : LVS-M5	
		5	Reference point (Gucha River) : LVS-M6	
		6	Reference point (Migori River) : LVS-M7	
Mara River	Environmental monitoring	1	Reference point (Upper reaches of the Masai-Mara National Park) : LVS-F8	Amala Dam
	Environmental monitoring	2	Reference point (Upper reaches of the Masai-Mara National Park) : LVS-F8	
Lake Victoria	Environmental monitoring	1	Nearly inflow point of the Nyando River : LVS-M9	-
		2	Nearly inflow point of the Sondu River : LVS-M10	-
		3	Nearly inflow point of the Gucha River : LVS-M11	-
Kisumu City and Homa Bay Town	Environmental monitoring	1	Kisumu City (Main discharge: lower reach of the Kibos River): LVS-M12	-
		2	Homa Bay Town (Main discharge) : LVS-M13	-

Source: JICA Study Team (Ref. Main Report Part C, Sub-section 4.9.3.)

In addition, environmental survey for setting of environmental flow rate (current river flow rate, water quality, and river ecosystem) shall be conducted in Nyando, Sondu, and Gucha-Migori rivers.

9. RIFT VALLEY CATCHMENT AREA

9.1 Catchment Area Characteristics

RVCA is located in the central-western part of the country as shown in Figure 1.3.1. 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 a width of about 100 to 300 km in the east-west direction. RVCA borders on South Sudan and Ethiopia in the north, ENNCA, TCA, and ACA in the eastern side, Tanzania in the south, and Uganda, LVSCA, and LVNCA 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.

Total area of RVCA is 130,452 km^2, corresponding to 22.7% of the country's total land area. Based on the Census 2009, population of the area in 2010 is 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, with Lake Turkana at 375 m amsl in the north to the mountainous areas of more than 3,000 m amsl in the central part and to Lake Magadi at 579 m amsl in the south.

There are seven lakes along the Rift Valley, namely, Lakes Turkana, Baringo, Bogoria, Nakuru, Elementeita, Naivasha, and Magadi in the north. Only Lake Baringo and Lake Naivasha has fresh water. Other lakes have saline water. Rivers in RVCA originate from the 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 to 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. 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 the 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 the RVCA has the second largest drainage area of 8,349 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, etc, 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 Elementeita with 543 km^2. Of these lakes, Lake Naivasha is recently facing significant water level decrease during the dry season due to increased water use due to rapid population growth.

The northern part of RVCA is classified as an arid land, central part as 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 RV is 510 mm. The renewable water resources, which is defined as precipitation minus evapotranspiration, is estimated at 3.58 BCM/year in 2010 for RVCA and the per capita renewable water resources is calculated at 737 m^3/year/capita.

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[23] . The study was conducted through integration of remote

[23] The master plan report was 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 on the Northern and Central Turkana County was provided from the Kenyan government side. Descriptions were given based on the request from Kenyan government side.

sensing and geophysical exploration technologies to identify the locations of groundwater potential, then estimated the potential as groundwater resources through drilling of boreholes at the identified locations (The target area for the study is northern and central part of Turkana County with an area of 36,000 km^2). 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 NWMP 2030, however, it is recommended to utilise the data for scrutinising groundwater potential as described in "Chapter 20 Recommendations."

9.2 Water Resources, Water Demands and Water Allocation

The available water resources were estimated in RVCA for the years of 2010 (present) and 2030 (future) as explained in Section 4.4 and summarised below. The estimate for 2030 includes impacts of climate change.

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
Ratio of 2010 to 2030	124%	100%	123%

Source: JICA Study Team (Ref. Main Report Part D, Section 3.2.)

The annual water demands were estimated for the year 2010 and projected for 2030 in RVCA as described in Section 5.2 and summarised below. The projection for 2030 followed the national development targets of Kenya Vision 2030 and socioeconomic framework, but without considering the available water resources.

Water Demands by Subsector (RVCA)

Year	Water Demands (MCM/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 D, Section 3.3.)

In order to assess severity of water balance, ratios of available water resources and water demands presented above and those of water demands and water deficits discussed in Section 5.3 are tabulated for both 2010 and 2030 as follows:

Ratios of Water Demands/Available Water Resources and Water Deficits/Water Demands (RVCA)

Description	2010	2030
Available Water Resources (MCM/year)	2,559	3,147
Water Demands (MCM/year)	357	1,494
Water Demands/Available Water Resources	14%	47%
Water Deficits (MCM/year)	92	867
Water Deficits/Water Demands	26%	58%

Source: JICA Study Team (Ref. Main Report Part D, Section 3.4 (1) and Sectoral Report (G), Sub-section 3.4.2.)

Although the present water demands in 2010 are estimated to be 14% of the available water resources (water stress ratio), the water demands for 2030 are expected to sharply increase to about 47% against

the available water resources in 2030. As the water stress ratio in 2030 is over 40%, RVCA will be in the severe water stress in the future. The above table also shows the estimated water deficits of 92 MCM/year in 2010 and increased deficits of 867 MCM/year in 2030. The appropriate water resources development is inevitable for satisfying the demands.

The water balance study was carried out based on the proposed water resources development plans of the related subsectors described in the following sections. The water demands that can be covered by the available water resources are presented in Table 7.2.1. The allocated amounts of the surface water and groundwater to satisfy the 2030 water demands are as follows:

Water Resources Allocation Plan for Water Demands in 2030 after Water Balance Study (RVCA)

(Unit: MCM/year)

Subsector	Water Demand (2030)	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 (Ref. Main Report Part D, Section 3.4 (3) and Sectoral Report (G), Sub-section 4.6.3 (2).)

It was concluded that interim target of new irrigation development area of 63,493 ha for 2030 can be extended to 92,166 ha from the viewpoint of the available water resources as stated in Sections 6.5 and 9.5.

The abovementioned water resources allocation plan should be the base data for future water resources management plan of the RVCA.

9.3 Water Supply Development Plan

(1) Current Situation of Water Supply

Current population of RVCA in 2010 is estimated to be 4.86 million including an urban population of 1.41 million and a rural population of 3.45 million. The population is concentrated in Nakuru area and Naivasha area. Based on the 2009 Census data, the current situation of water connection in 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, ponds without proper treatment are categorised as an unimproved drinking water source. Around 40% of the

population gets drinking water from such unimproved drinking water sources. Also, around 32% of the population gets water from springs, wells or boreholes. Unprotected wells and springs are categorised as unimproved drinking water sources, but the utilisation ratio of unprotected ones is not known.

It is projected that urban population will increase by 3.08 million, the rural population will decrease by 0.49 million and the total population will be 7.45 million in 2030. Currently, piped water supply covers 52% of the urban population of RVCA, of which the target coverage ratio for 2030 is 100%. It is therefore required to implement a large-scale urban water supply system development to cope with rapid growth of the urban population and achieve the target coverage ratio of 100%.

(2) Development Strategy

RVCA is divided into three areas such as humid area of Nakuru and its surrounding area, north arid area, and south semi-arid area for UWSS planning considering the characteristics of the three areas.

Based on the overall concept mentioned in Section 6.3, UWSS are planned for 13 urban centres (UCs) in RVCA. In case the same water resources are used for several UCs in the seven UCs in Nakuru (Nakuru, Naivasha, Gilgil, Molo, Njoro, Eldama Ravine, Ol Kalou), one water supply system is planned to cover several UCs. However, UWSS in the other six UCs are planned for each UC independently.

The water supply capacity required for UWSS in the RVCA in 2030 is 398,000 m^3/day against the current water supply capacity (including capacity under construction) of 129,000 m^3/day. Therefore, additional capacity of 269,000 m^3/day is to be developed by 2030. It is to be developed through the following three types of projects.

a) Rehabilitation of existing UWSS: In order to achieve 20% NRW ratio, water meters are to be installed for all households and old pipes of existing UWSS of the ten UCs, which has a water supply capacity of 129,000 m^3/day, are to be replaced. In addition, the rehabilitation will include 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 above ten UCs to meet the water demand in 2030. The total capacity of expansion is 254,000 m^3/day.
c) Construction of new UWSS: The construction of new UWSS is planned for the three UCs which have no UWSS. The total capacity of new construction is 15,000 m^3/day.
d) According to data from WSBs, there are four plans of urban water supply development projects to cover nine UCs and surrounding areas in RVCA[24], 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 taken ito account for planning.

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.

[24] Refer to Sectoral Report (C), Section 2.4.

Based on the overall concept mentioned in Section 6.3, rural water supply systems are planned to be developed by LSRWSS and SSRWSS.

a) Development of LSRWSS: LSRWSS is proposed mainly for areas with high population density or areas with difficulties in groundwater use on a personal or community basis. LSRWSS is to be developed for 1.70 million residents in 18 counties of the RVCA.
b) Development of SSRWSS: SSRWSS is proposed for 2.41 million residents in 18 counties of RVCA, and it includes construction and improvement of boreholes, wells, and springs on a personal and community basis. As this type of works is to be implemented on a personal and community basis, only the water demand projection is carried out for SSRWSS in the master plan.

(3) Proposed Water Supply Development Plan

Based on the development strategy mentioned above, the proposed UWSS is presented in Table 9.3.1, and the proposed LSRWSS and SSRWSS are in Tables 9.3.2 and 9.3.3, respectively. Figure 7.3.1 shows urban centers subject to urban water supply system development.

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 (Prepared based on Tables 9.3.1 to 9.3.3.)

Based on the above water supply development plan, the water supply situation of RVCA in 2030 will be improved 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 prepared by reference to Sectoral Report (C), Section 2.3. Figures for 2030 were prepared based on Tables 9.3.1 to 9.3.3.)

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 presented in Tables 7.7.1 and 7.7.2, as the result of the water balance study.

9.4 Sanitation Development Plan

(1) Current Situation of Sanitation Development

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

Current Situation of 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 areas in RVCA and current sewerage coverage ratio is only 4%. There are four small-scale wastewater treatment plants in Nakuru, Naivasha, and Molo, with a total treatment capacity of about 18,393 m^3/day. Around 69% of the population use on-site treatment facilities such as septic tanks, etc. The on-site treatment facilities include unimproved ones, but the ratio of the unimproved facilities is not known. Around 27% of the population does not have any treatment facilities and resort to unsanitary waste disposal.

(2) Development Strategy

Based on the overall concept and framework mentioned in Section 6.4, sewerage system development is planned for nine UCs in RVCA. The sewerage system development is conducted through the following three types of projects:

a) Rehabilitation of existing sewerage system: Rehabilitation includes the repair and replacement of mechanical and electrical equipment of wastewater treatment plants (WWTPs) and pumping stations, and replacement of corroded sewer pipes in three UCs, which have sewerage systems with a total capacity of 18,000 m^3/day.
b) Expansion of sewerage system: In order to cover the demand in 2030, capacities of existing sewerage systems of three UCs are to be expanded. This includes expansion and/or new construction of sewerage pipes, pumping stations, and WWTPs. The total capacity of expansion is 150,000 m^3/day.
c) Construction of new sewerage system: There are no sewerage systems in six UCs. New sewerage systems are to be constructed in these UCs with total capacity of 72,000 m^3/day.
d) According to data from WSBs, there are seven plans of sewerage development projects to cover seven urban centres in RVCA[25], which have 106,000 m^3/day of total treatment capacity. (Refer to Sectoral Report (D), Section 2.4) These plans are to be taken into account for planning.

Outside the sewerage service area, improved on-site treatment facilities will be available for the remaining 4.29 million residents in 2030. Currently, 3.35 million residents (69% of the entire population) are using existing on-site treatment facilities, but unimproved ones are to be improved

[25] Refer to Sectoral Report (D), Section 2.4.

with new housing construction. Development of on-site treatment facilities is planned for 18 counties in the RVCA.

(3) Proposed Sanitation Development Plan

Based on the development strategy mentioned above, the sewerage development plan is shown in Table 9.4.1 and the on-site treatment development plan is shown in Table 9.4.2. The proposed sanitation development plan for RVCA is outlined 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 (Prepared based on Tables 9.4.1 and 9.4.2.)

Out of 4.49 million of the urban population in the RVCA, 70% is expected to be covered by the sewerage system. The ratio of the RVCA is little lower than the national target of 80%, because there are only a few large-scale UCs which have priority of sewerage system development. By the above sanitation development, the sanitation situation of the RVCA in 2030 will be as follows:

Sanitation Situation in 2030 Plan (RVCA)

Items		Sewerage System	Septic Tank, etc (On-site Treatment Facilities)
Service Population (million)	2010	0.20	3.38
	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 were prepared by reference to Sectoral Report (D), Section 2.3. Figures for 2030 were prepared based on Tables 9.4.1 and 9.4.2.)

9.5 Irrigation Development Plan

(1) Current Situation of Irrigation Development

RVCA stretches about 800 km from north to south. The central part of RVCA is highland. The climate in RVCA is widely variable by elevation from wet zones on the highland to semi-arid and arid zones in the lowland. The cropping area in 2011 was 303,856 ha. Planting area and production of maize in RVCA is the highest among catchment areas. The irrigation area in RVCA is located mostly on the highland. The existing irrigation area in 2010 was 9587 ha, consisting of 774 ha (8%) of public irrigation schemes, 5,791 ha (60%) of smallholder irrigation schemes, and 3,022 ha (32%) of private schemes. Most of all the existing irrigation systems (excluding private schemes) have deteriorated mainly due to poor maintenance.

(2) Development Strategy

Based on the overall concept and frameworks mentioned in Section 6.5, the strategy for irrigation development in RVCA was set as follows:

a) To utilise available water resources efficiently for the maximisation of irrigation development, water-saving irrigation methods to improve water productivity should be introduced for all irrigation areas;
b) 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 ample land resources available, but limited water resources for irrigation in RVCA, priority should be given to dam irrigation in arid and semi-arid lands to maximise irrigation area. Furthermore, small-scale dam irrigation and groundwater irrigation should be developed as long as water resources are available.

(3) Proposed Irrigation Development Plan

As a result of the water balance study by sub-basins in RVCA, possible irrigation development areas under application of the water-saving irrigation methods were estimated as summarised below.

Possible Irrigation Area in 2030 (RVCA)

(Unit: ha)

Type of Irrigation	Existing Irrigation Area in 2010	New Irrigation Area in 2030						Total Irrigation Area in 2030
		Surface Water Irrigation			Groundwater Irrigation	Water Harvesting Irrigation	New Irrigation Total	
		River Water	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	88,623	2,091	2,890	92,166	101,753

Source: JICA Study Team (Ref. Main Report Part D, Sub-section 4.4.3.)

Against the provisional target of new irrigation development area of 64,693 ha (distributed to RVCA for the national target of 1.2 million ha) mentioned in Section 6.5, the possible new irrigation development area comes to 92,166 ha (increase of 28,673 ha) with maximum water resources development presented in Section 9.7. Table 7.5.1 shows the maximum irrigation area by catchment area in 2030.

As for the large-scale irrigation projects (more than 500 ha), 30 projects proposed by the government authorities listed in Table 6.5.1 were taken up for the water balance study, and nine projects listed in Table 7.5.2 (78,850 ha in total) were selected as the possible projects in RVCA from a viewpoint of surface water resources availability for irrigation. The locations of the selected projects are shown in Figure 7.5.1. Among them, the large scale irrigation projects more than 5,000 ha are as follows.

a) Arror Irrigation Project (10,850 ha, Arror multipurpose dam)
b) Turkwel Irrigation Project (5000 ha, existing dam)
c) Lower Ewaso Ng'iro Irrigation Project (15,000 ha, Oletukat multipurpose dam)
d) Todonyang-Omo Irrigation Project (35,000 ha, Gibe 3 Hydropower dam in Ethiopia)

The irrigation water demand for the above irrigation development was estimated at 1,393 MCM/year as given in Table 7.2.1.

9.6 Hydropower Development Plan

(1) Current Situation of Hydropower Development

In RVCA, there is an existing hydropower station, the Turkwel Hydropower Station located in the upstream area of Turkwel River. Of the elongated shape of catchment area from north to south, areas for hydropower potential is limited to the humid area in the south-central part of the catchment area.

(2) Development Strategy

As there is no plan taken up in the Least Cost Power Development Plan (LCPDP) in RVCA, the hydropower component of multipurpose-type development scheme is to be taken up based on the overall concept and frameworks mentioned in Section 6.6. Hydropower components of multipurpose dam development plans in the major rivers are to be taken up as hydropower development plan of RVCA.

(3) Proposed Hydropower Development Plan

Based on the development strategy mentioned above, the proposed hydropower development plan consists of the following six plans which are the hydropower components of multipurpose dam development projects in RVCA. Locations of the proposed hydropower development sites are shown in Figure 7.6.1.

Proposed Hydropower Development Plans (RVCA)

Name of the plan	River	Installed Capacity	Purpose
Embobut Multipurpose Dam Development Plan	Turkwel River	45 MW	Water Supply, Irrigation, Hydropower
Arror Multipurpose Dam Development Plan	Arror River	80 MW	Water Supply, Irrigation, Hydropower
Kimwarer Multipurpose Dam Development Plan	Kerio River	20 MW	Water Supply, Irrigation, Hydropower
Oletukat Multipurpose Dam Development Plan	Ewaso Ng'iro South River	36 MW	Water Supply, Hydropower
Leshota Multipurpose Dam Development Plan	Ewaso Ng'iro South River	54 MW	Water Supply, Hydropower
Oldorko Multipurpose Dam Development Plan	Ewaso Ng'iro South River	90 MW	Water Supply, Irrigation, Hydropower
Total		325 MW	

Source: JICA Study Team, based on information from MORDA, KVDA and ENSDA. (Ref. Main Report Part D, Sub-section 4.5.3.)

Of the above proposed multipurpose dam development plans, the costs of three hydropower components that are planned on Ewaso Ng'iro South River, namely, Oletukat, Leshota, and Oldorko, seem to be too low. As the feasibility study of these three components are underway, it is necessary to review the cost based on the results of the study.

9.7 Water Resources Development Plan

(1) Current Situation of Water Resources Development

RVCA has a total catchment area of 130,452 km^2 (23% of the country), 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 1,000 mm near the Kenya Water Towers. The available water resources estimated in RVCA for 2010 (present) are 2,457 MCM/year for surface water and 1,402 MCM/year for groundwater. The available surface water resources for 2030 were estimated to increase to 3,045 MCM/year considering the effect of climate change and the available groundwater resources is 1,392 MCM/year which is almost same as the amount of 2010.

The present (2010) water demands in RVCA were estimated to be 357 MCM/year which consist mainly of domestic water demands for the population of 4.86 million (12.6% of national population), irrigation water demands for the irrigation area of 9,587 ha and livestock water demands. The population is concentrated in the Greater Nakuru area, and scarce in the northern part of the catchment area. Among 13 urban centres situated in the catchment area, ten centres have existing water supply systems. About 32% of the population is supplied with groundwater.

The existing water resource structures/facilities except for direct intake facilities from the rivers to satisfy the present water demands are: i) five dams (one for hydropower generation, four for the domestic water supply, with total storage volume of 1,653 MCM almost all of which are for hydropower); ii) an inter-basin water transfer facility; iii) 660 small dams/water pans (for domestic and livestock water supply, with total storage volume of 12 MCM); and iv) 2,094 boreholes (mainly for domestic water supply, with total abstraction volume of 115 MCM/year). 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.

One dam is under construction (for domestic water supply purpose with intra-basin water transfer and storage volume of 10 MCM).

(2) Development Strategy

As mentioned in Sections 9.3 and 9.5, the projected 2030 water demand of 2,146 MCM/year show a large increase of about 6.0 times compared to the present demand due to considerable increase in population to 7.45 million and irrigation areas to 146,492 ha expected by the year 2030 in RVCA. Judging from the estimated 2030 water deficits discussed in Section 9.2, it is certain that the existing water resource structures/facilities will not be able to satisfy the greatly increased 2030 water demands because of the uneven distribution of water resources both spatially and temporally. Therefore, new water resource structures/facilities are required to be developed.

Attention needs to be paid to the domestic water supply to the Greater Nakuru area where the future domestic water demand will increase drastically but the available water resources are limited. Water transfer from the LVSCA will be inevitable for this purpose.

Strategies for the water resources development in RVCA were enumerated below to formulate the well balanced development plan between water resources and demands, based on the overall concept and framework mentioned in Section 6.7 and the current situation of the catchment area and future water demands.

a) The inter-basin water transfer facility from Itare and Londiani dams in adjacent catchment area of the neighbouring LVSCA to RVCA is to be developed to supply domestic water to the Greater Nakuru area where heavily concentrated domestic water demands are expected in 2030 but where both of surface and groundwater resources are insufficient. The inter-basin water transfer plan from the Amala dam in LVSCA to RVCA is 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 Section 9.2 for RVCA.

b) Dam development is essential and to be promoted to satisfy sharply increased large future water demands such as domestic, industrial and irrigation water demands at locations where the demands exist particularly in central and southern parts of the catchment area. Candidates of dam development for maximum surface water exploitation include, in principle: i) dams proposed by the NWMP (1992), and ii) dams under the design and/or planning stage by the government including the Kenya Vision 2030 flagship projects.

c) Small dams and/or water pans are to be constructed 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 possible for large dams but where surface water is available. The small dams and water pans are to be planned for almost the entire catchment area except for the northernmost part where rainfall is minimal.

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

(3) Proposed Water Resources Development Plan

The water balance study was carried out for 2030 between the available water resources and water demands in RVCA based on the overall concept and framework for the planning and development strategy. As a result of the water balance study, the required new water resource structures/ facilities in addition to direct intake facilities from rivers are as follows:

Existing Structures/Facilities and Proposed Water Resources Development Plan (RVCA)

Structure		No.	Purpose	Dimension/ Capacity	Remarks
Dam	Existing	5	Domestic and hydropower	Total storage volume of 1,653 MCM	
	Proposed	10	Domestic, industrial, irrigation, hydropower and flood control	Total storage volume of 659 MCM	
Inter-basin Water Transfer	Existing	1	Domestic	Transfer volume of 1 MCM/year from Kirandich Dam to Kabarnet	
	Proposed	1	Domestic	Transfer volume of 41 MCM/year from Itare and Londiani dams in LVSCA to Nakuru area in RVCA	
	Proposed	1	Domestic, irrigation and hydropower	Transfer volume of 82 MCM/year from Amala Dam in LVSCA to RVCA	
Small Dam/ Water Pan	Existing	660	Domestic and livestock	Total storage volume of 12 MCM	
	Proposed	3,640	Rural domestic, livestock, irrigation, wildlife and fisheries	Total storage volume of 182 MCM	
Borehole	Existing	2,094	Domestic	Total abstraction of 115 MCM/year	
	Proposed	160	Domestic, industrial, and irrigation	Total abstraction of 16 MCM/year	

Note: The water supply reliability applied in the plan is 1/10 for domestic and industrial use and 1/5 for irrigation use.
Source: JICA Study Team (Ref. Main Report Part D, Sub-sections 4.6.1 and 4.6.3.)

A list of the proposed dams is represented in Table 7.7.1 and a list of the proposed water transfer facilities is shown in Table 7.7.2. Figure 7.7.1 illustrates locations of the dams and water transfer facilities.

The water demand and supply balance for 2030 in RVCA under the condition of proposed water resources development structures mentioned above is summarised in Table 9.7.1.

The water supply reliabilities for 2010 and 2030 at the reference points proposed for water resources management in RVCA are estimated as below:

Water Supply Reliability at Reference Point (RVCA)

Reference Point	Present (2010) Water Supply Reliability (with Existing Facilities)	Future (2030) Water Supply Reliability (with Existing and Proposed Facilities)
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. Sectoral Report (G), Section 4.6)

The future water supply reliabilities in 2030 at Lodwar in Turkwel River and Narok in Ewaso Ng'iro South River are 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 reliabilities at Kolowa in Kerio River and Naivasha in Malewa River are estimated at 1/10 since water demand downstream of the reference points is domestic use only.

The naturalised flows, reserves, water demands, yields and water supply reliabilities at the reference points are presented in Table 7.7.4. Estimated river flows for 2010 and 2030 are illustrated in Figure 9.7.1 for the reference points in RVCA.

The proposed water resources development plan listed above is a basis of the proposed water resources allocation plan for 2030 water demands stated in Section 9.2.

9.8 Water Resources Management Plan

(1) Current Situation of Water Resources Management

Water resources monitoring systems in RVCA are established, covering the seven major lakes along the Rift Valley and major rivers of Turkwel, Kerio and Ewaso Ng'iro South. As for the current monitoring situation, the ratio of actual monitoring stations against the WRMA's target is 61% (25 stations) for surface water level, 65% (24 stations) for groundwater level and 75% (45 stations) for rainfall as presented in Table 6.8.1. The ratio of surface water and groundwater monitoring against the target are relatively low.

Water resources evaluation is not being properly done using the above monitored data, therefore it is necessary to establish a system to evaluate water resources in the catchment.

Water permit issuance and control is not well managed as the ratio of effective water permit/issued permit is as low as 42% (surface water 32%, groundwater 68%), therefore further improvement is necessary.

For watershed conservation, Cherangani Hills and the Mau Forest Complex of the Five Water Towers, are major water sourcesof Turkwel and Ewaso Ng'iro South rivers. Decrease in forest areas is significant in the water source forests. According to the analysis conducted in this study[26], about 40% of forest area has disappeared in RVCA since 1990. In addition, degradation of small water sources is an issue in this catchment area.

(2) Management Strategy

Based on the overall concept and frameworks mentioned in Section 6.8, strategies for water resources management in RVCA are to be considered for four major aspects of: a) monitoring, b) water resources evaluation, c) water permit issuance and control, and d) watershed conservation, as described hereunder:

1) Monitoring

Monitoring items are surface water, groundwater and rainfall. For the surface water and groundwater, water quantity and quality are monitored. To make the current monitoring system more effective, review is to be made on surface water monitoring stations of major seven lakes and major rivers of Turkwel, Kerio, and Ewaso Ng'iro South and major tributaries. 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.

Rainfall monitoring stations are to be reviewed considering the climate division (arid area that covers most of the northern part, semi-arid areas in the central-western and southern parts and

[26] Refer to Sectoral Report (B), Section 8.3.

humid area in the central-southern part including highlands of Nakuru) of the catchment area and corresponding rainfall station densities to establish proper monitoring system.

Groundwater monitoring stations are to be set at areas where groundwater demand will increase in the future, namely, areas that have both a water supply development plan and a sewerage development plan. In such areas, groundwater is to be monitored using dedicated boreholes for monitoring.

2) Evaluation of Water Resources

As mentioned in the overall concept and frameworks in Section 6.8, regional offices should enhance the capacity for evaluation of water resources in both quantity and quality so as to determine available water resources for water permit issuance based on the monitored data, and to judge necessity of water resources development.

3) Water Permit Issuance and Control

Based on the overall concept mentioned in Section 6.8, in preparation of increased water demand in the future, the latest version of the issued water permits is to be maintained to enable accurate control of issued water permits that reflect the current water use. In addition, revision of standards such as "Guidelines for Water Allocation (WRMA, First Edition, March 2010)" is to be considered to enable issuance of water permits that reflect the current water use and available water resources. Furthermore, in view of the current working conditions in the issuance of water permits in regional offices, water rights officers in charge of water permit issuance and control are to be increased for regional/subregional offices for smooth work.

4) Watershed Conservation

Based on the overall concept and frameworks as mentioned in Section 6.8, forest recovery is to be implemented through reforestation focusing on the Mau Forest Complex and Cherangani Hills. Furthermore, conservation of small water sources should be considered in this catchment area.

(3) Proposed Water Resources Management Plan

Based on the management strategy mentioned above, the water resources management plan proposed for RVCA is as follows:

1) Monitoring

Proposed layout of monitoring stations for surface water, groundwater, rainfall and reference point is shown in Figures 7.8.1 and 19.1.6. Water quantity and quality are monitored at surface water monitoring and groundwater monitoring stations, while rainfall amount is monitored at rainfall monitoring stations. WRMA's target number and the proposed number of monitoring stations are as shown in Table 6.8.1.

In view of covering representative locations of major rivers, lakes and springs, current layout of the surface water monitoring stations were reviewed. Proposed surface water monitoring stations are two stations in Turkwel River, two stations in Kerio River, two stations in Ewaso

Ng'iro South River, one station each in the seven major lakes and ten stations in total for rivers draining into the seven lakes. In total, 23 stations are proposed against WRMA's target number of 41 for surface water monitoring network in RVCA.

In addition, the reference points representing the flow conditions of major rivers were set at four representative surface water monitoring stations, one each for the Turkwel, Kerio, Ewaso Ng'iro South rivers and Malewa River draining into Lake Naivasha as shown in Figure 19.1.6.

Based on the overall concept described in Section 6.8 (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 the respective rivers.

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. Sectoral Report (H), Sub-section 3.5.2)

The above normal discharges are to be reviewed and revised as necessary in the "Evaluation of Water Resources" 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.

As a result of the review based on the overall concept mentioned in Section 6.8 (2), 47 rainfall monitoring stations are proposed against WRMA's target number of 60.

As for groundwater monitoring stations, ten locations which are ten urban centers having both a water supply development plan and a sewerage development plan in this study are proposed against WRMA's target number of 37 considering increase of groundwater demand toward future. Groundwater monitoring is to be conducted using dedicated boreholes.

2) Evaluation of Water Resources

As for the enhancement of water resource quantity evaluation system, an evaluation team is formed by assigning a chief hydrologist from RV Regional Office in Nakuru as the leader and assistant hydrologists from each subregional office of Lodwar, Kapenguria, Kabarnet, Naivasha, and Narok as members. The evaluation team will target the whole area of RVCA to evaluate water resources of the catchment area once a year on the items mentioned in Section 6.8 (2) b)..

For water resource quality evaluation, in addition to the existing water quality testing laboratory in Nakuru, two more laboratories are to be proposed in Lodwar and Kapenguria for timely analysis of monitored water quality data in the northern and western parts of the catchment area. For the existing and new laboratories, adequate number of water quality experts should be assigned to establish a system for proper evaluation of qualities of surface water and groundwater at a monitoring time.

3) Water Permit Issuance and Control

As for water permit issuance and control, the following activities are proposed:

a) To maintain the latest version of the issued water permits through periodic updating of the water permit database and establishment of a notification system for permit expiry;
b) To revise standards of WRMA such as "Guidelines for Water Allocation (WRMA, First Edition, March 2010)" based on future water demands and available water resources; and
c) To enable smooth water permit issuance and control, it is proposed to increase water rights officers of RV regional office in Nakuru and Lodwar, Kapenguria, Kabarnet, Naivasha and Narok subregional offices from the current six to 15 by adding nine additional officers, three each in Naivasha and Lodwar subregional office, two in Kabarnet subregional office and one in Kapenguria subregional office.

4) Watershed Conservation

For reforestation for forest recovery, about 1,010,000 ha of reforestation is proposed for RVCA to achieve the target of the Kenya Vision 2030. Of the target, gazetted forest is supposed to be implemented by KFS.

As for conservation of small water sources, it is proposed to conduct surveys for target locations first to formulate plans.

9.9 Flood and Drought Disaster Management Plan

(1) Current Situation of Flood Disaster Management

In RVCA, severe floods occur mainly around the major five water tower areas. In particular, 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 during times of flood. Mogotio is a relatively small-scale urban centre. However, the Melo River passes through the urban area of Mogotio and it causes flood damages to the area. At this time, it could be said that systematic flood disaster 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.

(2) Current Situation of Drought Disaster Management

Most areas in RVCA except for its central part in and around Nakuru town are categorised as arid land for the northern side and semi-arid land for the southern side.

As for drought disaster management at local government and community levels, Arid Land Resources Management Project II was completed in December 2010. The project formulated institutional arrangement for drought disaster management at local levels for all the arid and semi-arid land districts in RVCA.

On the other hand, for drought disaster management at catchment level, WRMA RV Regional Office implements water use restriction in times of drought. However, reference water levels for restriction are not clearly determined in the RVCA. This means there is an operational issue from the view point of clear timing for actions against drought.

There are five existing dams for hydropower, irrigation and domestic water supply purposes. A drought disaster management plan including water use restriction of the reservoirs has not been implemented.

(3) Flood Disaster Management Strategy

As explained in the overall concept e) mentioned in Section 6.9, 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 and Narok. Lower/Middle Turkwel and Lower Kerio are to be excluded from NWMP 2030 because severe flood damage has been rarely reported while river-induced inundation was confirmed.

Regarding floods in Narok, in consideration of the abovementioned impact to major transportation, high population density and 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 of mitigating human damages since structural measures alone have limited effectivity against floods exceeding a design level. Hazard maps and an evacuation plan should be prepared. Regarding urban drainage issue in Narok, the drainage system should be also improved in consideration of the high population density.

Since it is effective to drain floodwaters downstream, the discharge capacity of the Melo River shall be improved through river improvement works. In addition, it is more effective to adopt a strategy of mitigating human damages since structural measures alone have limited effectivity against floods exceeding a design level. Hazard maps and an evacuation plan should be prepared.

The type of floods that occurred in Nakuru are not river-induced floods, but rather flood resulting from urban drainage issues. In consideration of the high population density in Nakuru, the drainage system should be improved.

(4) Drought Disaster Management Strategy

Based on the overall concept mentioned in Section 6.9, the drought disaster management strategy for RVCA is to be: i) preparation of water use restriction rules for existing and proposed reservoir, ii) establishment of Basin Drought Conciliation councils, and iii) establishment of drought early warning system.

(5) Proposed Flood and Drought Disaster Management Plan

Based on the management strategy mentioned above, the flood disaster management plan for RVCA is proposed as follows:

a) Implementation of flood control measures as well as preparing hazard map and evacuation plan in Narok,
b) Implementation of flood control measures as well as preparing hazard map and evacuation plan in Mogotio,
c) Implementation of urban drainage measures in Narok, and
d) Implementation of urban drainage measures in Nakuru.

Based on the management strategy mentioned above, the drought disaster management plan for RVCA is proposed as follows:

a) Preparation of water use restriction rules for reservoirs in the five existing and ten proposed dams including setting of reference reservoir water level, and determination of reduction rate,
b) Monitoring of reference water levels which correspond to reserve or normal discharge (this work is to be implemented as a part of water resources management plan),
c) Establishment of seven basin drought conciliation councils with legal status on the basis of a river basin unit, and
d) Establishment of specialised drought early forecast system for water use restriction, that are linked to expected fluctuation of percentage of the above 15 reservoirs.

Figure 7.9.1 shows the flood disaster management plan and drought disaster management plan.

9.10 Environmental Management Plan

(1) Current Situation of Environmental Management

RVCA has poor freshwater resources as most of rivers in RVCA are seasonal rivers or small rivers. Main rivers are the Turkwel, the Kerio, and the Ewaso Ng'iro South rivers. Lower reaches of Kerio and Ewaso Ng'iro South rivers are seasonal rivers. WRMA has monitoring points of river flow and water quality for those rivers. However, the data are not enough to confirm the time-dependent change of the water environment.

There are seven lakes in RVCA including Lake Naivasha which is a rare freshwater lake in Kenya and Lake Nakuru, an alkali lake which is famous as the habitat of flamingos. The lakes and surrounding wetlands are world heritage sites, national parks and national reserves. These areas are important natural resources.

Lake Nakuru and Lake Naivasha, which are located near town areas, are threatened by water pollution caused by sewage increase brought by population growth. The water pollution of Lake Naivasha from agricultural water and sewage inflow has been increasing. Similarly, sewage and industrial wastewater from Nakuru City has the potential to give a large negative impact on the natural ecosystem of the Nakuru National Park. Similar situation is observed in Lake Turkana, Lake Baringo and Lake Bogoria

in recent years. It is required to consider adequate countermeasures based on regular environmental monitoring to prevent any further environmental degradation.

The Mau Forest Complex, Cherangani Hills, and the Aberdare Range among the Five Water Towers are located in RVCA. The decrease of forest areas has affected water resource conservation like other catchment areas.

(2) Management Strategy

Based on the overall concept mentioned in Chapter 6.10, it is proposed to set environmental flow rate and to carry out environmental monitoring in main rivers and lakes in RVCA.

The water resource development projects in NWMP 2030 are mostly proposed on 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 the six alkali lakes which are important habitats for large mammals, amphibian 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 polluting Lake Nakuru and Lake Naivasha, because future population growth of the cities will worsen the water pollution in the two lakes.

(3) Proposed Environmental Management Plan

Based on the management strategy mentioned above, and point selection criteria mentioned in 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 point are as shown Figure 9.10.1.

Environmental Flow Rate Setting Points and Environmental Monitoring Points (RVCA)

Target	Setting Point			Proposed Major Development Projects
Turkwel River	Environmental flow rate	1	Reference point (Lodwar Town) : RV-F1	Embobut Dam and Turkwel irrigation
		2	Confluence point of Suam River (Lower reaches of Turkwel Dam) : RV-F2	
	Environmental monitoring	3	Reference point (Lodwar Town) : RV-M1	
		4	Confluence point of the Suam River (Lower reaches of Turkwel Dam) : RV-M2	
Kerio River	Environmental flow rate	1	Reference point (Lower reaches of the Arror River confluence point) : RV-F3	Arror, Murung-Sebit and Kimwarer dams
	Environmental monitoring	2	Lower reaches of the South Turkana National Reserve : RV-M3	
		3	Reference point(Lower reaches of the Arror River confluence point) : RV-M4	
Ewaso Ng'iro South River	Environmental flow rate	1	Reference point (Narok Town) : RV-F4	Upper Narok, Oletukat, Leshota, and Ololorko dams
	Environmental monitoring	2	Lower reaches of the Ewaso Ng'iro South River: RV-M5	
Lake Turkana	Environmental flow rate	1	Representative location point : RV-F5	-
	Environmental monitoring	2	Representative location point : RV-M6	
Lake Baringo	Environmental flow rate	1	Representative location point : RV-F6	-
	Environmental monitoring	2	Representative location point : RV-M7	
Lake Bogoria	Environmental flow rate	1	Representative location point : RV-F7	Waseges Dam
	Environmental monitoring	2	Representative location point : RV-M8	
Lake Nakuru	Environmental flow rate	1	Representative location point : RV-F8	-
	Environmental monitoring	2	Representative location point : RV-M9	
Lake Elementaita	Environmental flow rate	1	Representative location point : RV-F9	-
	Environmental monitoring	2	Representative location point : RV-M10	
Lake Naivasha	Environmental flow rate	1	Representative location point : RV-F10	Malewa Dam
	Environmental monitoring	2	Representative location point : RV-M11	
Lake Magadi	Environmental flow rate	1	Representative location point : RV-F11	-
	Environmental monitoring	2	Representative location point : RV-M12	
Nakuru and Naivasha towns	Environmental monitoring	1	Nakuru Town (Main discharge point) : RV-M13	-
		2	Naivasha Town (Main discharge point) : RV-M14	-

Source: JICA Study Team (Ref. Main Report Part D, Sub-section 4.9.3.)

In addition, environmental survey for setting of environmental flow rate (current river flow rate, water quality and river ecosystem) shall be conducted in the Turkwel, the Kerio, and the Ewaso Ng'iro South rivers and above the six alkali lakes except Lake Naivasha.

10. ATHI CATCHMENT AREA

10.1 Catchment Area Characteristics

ACA is located in the southern part of the country as shown in Figure 1.3.1 and borders on the Tana Catchment Area in the north, the Indian Ocean in the east, Tanzania in the south and the Rift Valley Catchment Area in the west. The Aberdare Range, one of the Five Water Towers, lies in the northern edge of the area. Total area of ACA is 58,639 km^2, corresponding to 10.2% of the country's total land area. Based on the Census 2009, population of the area in 2010 is estimated at 9.79 million, or 25.4% of the total population of Kenya. Population density is 167 persons/km^2.

The topography of ACA varies, from the highland in the Aberdare Range at around 2,600 m amsl to the coastal area at sea level. ACA is divided into three zones, with the upper zone at 2600-1500 m amsl, middle zone at 1,500-500 m amsl, and coastal zone at 500-0 m amsl.

The Athi River flows from the southeast of Nairobi north-eastward in the upstream reaches and then turns to the southeast in the north of Ol Doinyo Sapuk National Park and flows along the catchment area boundary with Tana Catchment Area and pours into the Indian Ocean in the north of Malindi. The drainage area of the Athi River is 37,750 km^2, or 64.4% of the Athi Catchment Area. The Lumi River, Lake Jipe, and Lake Chala flow into Tanzania and the Umba River flows from Tanzania to Kenya. Other rivers such as the Rare, Mwachi, Pemba, and Ramisi rivers flow into the Indian Ocean and the total drainage area is 19, 493 km^2.

There are several springs in ACA such as Mzima, Kikuyu, Njoro Kbwa, Nol Turesh springs, etc.

ACA is classified as a semi-arid land except the upstream area of the Athi River which is classified as non-ASAL. The mean annual rainfall ranges between 600 mm in the central part of the area to 1,200 mm in the upstream area of the Athi River. The catchment area average mean annual rainfall is 810 mm. The renewable water resources, which is defined as precipitation minus evapotranspiration, is estimated at 4.54 BCM/year in 2010 for ACA and the per capita renewable water resources is calculated at 464 m^3/year/capita.

10.2 Water Resources, Water Demands and Water Allocation

The available water resources were estimated in ACA for the years of 2010 (present) and 2030 (future) as explained in Section 4.4 and summarised below. The estimate for 2030 includes impacts of climate change.

Annual Available Water Resources (ACA)

(Unit: MCM/year)

Year	Surface Water	Groundwater	Total
2010	1,198	305	1,503
2030	1,334	300	1,634
Ratio of 2030 to 2010	111%	98%	109%

Source: JICA Study Team (Ref. Main Report Part E, Section 3.2.)

The annual water demands were estimated for the year 2010 and projected for 2030 in ACA as described in Section 5.2 and summarised below. The projection for 2030 followed the national development targets of Kenya Vision 2030 and socioeconomic framework, but without considering the available water resources.

Water Demands by Subsector(ACA)

Year	Water Demands (MCM/year)						
	Domestic	Industrial	Irrigation	Livestock	Wildlife	Fisheries	Total
2010	519	93	498	25	3	7	1,145
2030	941	153	3,418	59	3	12	4,586

Source: JICA Study Team (Ref. Main Report Part E, Section 3.3.)

In order to assess severity of water balance, ratios of available water resources and water demands presented above and those of water demands and water deficits discussed in Section 5.3 are tabulated for both 2010 and 2030 as follows:

Ratios of Water Demands/Available Water Resources and Water Deficits/Water Demands (ACA)

Description	2010	2030
Available Water Resources (MCM/year)	1,503	1,634
Water Demands (MCM/year)	1,145	4,586
Water Demands/Available Water Resources	76%	281%
Water Deficits (MCM/year)	745	4,153
Water Deficits/Water Demands	65%	91%

Source: JICA Study Team (Ref. Main Report Part E, Section 3.4 (1) and Sectoral Report (G), Sub-section 3.4.2.)

The present water demands of 1,145 MCM/year in 2010 is equivalent to 76% of the available water resources (water stress ratio). This ratio exceeds the severe water stress ratio of 40% and ACA has already been in severe water stress. The water stress ratio is expected to increase to 281% by 2030. The above table also shows the estimated water deficits of 745 MCM/year in 2010 and increased deficits of 4,153 MCM/year in 2030. This implies that irrigation water demand representing about 75% of the total demand should be reduced as well as proper water resources development.

The water balance study was carried out based on the proposed water resources development plans of the related subsectors described in the following sections. The water demands that can be covered by the available water resources are presented in Table 7.2.1. The allocated amounts of the surface water and groundwater to satisfy the 2030 water demands are as follows:

Water Resources Allocation Plan for Water Demands in 2030 after Balance Water Study (ACA)

(Unit: MCM/year)

Subsector	Water Demand (2030)	Water Resources Allocation	
		Surface Water	Groundwater
Domestic	941	819	122
Industrial	153	77	76
Irrigation	917	*882	35
Livestock	59	59	0
Wildlife	3	3	0
Fisheries	12	12	0
Total	2,085	1,852	233

Note: *= Including water demand to be supplied by water resources of Tanzania of 154 MCM/year (groundwater)

Source: JICA Study Team (Ref. Main Report Part E, Section 3.4 (3) and Sectoral Report (G), Sub-section 4.7.3 (2).)

Because of the limited water resources, it was concluded that interim target of new irrigation development area of 233,628 ha for 2030 needed to be reduced to 46,108 ha as stated in Sections 6.5 and 10.5.

The above mentioned water resources allocation plan should be the base data for the future water resources management plan of the ACA.

10.3 Water Supply Development Plan

(1) Current Situation of Water Supply

Current population of ACA in 2010 is estimated to be 9.79 million including an urban population of 6.51 million and a rural population of 3.28 million. The population is concentrated in Nairobi area and Mombasa area. Based on the 2009 Census data, the current situation of water connection of ACA was estimated as shown below:

Current Situation of Water Connection (ACA)

Type	Piped by WSPs	Spring/Well/Borehole	Water Vendor	Stream/Lake/Pond/Others
Urban Population	63%	17%	17%	3%
Rural Population	28%	34%	3%	35%
Total Population	54%	22%	13%	11%

Source: JICA Study Team based on Census 2009 data (Ref. Sectoral Report (C), Sub-section 2.3.6.)

The water provided by unregistered water vendors and water taken from streams, lakes and ponds without proper treatment are categorised as an unimproved drinking water source. Around 24% of the population gets drinking water from such unimproved drinking water sources. Also, around 22% of the population gets water from springs, wells or boreholes. Unprotected wells and springs are categorised as unimproved drinking water sources, but the utilisation ratio of unprotected ones is not known.

It is projected that urban population will increase by 11.22 million and the rural population will decrease by 0.47 million and the total population will be 20.54 million in 2030. Currently, piped water supply covers 63% of the urban population of ACA, and this ratio is the highest in all six catchment areas. However, it is required to implement a large-scale urban water supply system development to cope with the urban population increase of 1.08 million and achieve the target coverage ratio of 100%. Two studies: ”Feasibility Study and Master Plan for Developing New Water Sources for Nairobi and Satellite Towns” and ”Water Supply Master Plan for Mombasa and Other Towns Within the Coast Province” are still under implementation by the World Bank fund. The water sources development plans proposed or studied in these studies are same as those of NWMP 2030.

(2) Development Strategy

ACA is divided into three areas, such as Nairobi surrounding area, Mombasa surrounding area and other area for urban water supply systems (UWSS) planning considering the characteristics of the three areas.

Based on the overall concept mentioned in Section 6.3, UWSS are planned for 32 UCs in ACA. In case the same water resources are used for several urban centres (UCs) in 16 UCs in Nairobi and satellite towns and nine UCs in Mombasa and coastal surrounding area, one water supply system is planned to cover several UCs. However, UWSS in the other seven UCs are planned for each UC independently.

The water supply capacity required for UWSS in ACA in 2030 is 2,260,000 m^3/day against the current water supply capacity (including capacity under construction) of 699,000 m^3/day. Therefore, additional

capacity of 1,560,000 m^3/day is to be developed by 2030. It is to be developed through the following three types of projects.

a) Rehabilitation of existing UWSS: In order to achieve 20% NRW ratio, water meters are to be installed for all households and old pipes of existing UWSS of the 30 UCs, which has a water supply capacity of 699,000 m^3/day, are to be replaced. In addition, the rehabilitation will include 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 28 UCs out of the above 29 UCs to meet the water demand in 2030. The total capacity of expansion is 1,542,000 m^3/day.

c) Construction of new UWSS: The construction of new UWSS is planned for the two UCs which have no UWSS. The total capacity of new construction is 19,000 m^3/day.

d) According to data from WSBs, there are 31 plans of urban water supply development projects to cover 21 UCs and surrounding areas in ACA[27], which have 1,215,000 m^3/day of total water supply capacity. (Refer to Sectoral Report (C), Section 2.4) These plans are to be taken into account for planning.

Based on the overall concept mentioned in Section 6.3, rural water supply systems are planned to be developed by LSRWSS and SSRWSS.

a) Development of LSRWSS: The LSRWSS is proposed mainly for areas with high population density or areas with difficulties in groundwater use on a personal or community basis. The LSRWSS is to be developed for 2.04 million residents in ten counties of ACA.

b) Development of SSRWSS: The SSRWSS is proposed for 2.00 million residents in 10 counties of ACA, and it includes construction and improvement of boreholes, wells, and springs on a personal and community basis. As this type of works is to be implemented on a personal and community basis, only the water demand projection is carried out for SSRWSS in the master plan.

(3) Proposed Water Supply Development Plan

Based on the development strategy mentioned above, the proposed UWSS is presented in Table 10.3.1, and the proposed LSRWSS and SSRWSS are in Tables 10.3.2 and 10.3.3, respectively. Figure 7.3.1 shows urban centers subject to urban water supply system development.

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

Proposed Water Supply Development Plan (ACA)

Type of Project		Target Area	Total Capacity (m^3/day)	Service Population (million persons)
Urban Water Supply	Rehabilitation	30 UCs	699,000	17.01
	Expansion	29 UCs	1,542,000	
	New Construction	2 UCs	19,000	
	Total	32 UC	2,260,000	
Rural Water Supply	LSRWSS	10 Counties	209,000	4.04
	SSRWSS	10 Counties	110,000	
	Total	10 Counties	319,000	

Note: The water supply development plan of ACA includes Thika with 0.51 million population in 2030. Thika is located in TCA, but it has been covered by water supply system in ACA.
Source: JICA Study Team (Prepared based on Tables 10.3.1 to 10.3.3.)

[27] Refer to Sectoral Report (C), Section 2.4.

By the above water supply development plan, the water supply situation of ACA in 2030 will be improved as follows:

Water Supply Situation in 2030 (ACA)

Items		Urban Water Supply	Large-scale Rural Water Supply	Small-scale Rural Water Supply	Total
Service Population (million)	2010	5.29		2.15	7.44
	2030	17.01	2.04	2.00	21.05
Water Supply Capacity (m^3/day)	2010	699,000	100,000	108,000	907,000
	2030	2,260,000	209,000	110,000	2,579,000
Operating Body		Registered WSPs	Registered WSPs	Individual, Community, etc.	--
Target Towns/ Areas		32 UCs	10 Counties		--

Source: JICA Study Team (Figures for 2010 were prepared by reference to Sectoral Report (C), Section 2.3. Figures for 2030 were prepared based on Tables 10.3.1 to 10.3.3.)

In order to ensure water sources required for the water supply systems in Nairobi and surrounding area, it is proposed to construct eight new dams in ACA and five new dams in TCA, and also expand the inter-basin water transfer system from TCA presented in, as the result of the water balance study.

For the water supply systems in Mombasa and coastal area, it is proposed to construct three new dams in ACA and expand two existing intra-basin water transfer systems. Also, a desalination plant is necessary for Mombasa and coastal area.

For the water supply systems in other area in ACA, it is proposed to construct four new dams in ACA.

Tables 7.7.1 and 7.7.2 present the proposed dams and water transfer facilities mentioned above.

10.4 Sanitation Development Plan

(1) Current Situation of Sanitation Development

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

Current Situation of Access to Sanitation Facilities (ACA)

Type	Sewerage System	Septic Tank, Pit Latrine, Cesspool (On-site Treatment Facilities)	Bush, etc (No Treatment)
Urban Population	30%	69%	1%
Rural Population	0%	77%	23%
Total Population	22%	71%	7%

Source: JICA Study Team based on Census 2009 data (Ref. Sectoral Report (D), Sub-section 2.3.5.)

Sewerage system has been developed in limited areas in ACA and current sewerage coverage ratio is 22% which is the highest coverage ratio in the six catchment areas. There are eight waste water treatment plants in six UCs around Nairobi and Mombasa, with a total treatment capacity of about 222,000 m^3/day. Around 71% of the population use on-site treatment facilities such as septic tanks, etc. The on-site treatment facilities include unimproved ones, but the ratio of the unimproved facilities is not known. Around 7% of the population does not have any treatment facilities and resort to unsanitary waste disposal.

(2) Development Strategy

Based on the overall concept and framework for planning described in Section 6.4, sewerage system development is planned for 25 UCs in ACA. The sewerage system development is conducted through the following three types of projects:

a) Rehabilitation of existing sewerage system: Rehabilitation includes the repair and replacement of mechanical and electrical equipment of wastewater treatment plants (WWTPs) and pumping stations, and replacement of corroded sewer pipes in six UCs, which have sewerage systems with a total capacity of 244,000 m^3/day.

b) Expansion of sewerage system: In order to cover the demand in 2030, capacities of existing sewerage systems of six UCs are to be expanded. This includes expansion and/or new construction of sewerage pipes, pumping stations, and WWTPs. The total capacity of expansion is 715,000 m^3/day.

c) Construction of new sewerage system: There are no sewerage systems in 19 UCs. New sewerage systems are to be constructed in these UCs with total capacity of 430,000 m^3/day.

d) According to data from WSBs, there are 15 plans of sewerage development projects in ACA, which have 396,000 m^3/day of total treatment capacity[28]. These plans are to be taken into account for planning.

Outside the sewerage service area, improved on-site treatment facilities will be available for the remaining 4.28 million residents in 2030. Currently, 6.95 million residents (71% of the entire population) are using existing on-site treatment facilities, but unimproved ones are to be improved with new housing construction. Development of on-site treatment facilities is planned for 10 counties in ACA.

(3) Proposed Sanitation Development Plan

Based on the development strategy mentioned above, the sewerage development plan is shown in Table 10.4.1 and the on-site treatment development plan is shown in Table 10.4.2. The proposed sanitation development plan for ACA is outlined below.

Proposed Sanitation Development Plan (ACA)

Type of Project		Target Area	Total Capacity (m^3/day)	Service Population (million persons)
Sewerage System (Off-site Treatment)	Rehabilitation	6 UCs	244,000	16.26
	Expansion	6 UCs	715,000	
	New Construction	19 UCs	430,000	
	Total	25 UCs	1,389,000	
On-site Treatment Facilities		10 Counties	--	4.28

Source: JICA Study Team (Prepared based on Tables 10.4.1 and 10.4.2.)

Out of 17.73 million of the urban population in ACA in 2030, 92% is expected to be covered by the sewerage system. The ratio in ACA is higher than the national target of 80%, because there are many large-scale UCs which have priority of sewerage system development. By the above sanitation development, the sanitation situation of ACA in 2030 will be as follows:

[28] Refer to Sectoral Report (D), Section 2.4.

Sanitation Situation in 2030 (ACA)

Items		Sewerage System	Septic Tank, etc (On-site Treatment Facilities)
Service Population (million)	2010	2.15	6.95
	2030	16.26	4.28
Required Treatment Capacity (m^3/day)	2010	244,000	-----
	2030	1,389,000	-----
Operating Body		Registered WSPs	Individual, Community, etc.
Target Towns/ Areas		25 UCs	10 Counties

Source: JICA Study Team (Figures for 2010 were prepared by reference to Sectoral Report (D), Section 2.3. Figures for 2030 were prepared based on Tables 10.4.1 and 10.4.2.)

10.5 Irrigation Development Plan

(1) Current Situation of Irrigation Development

The Athi River runs from the highland near Nairobi to the Indian Ocean near Mombasa. The highland receives ample rainfall and has a wet climate. However, available water is very tight due to large water users such as domestic water use in urban areas and irrigated agriculture. On the other hand, some areas in the southwest of ACA, near Tanzania, receives stable river water and groundwater originating from the skirts of Mt. Kilimanjaro. The total cropping area in ACA in 2011 was 876,544 ha producing horticultural crops and food crops such as maize and beans. The existing irrigation area in ACA was estimated at 44,898 ha in 2010, consisting of 13,524 ha (30%) of small-scale schemes, and 31,374 ha (70%) of private schemes. The share of irrigation area against cropping area is 5.1%. Most of the existing irrigation systems have deteriorated mainly due to poor maintenance.

(2) Development Strategy

Following the overall concept and frameworks for irrigation development mentioned in section 6.5, strategy for irrigation development in ACA was set as follows:

a) Owing to ample available land resources but quite limited water resources for irrigation in ACA, priority should be given to expansion of existing irrigation schemes through the construction of storage dams in semi-arid lands to maximise irrigation area. Development of small-scale dam irrigation and groundwater irrigation should be promoted as long as water resources are available;
b) To strengthen the agricultural sector in ACA, irrigation development should be focused in increasing agricultural productivity by increasing cropping intensity of existing irrigation areas through rehabilitation and upgrading of existing irrigation systems; and
c) To utilise limited water resources efficiently, water-saving irrigation methods to improve water productivity should be introduced for all irrigation areas.

(3) Proposed Irrigation Development Plan

As a result of the water balance study by sub-basins in ACA, possible irrigation development areas under application of the water-saving irrigation methods were estimated as summarised below.

Possible Irrigation Area in 2030 (ACA)

(Unit: ha)

Type of Irrigation	Existing Irrigation Area in 2010	New Irrigation Area in 2030						Total Irrigation Area in 2030
		Surface Water Irrigation			Groundwater Irrigation	Water Harvesting Irrigation	New Irrigation Total	
		River Water	Dam	Total				
Large Scale	0	5,280	32,000	37,280	0	0	37,280	37,280
Small Scale	13,524	35	0	35	2,309	4,140	6,484	20,008
Private	31,374	35	0	35	2,309	0	2,344	33,718
Total	44,898	5,350	32,000	37,350	4,618	4,140	46,108	91,006

Source: JICA Study Team (Ref. Main Report Part E, Sub-section 4.4.3.)

Against the provisional target of new irrigation development area of 233,628 ha (distributed to ACA for the national target of 1.2 million ha) mentioned in Section 6.5, the possible new irrigation development area comes to 46,108 ha (decrease of 187,520 ha) even with maximum water resources development presented in Section 10.7 due to limitation of available water resources. Table 7.5.1 shows the maximum irrigation area by catchment area in 2030.

As for the large-scale irrigation projects (more than 500 ha), 13 projects proposed by the government authorities listed in Table 6.5.1 were taken up for the water balance study, and four projects listed in Table 7.5.2 (37,280 ha in total) were selected as the possible projects in ACA from a viewpoint of surface water resources availability for irrigation. The locations of the selected projects are shown in Figure 7.5.1. Among them, the large scale irrigation projects more than 5,000 ha are as follows.

a) Kibwez Irrigation Project (17,000 ha, Thwake multipurpose dam)
b) Kanzal Irrigation Project (15,000 ha, Munyu multipurpose dam)

The irrigation water demand for the above new irrigation development and existing irrigation was estimated at 925 MCM/year as given in Table 7.2.1.

10.6 Hydropower Development Plan

(1) Current Situation and Strategy for Hydropower Development

In ACA, there are no existing hydropower stations. ACA has the least hydropower potential among the WRMA's six catchment areas.

As there is no plan taken up in the Least Cost Power Development Plan (LCPDP) in ACA, the hydropower component of multipurpose-type development schemes will be taken up based on the overall concept and frameworks mentioned in Section 6.6. Hydropower components of multipurpose dam development plans in the major rivers will be taken up as hydropower development plan of ACA.

(2) Proposed Hydropower Development Plan

Based on the development strategy mentioned above, the proposed hydropower development plan is formulated. The plan consists of the following two plans which are the hydropower components of multipurpose dam development projects in ACA:

Hydropower Development Plan (ACA)

Name of the plan	River	Installed Capacity	Purpose
Munyu Multipurpose Dam Development Plan	Athi River	40 MW	Irrigation, Hydropower
Thwake Multipurpose Dam Development Plan	Athi River	20 MW	Water Supply, Irrigation, Hydropower
Total		60 MW	

Source: JICA Study Team, based on information from MORDA and TARDA. (Ref. Main Report Part E, Sub-section 4.5.3.)

Of the above proposed plans, maturity of the studies seems to be low. Additional studies are required to confirm the planned installed capacity and amount of power generation.

10.7 Water Resources Development Plan

(1) Current Situation of Water Resources Development

ACA has a total catchment area of 58,639 km^2, and an annual average rainfall of 810 mm which is between rather high rainfall of around 1,300-1,400 mm in LVNCA and LVSCA and low rainfall of around 500 mm in RVCA and ENNCA. The annual rainfall differs spatially within the catchment area, ranging from around 500 mm in the southern part near the border with Tanzania to 1,200 mm in the western mountainous area. The available water resources estimated in ACA for 2010 (present) are 1,198 MCM/year for surface water and 333 MCM/year for groundwater. The available surface water resources in 2030 were estimated to be 1,334 MCM/year considering the effect of climate change, while the available groundwater resources is 303 MCM/year which is almost same as the amount of 2010.

The present (2010) water demands in ACA were estimated to be 1,145 MCM/year, which consist mainly of domestic water demands for the population of 9.79 million and irrigation water demands for the irrigation area of 44,898 ha. The population is concentrated in and around Nairobi and Mombasa and its surrounding area along the coastal area. Among 32 urban centres situated in the catchment area, 30 centres have water supply systems. About 22% of the population is supplied with groundwater.

The existing water resource structures/facilities except for direct intake facilities from the rivers to satisfy the present water demands are: i) seven dams (all for domestic water supply, with total storage volume of 10 MCM); ii) seven intra-basin and three inter-basin water transfer facilities; iii) 1,326 small dams/water pans (for domestic, livestock and irrigation water supply, with total storage volume of 12 MCM); and iv) 5,351 boreholes (for mainly domestic water supply, with total abstraction volume of 230 MCM/year). The values of present water supply reliability in ACA were estimated by the water balance study to be 1/2 at the reference point of Wamunyu (3DB01) in the middle reach of Athi River and 1/1 at Epiya Chapeyu (3HA12) in the lower reach of Athi River under the condition of existing water resource structures/facilities mentioned above. One dam is under construction (for domestic water supply purpose with intra-basin water transfer and storage volume of 1 MCM).

It is observed that the water balance is tight in and around the areas of Nairobi and Mombasa for domestic use.

(2) Development Strategy

As explained in Sections 10.3 and 10.5, the projected 2030 water demand of 2,124 MCM/year shows a large increase of about 1.9 times compared to the present demand due to considerable increase in population to 20.54 million and irrigation areas to 96,158 ha expected by the year 2030 in ACA. Judging from the estimated 2030 water deficits discussed in Section 10.2, it is certain that the existing water resource structures/facilities will not be able to satisfy the greatly increased 2030 water demand because of the uneven distribution of water resources both spatially and temporally. Therefore, new water resources structures/facilities are required to be developed.

Attention needs to be paid to the domestic water supply in Nairobi and satellite towns, and also in Mombasa and coastal areas where future domestic water demands will increase drastically, but the available water resources are limited.

Strategies for the water resources development in ACA were enumerated below to formulate the well balanced development plan between water resources and demands, following the overall concept and framework for the planning as stated in Section 6.7 and based on the current situation of the catchment area and future water demands.

a) The inter-basin water transfer facilities from dams in adjacent catchment area of TCA to ACA are to be developed to supply domestic water to Nairobi and satellite towns where heavily concentrated domestic water demands are expected in 2030. The volume of water transferred from these dams to ACA is included in the water demands mentioned in Section 10.2 for ACA.
b) Dam development is essential and to be promoted in the northwestern part of the catchment area, along the Athi River and in the coastal area including Mombasa to satisfy sharply increased future large water demands such as domestic, industrial and irrigation water demands expected in these areas. Candidates for dam development for maximum surface water exploitation include, in principle: i) dams proposed by the NWMP (1992), and ii) dams under the design and/or planning stage by the government including the Kenya Vision 2030 flagship projects.
c) Dams identified in the most upstream area of the Athi River are to be developed for only the domestic water supply purpose to Nairobi and satellite towns considering the limited water resources against the large domestic water demands expected in these areas. The identified dams include Upper Athi, StonyAthi, Kikuyu, Ruaka, Kamiti 1, Ruiru-A, and Ndarugu dams.
d) Dams, intra-basin water transfer expansion schemes from the existing springs and Ahi River, and/or desalination are to be studied to incorporate them into the development plan for the domestic water supply to Mombasa and coastal areas.
e) Small dams and/or water pans are to be constructed in small rivers throughout 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 suitable for large dams but where surface water is available.
f) Groundwater usage through boreholes is considered mainly for domestic, industrial and irrigation water demands where surface water is not available.

(3) Proposed Water Resources Development Plan

The water balance study was carried out for 2030 between the available water resources and water demands in ACA based on the overall concept and framework for the planning and development strategy. As a result of the water balance study, the required new water resource structures/facilities in addition to direct intake facilities from rivers are as follows:

Existing Structures/Facilities and Proposed Water Resources Development Plan (ACA)

Structure		No.	Purpose	Dimension/ Capacity	Remarks
Dam	Existing	7	Domestic	Total storage volume of 10 MCM	
	Proposed	16	Domestic, industrial, irrigation, hydropower and flood control	Total storage volume of 1,689 MCM	
Intra-basin Water Transfer	Existing	7	Domestic	Total transfer volume of 65 MCM/year	
	Proposed	1	Domestic	Transfer volume of 37 MCM/year from Mzima Springs to Mombasa	Expansion
	Proposed	1	Domestic	Transfer volume of 31 MCM/year from Athi River to Mombasa	Expansion
Inter-basin Water Transfer	Existing	3	Domestic	Total transfer volume of 184 MCM/year	
	Proposed	1	Domestic	Transfer volume of 168 MCM/year from TCA to Nairobi	Expansion
Small Dam/ Water Pan	Existing	1,326	Domestic, livestock and irrigation	Total storage volume of 12 MCM	
	Proposed	1,800	Rural domestic, livestock, irrigation, wildlife and fisheries	Total storage volume of 94 MCM	
Borehole	Existing	5,351	Domestic	Total abstraction of 230 MCM/year	
	Proposed	350	Domestic, industrial, and irrigation	Total abstraction of 35 MCM/year	
Desalination	Existing	0			
	Proposed	-	Domestic	Production volume of 93 MCM/year	

Note: The water supply reliability applied in the plan is 1/10 for domestic and industrial use and 1/5 for irrigation use.
Source: JICA Study Team (Ref. Main Report Part E, Sub-sections 4.6.1 and 4.6.3.)

A list of the proposed dams is represented in Table 7.7.1 and a list of the proposed water transfer facilities is shown in Table 7.7.2. Figure 7.7.1 illustrates locations of the dams and water transfer facilities.

The water demand and supply balance for 2030 in ACA under the condition of proposed water resources development structures mentioned above is summarised in Table 10.7.1.

The water supply reliabilities for 2010 and 2030 at the reference points proposed for water resources management in ACA are estimated as below:

Water Supply Reliability at Reference Point (ACA)

Reference Point	Present (2010) Water Supply Reliability (with Existing Facilities)	Future (2030) Water Supply Reliability (with Existing and Proposed Facilities)
Athi River, middle reaches (3DB01), Wamunyu	1/2	1/5
Athi River, lower reaches (3HA12), Epiya Chapeyu	1/1	1/10

Source: JICA Study Team (Ref. Sectoral Report (G), Section 4.7)

The future water supply reliability in 2030 at Wamunyu in Middle Athi River is estimated at 1/5 since water demand downstream of the reference point is irrigation use mainly, while the future water

supply reliability at Epiya Chapeyu in Lower Athi River is estimated at 1/10 since water demand downstream of the reference point is domestic use only.

The naturalised flows, reserves, water demands, yields and water supply reliabilities at the reference points are presented in Table 7.7.4. Estimated river flows for 2010 and 2030 are illustrated in Figure 10.7.1 for the reference points in ACA.

The proposed water resources development plan listed above is a basis of the proposed water resources allocation plan for 2030 water demands stated in Section 10.2.

10.8 Water Resources Management Plan

(1) Current Situation of Water Resources Management

Water resources monitoring systems in ACA are established, covering the major rivers of Athi and its tributaries, rivers draining directly to Indian Ocean. As for the current monitoring situation, the ratio of actual monitoring stations against the WRMA's target is 58% (18 stations) for surface water level, 35% (25 stations) for groundwater level and 66% (33 stations) for rainfall as presented in Table 6.8.1. The ratio is relatively low, especially the groundwater monitoring ratio.

Water resources evaluation is not being properly done using the above monitored data, therefore it is necessary to establish a system to evaluate water resources in the catchment area.

Water permit issuance and control is not well managed as the ratio of effective water permit/issued permit is as low as 40% (surface water 42%, groundwater 38%), therefore further improvement is necessary.

For watershed conservation, the Aberdare Range of the Five Water Towers is a major water source of Athi River. Decrease of forest areas is significant in the water source forests in the Aberdare Range as well as gazetted forests in the coastal areas, namely Arabuko Sokoke and Shimba Hills. According to the analysis conducted in this study[29], about 53% of forest area has disappeared in ACA since 1990. In addition, degradation of small water sources is an issue in this catchment area.

(2) Management Strategy

Based on the overall concept and frameworks mentioned in Section 6.8, strategies for water resources management in ACA is to be considered for four major aspects of: a) monitoring, b) water resources evaluation, c) water permit issuance and control, and d) watershed conservation, as described hereunder:

1) Monitoring

Monitoring items are surface water, groundwater and rainfall. For the surface water and groundwater, water quantity and quality are monitored. To make the current monitoring system more effective, review is to be made on surface water monitoring stations which are concentrated in the upper reaches of the Athi River and its tributaries. In addition, a reference

[29] Refer to Sectoral Report (B), Section 8.3.

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.

Rainfall monitoring stations are to be reviewed considering the climate division (semi-arid area that covers most of the catchment area and humid area in the north-western part including Nairobi) of the catchment area and corresponding rainfall station densities to establish proper monitoring system.

Groundwater monitoring stations are to be set at areas where groundwater demand will increase in the future, namely, areas that have both a water supply development plan and a sewerage development plan. In such areas, groundwater is to be monitored using dedicated boreholes for monitoring.

2) Evaluation of Water Resources

As mentioned in the overall concept and frameworks in Section 6.8, regional offices should enhance the capacity for evaluation of water resources in both quantity and quality so as to determine available water resources for water permit issuance based on the monitored data, and to judge necessity of water resources development.

3) Water Permit Issuance and Control

Based on the overall concept mentioned in Section 6.8, in preparation of increased water demand in the future, the latest version of the issued water permits is to be maintained to enable accurate control of issued water permits that reflect the current water use. In addition, revision of standards such as "Guidelines for Water Allocation (WRMA, First Edition, March 2010)" is to be considered to enable issuance of water permits that reflect the current water use and available water resources. Furthermore, in view of the current working conditions in the issuance of water permits in regional offices, water rights officers in charge of water permit issuance and control are to be increased for regional/subregional offices for smooth works.

4) Watershed Conservation

Based on the overall concept and frameworks as mentioned in Section 6.8, forest recovery is to be implemented through reforestation focusing on the Aberdare Range and gazetted forests in the coastal areas. Furthermore, conservation of small water sources in this catchment area is to be considered.

(3) Proposed Water Resources Management Plan

Based on the management strategy mentioned above, the water resources management plan proposed for ACA is as follows:

1) Monitoring

Proposed layout of monitoring stations for surface water, groundwater, rainfall and reference point is shown in Figures 7.8.1 and 19.1.8. Water quantity and quality are monitored at surface water monitoring and groundwater monitoring stations, while rainfall amount is

monitored at rainfall monitoring stations. WRMA's target number and the proposed number of monitoring stations are as shown in Table 6.8.1.

In view of covering representative locations of major rivers, lakes and springs, current layout of the surface water monitoring stations were reviewed. Proposed surface water monitoring stations are ten stations in the upper reach of Athi River and its tributaries, one station each in Namanga and Lumi international rivers, international lakes of Jipe and Chala, four stations in the rivers in the central part of the catchment area, two stations in major springs in the middle reaches of Athi River, and six stations in rivers draining directly into Indian Ocean. In total, 26 stations are proposed against WRMA's target number of 31 for surface water monitoring network in ACA.

In addition, the reference points representing the flow conditions of major rivers were set at two representative surface water monitoring stations on the main stream of the Athi River as Figure 19.1.8.

Based on the overall concept described in Section 6.8 (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 of Athi River.

Normal Discharge at Reference Point (ACA)

(Unit: m^3/sec)

Reference Point	Normal Discharge (Reserve + Water Demand for the Downstream of Reference Point)	
	2010	2030
Athi River (middle) (3DB01)	8.7 (=8.6+0.1)	8.7 (=8.6+0.1)
Athi River (lower) (3HA12)	9.0 (=8.9+0.1)	9.0 (=8.9+0.1)

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

The above normal discharges are to be reviewed and revised as necessary in the "Evaluation of Water Resources" 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.

As a result of the review based on the overall concept mentioned in Section 6.8 (2), 38 rainfall monitoring stations are proposed against WRMA's target number of 50.

As for groundwater monitoring stations, 24 locations which are 24 urban centers having both a water supply development plan and a sewerage development plan in this study are proposed against WRMA's target number of 71 considering increase of groundwater demand toward future. Groundwater monitoring is to be conducted using dedicated boreholes.

2) Evaluation of Water Resources

As for the enhancement of water resource quantity evaluation system, an evaluation team is to be formed by assigning a chief hydrologist from Athi regional office in Machakos as the leader and assistant hydrologists from each subregional office of Kiambu, Nairobi, Kibwezi, Loitoktok, and Mombasa as members. The evaluation team will target the whole area of ACA to evaluate water resources of the catchment area once a year on the items mentioned in Section 6.8 (2) b)..

For water resource quality evaluation, in addition to the existing water quality testing laboratory in Machakos, one more laboratory will be proposed in Mombasa for timely analysis of monitored water quality data in the central and coastal part of the catchment area. For the existing and new laboratories, an adequate number of water quality experts should be assigned to establish a system for proper evaluation of qualities of surface water and groundwater at a monitoring time.

3) Water Permit Issuance and Control

As for water permit issuance and control, the following activities are proposed:

a) To maintain the latest version of the issued water permits through periodic updating of the water permit database and establishment of a notification system for permit expiry;
b) To revise standards of WRMA such as "Guidelines for Water Allocation (WRMA, First Edition, March 2010)" based on future water demands and available water resources; and
c) To enable smooth water permit issuance and control, it is proposed to increase water rights officers of Athi regional office in Machakos and Kiambu, Nairobi, Kibwezi, Loitoktok, and Mombasa subregional offices from the current six to 16 by adding ten additional officers, three in Mombasa subregional office, two each in Athi Regional Office and Nairobi subregional office, one each in Kiambu, Kibwezi, and Loitoktok subregional offices.

4) Watershed Conservation

For reforestation for forest recovery, about 870,000 ha of reforestation is proposed for ACA to achieve the target of the Kenya Vision 2030. Of the target, gazetted forest is supposed to be implemented by Kenya Forest Service (KFS).

As for conservation of small water sources, it is proposed to conduct surveys for target locations first to formulate plans.

10.9 Flood and Drought Disaster Management Plan

(1) Current Situation of Flood Disaster Management

Coastal areas in ACA suffer from flood damages nearly every year due to heavy rains. Downstream Athi, which is also known as lower Sabaki, has frequent inundation at the lower reaches where there are a lot of small-scale migratory settlements. Floods in Taita Taveta County frequently occur in the small villages along the Lumi River on the south side of Taveta urban area. At this time, it could be

said that systematic flood disaster management has not been implemented in ACA because setting of warning water levels at major river gauge stations have not been confirmed.

(2) Current Situation of Drought Disaster Management

Most of ACA except for its most upstream parts in and around Nairobi and Machakos is categorised as semi-arid land.

As for drought disaster management at local government and community levels, Arid Land Resources Management Project II was completed in December 2010. The project formulated institutional arrangement for drought disaster management at local levels for all the arid and semi-arid land districts in ACA.

On the other hand, for drought disaster management at catchment level, WRMA Athi Regional Office conducts water use restriction in times of drought. However, reference water levels for restriction have not been clearly determined in ACA. This means there is an operational issue from the viewpoint of clear timing for actions against drought.

There are eight existing dams for domestic water supply purposes. A drought disaster management program, including water use restriction of the reservoirs, has not been implemented.

(3) Flood Disaster Management Strategy

As explained in the overall concept e) mentioned in Section 6.9, the proposed examination areas in ACA are Downmost Athi, Lumi River mouth, Nairobi City, Kwale, and Mombasa.

In Downmost Athi, flood control measures will not be required because seasonal residents usually move to safe areas during flood season and thus, there are scarcely any densely-populated areas. Therefore, the basic strategy for the most downstream section of Athi is to develop CBDM system by installing a simplified flood forecasting system based on water level observation in the upper reaches.

Since most flood damages occurrs in small-scale villages, as is the case with Downmost Athi mentioned above, it is considered to be appropriate for Lumi River mouth to develop CBDM system.

In Kwale County, Vanga is the area most affected by flood as the area is located in the downstream reaches of the Umba River flowing nearby the Kenya-Tanzania national border. In this area, it is confirmed from satellite images that a built-up area has been formed. Therefore, Vanga shall be protected by river structural measures.

The type of floods that occurs in Nairobi and Mombasa is not river-induced floods, but caused by urban drainage issues. In consideration of the very high population density in Nairobi and Mombasa, the drainage systems should be improved.

(4) Drought Disaster Management Strategy

Based on the overall concepts mentioned in Section 6.9, drought disaster management strategy for ACA is to be: i) preparation of water use restriction rules for existing and proposed reservoir, ii) establishment of Basin Drought Conciliation councils, and iii) establishment of drought early warning system.

(5) Proposed Flood and Drought Disaster Management Plan

Based on the management strategy mentioned above, the flood disaster management plan for ACA is proposed as follows:

a) Establishment of community-based disaster management system in downmost Athi,
b) Establishment of community-based disaster management system in Lumi River mouth (near the entrance to Lake Jipe),
c) Implementation of flood control measures as well as preparing hazard map of Vanga in Kwale County,
d) Implementation of urban drainage measures in Nairobi, and
e) Implementation of urban drainage measures in Mombasa.

Based on the management strategy mentioned above, the drought disaster management plan for ACA is proposed as follows:

a) Preparation of water use restriction rules for reservoirs in the eight existing and sixteen proposed dams including setting of reference reservoir water level, and determination of reduction rate,
b) Monitoring of reference water levels which correspond to reserve or normal discharge (this work is to be implemented as a part of water resources management plan),
c) Establishment of six basin drought conciliation councils with legal status on the basis of a river basin unit, and
d) Establishment of specialised drought early forecast system for water use restriction, that are linked to expected fluctuation of percentage of the above 24 reservoirs.

Figure 7.9.1 shows the flood disaster management plan and drought disaster management plan.

10.10 Environmental Management Plan

(1) Current Situation of Environmental Management

Main river of ACA is the Athi River and its tributaries which are the main water sources for ACA. WRMA has monitoring points for river flow and water quality in this body of water. However, the data obtained was not enough to confirm the time-dependent change of water environment. Nairobi City is located in the uppermost area of ACA. The Athi and Nairobi rivers are contaminated because of inadequate wastewater treatment and illegal dumping from Nairobi City. Therefore, it is necessary to monitor the environmental impact through environmental monitoring. The excessive use of groundwater is also a serious challenge in the city.

The Lumi International River, as well as international lakes, Jipe and Chala are located in the border with Tanzania. The two lakes have lake ecosystems which include Hippopotamus and Crocodile habitats. In particular, there is one endemic fish species that only lives in Lake Jipe. Environmental monitoring is required in these two lakes because the lakes have been salified and water levels of the lakes are decreasing in recent years. In addition, the Amboseli National Park is an important natural environment located near the border with Tanzania and its water level changes in the dry and rainy seasons.

Mombasa City, the second largest city in Kenya, is located in the coastal area. Inadequate management of sewage and waste from Mombasa City causes water pollution and mangrove forest degradation in the marine reserve area.

(2) Management Strategy

Based on overall concept mentioned in Chapter 6.10, setting of environmental flow rate and environmental monitoring are proposed in main rivers and lakes in ACA.

Water resource development projects of ACA are proposed on the Athi, Nairobi, Lumi, Mwachi, and Kaiti rivers etc. Appropriate environmental flow rate should be set for these rivers in the future. It is proposed to set environmental flow rate and to carry out environmental monitoring for the Athi and Lumi rivers as representative rivers. Lake Chala and Lake Jipe are also proposed to have lake water level and environmental monitoring because they are international lakes and have important ecosystems. In addition, it is proposed to carry out environmental monitoring for Lake Amboseli because the lake provides important natural resources.

Sewage and industrial wastewater from Nairobi and Mombasa cities have already affected the surrounding environment. Therefore, environmental monitoring is proposed for these two cities and also the Nairobi River which is directly affected by Nairobi City.

(3) Proposed Environmental Management Plan

Based on the management strategy mentioned above, and point selection criteria mentioned in overall concept and framework, target points of environmental flow rate and environmental monitoring of environmental management plan for ACA are shown in the following table. Locations of target point are shown Figure 10.10.1.

Setting Point of Environmental Flow Rate and Environmental Monitoring Points (ACA)

Target	Setting Point			Proposed Major Development Projects
Athi River	Environmental flow rate	1	Reference point (Confluence point of the Tsavo River) : ACA-F1	Upper Athi, Ruiru A, Kamiti1, Kikuyu, Stony Athi, Ndarugu, Thwake dams
		2	Upper reaches of Tsavo national parks : ACA-F2	
		3	Reference point(Kangunda Town) : ACA-F3	
	Environmental monitoring	4	Reference point (Confluence point of the Tsavo River) : ACA-M1	
		5	Upper reaches of the Tsavo national parks : ACA-M2	
		6	Reference point(Kangunda Town) : ACA-M3	
Lumi River	Environmental flow rate	1	Reference point : ACA-F4	Lake Chala Dam and Taita Taveta Irrigation
	Environmental monitoring	2	Reference point : ACA-M4	
Nairobi River	Environmental monitoring	1	Lower reaches of Nairobi City : ACA-M5	Ndarugu and Munyu irrigations
Lake Chala	Environmental flow rate	1	Representative location point : ACA-F5	-
	Environmental monitoring	2	Representative location point : ACA-M6	
Lake Jipe	Environmental flow rate	1	Representative location point : ACA-F6	Lake Chala Dam and Taita Taveta Irrigation
	Environmental monitoring	2	Representative location point : ACA-M7	

Target	Setting Point			Proposed Major Development Projects
Lake Amboseli	Environmental monitoring	1	Representative location point : ACA-M8	-
Nairobi and Mombasa cities	Environmental monitoring	1	Nairobi City (Main discharge point) : ACA-M9	-
		2	Mombasa City (Main discharge point) : ACA-M10	-

Source: JICA Study Team (Ref. Main Report Part E, Sub-section 4.9.3.)

In addition, environmental survey for setting of environmental flow rate (current river flow rate, water quality and river ecosystem) shall be conducted in the Athi and Lumi rivers, Lake Chala, Lake Jipe, and Lake Amboseli.

11. TANA CATCHMENT AREA

11.1 Catchment Area Characteristics

TCA is located in the south-eastern part of the country as shown in Figure 1.3.1. TCA borders on Ewaso Ng'iro North Catchment Area in the north, Somalia and Indian Ocean in the east, TCA in the south and southwest and the Rift Valley Catchment Area in the west. The Mt. Kenya and the Aberdare Range of the Five Water Towers lie in the western edge of the area. Total area of TCA is 126,026 km^2, corresponding to 21.9% of Kenya. Based on the Census 2009, population of the area in 2010 is estimated at 5.73 million, or 14.9% of the total population of Kenya. Population density is 45 persons/km^2.

The topography of TCA varies, from the highest peak of Mt. Kenya at 5,199 m amsl to the coast at less than 50 m amsl. The area is roughly divided into three zones, an upper zone of more than 1,000 m amsl, middle zone of 1,000-300 m amsl, and lower zone below 300 m amsl.

The Tana River is the largest river in the area and it originates from Mt. Kenya. It is the longest river in the country. The drainage area of the Tana River is 95,884 km^2, or 76.1% of TCA. In the upstream reaches of the Tana River, there are five hydropower stations, namely, Masinga, Kamburu, Gitaru, Kindaruma, and Kiambere power stations. The total installed capacity is 563.2 MW and total gross reservoir storage is 2,331 MCM. They play an important role in supplying about 40% of the total annual energy production in the country. After flowing through these reservoirs, the Tana River flows northeastward and then gradually change its direction eastward. After crossing Garissa Bridge, the Tana River flows southward and into the Indian Ocean.

In the uppermost reaches of the Tana River, there are two tributaries of the Chania and Thika rivers which divert the river water to Nairobi metropolitan area of TCA through Sasuma and Thika dams.

From the middle to the lower reaches of the Tana River, several tributaries such as Nihunguthu, Maua, Tiva, and Laga Bunda rivers join the Tana River mainstream, but they are seasonal rivers.

In the eastern part of TCA, there are rivers flowing to Somalia (13,281 km^2) or into the Indian Ocean (17,253 km^2). The total drainage area of these rivers accounts for 24.2% of TCA.

The upper part of TCA is classified as a humid land (non-ASAL), central and coast areas as semi-arid lands and the rest as arid lands. The mean annual rainfall ranges from 500 mm in the north-eastern part

of the area to 1,600 mm around Mt. Kenya. The catchment area average mean annual rainfall is 840 mm. The renewable water resources, which is defined as precipitation minus evapotranspiration, is estimated at 13.58 BCM/year in 2010 for TCA and the per capita renewable water resources is estimated at 2,369 m^3/year/capita.

11.2 Water Resources, Water Demands and Water Allocation

The available water resources were estimated in TCA for the years of 2010 (present) and 2030 (future) as explained in Section 4.4 and summarised below. The estimate for 2030 includes impacts of climate change.

Annual Available Water Resources (TCA)

(Unit: MCM/year)

Year	Surface Water	Groundwater	Total
2010	5,858	675	6,533
2030	7,261	567	7,828
Ratio of 2030 to 2010	124%	84%	120%

Source: JICA Study Team (Ref. Main Report Part F, Section 3.2.)

The annual water demands were estimated for the year 2010 and projected for 2030 in TCA as described in Section 5.2 and summarised below. The projection for 2030 followed the national development targets of Kenya Vision 2030 and socioeconomic framework, but without considering the available water resources.

Water Demands by Subsector (TCA)

Year	Water Demands (MCM/year)						
	Domestic	Industrial	Irrigation	Livestock	Wildlife	Fisheries	Total
2010	146	5	696	34	1	9	891
2030	343	42	7,770	69	1	16	8,241

Source: JICA Study Team (Ref. Main Report Part F, Section 3.3.)

In order to assess severity of water balance, ratios of available water resources and water demands presented above and those of water demands and water deficits discussed in Section 5.3 are tabulated for both 2010 and 2030 as follows:

Ratios of Water Demands/Available Water Resources and Water Deficits/Water Demands (TCA)

Description	2010	2030
Available Water Resources (MCM/year)	6,533	7,828
Water Demands (MCM/year)	891	8,241
Water Demands/Available Water Resources	14%	105%
Water Deficits (MCM/year)	336	5,822
Water Deficits/Water Demands	38%	71%

Source: JICA Study Team (Ref. Main Report Part F, Section 3.4 (1) and Sectoral Report (G), Sub-section 3.4.2.)

Although the present water demands in 2010 are estimated to be 14% of the available water resources (water stress ratio), the water demands for 2030 are expected to sharply increase to about 105% against the available water resources in 2030. As the water stress ratio in 2030 is over 40%, TCA will be in severe water stress. The above table also shows the estimated water deficits of 336 MCM/year in 2010 and increased deficits of 5,822 MCM/year in 2030. This implies that irrigation water demand, representing about 94% of the total demands, needs to be reduced to attain the appropriate water balance as well as proper water resources development.

The water balance study was carried out based on the proposed water resources development plans of the related subsectors described in the following sections. The water demands that can be covered by the available water resources are presented in Table 7.2.1. The allocated amounts of the surface water and groundwater to satisfy the 2030 water demands are as follows:

Water Resources Allocation Plan for Water Demands in 2030 after Water Balance Study (TCA)

(Unit: MCM/year)

Subsector	Water Demand (2030)	Water Resources Allocation	
		Surface Water	Groundwater
Domestic	343	303	40
Industrial	42	21	21
Irrigation	2,697	2,546	151
Livestock	69	69	0
Wildlife	1	1	0
Fisheries	16	16	0
Total	3,168	2,956	212

Source: JICA Study Team (Ref. Main Report Part F, Section 3.4 (3) and Sectoral Report (G), Sub-section 4.8.3 (2).)

Because of limited water resources, it was concluded that interim target of new irrigation development area of 482,450 ha for 2030 needed to be reduced to 161,799 ha as stated in Sections 6.5 and 11.5.

The above mentioned water resources allocation plan should be the base data for future water resources management plan of the TCA.

11.3 Water Supply Development Plan

(1) Current Situation of Water Supply

The current population of TCA in 2010 is estimated to be 5.73 million including an urban population of 1.04 million and a rural population of 4.70 million. The urban population ratio is relatively low, so the population growth is relatively low compared with other catchment areas. Based on the 2009 Census data, the current situation of water connection of TCA was estimated as shown below.

Current Situation of Water Connection (TCA)

Type	Piped by WSPs	Spring/Well/Borehole	Water Vendor	Stream/Lake/Pond/Others
Urban Population	58%	16%	6%	20%
Rural Population	29%	27%	3%	42%
Total Population	34%	25%	4%	37%

Source: JICA Study Team based on Census 2009 data (Ref. Sectoral Report (C), Sub-section 2.3.7.)

The water provided by unregistered water vendors and water taken from streams, lakes and ponds without proper treatment are categorised as an unimproved drinking water source. Around 41% of the population gets drinking water from such unimproved drinking water sources. Also, around 25% of the population gets water from springs, wells or boreholes. Unprotected wells and springs are categorised as un-improved drinking water sources, but the utilisation ratio of unprotected ones is not known.

It is projected that urban population will increase by 5.30 million, the rural population will decrease by 0.66 million and the total population will be 10.37 million in 2030. Currently, piped water supply covers 58% of the urban population of TCA. The ratio is relatively high. Large-scale urban water supply system developments are currently under implementation to meet future water demand.

(2) Development Strategy

TCA is divided into three areas such as the upper Tana, the arid areas and another area for urban water supply system (UWSS) planning considering the characteristics of the three areas.

Based on the overall concept mentioned in Section 6.3, UWSS are planned for 23 urban centres (UCs) in TCA. The water supply capacity required for UWSS in TCA in 2030 is 543,000 m^3/day against the current water supply capacity (including capacity under construction) of 106,000 m^3/day. Therefore, the additional capacity of 437,000 m^3/day will be developed by 2030. It is to be developed through the following three types of projects.

a) Rehabilitation of existing UWSS: In order to achieve 20% NRW ratio, water meters are to be installed for all households and old pipes of existing UWSS of 15 UCs which has a water supply capacity of 106,000 m^3/day, are to be replaced. In addition, the rehabilitation will include 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 14 out of the 15 UCs to meet the water demand in 2030. The total capacity of expansion is 397,000 m^3/day.
c) Construction of new UWSS: The construction of new UWSS is planned for eight UCs which have no UWSS. The total capacity of new construction is 88,000 m^3/day.
d) According to data from WSBs, there are 10 plans of water supply development projects to cover 18 UCs and surrounding areas in TCA[30], which have 880,000 m^3/day of total water supply capacity. (Refer to Sectoral Report (C), Section 2.4) The planned total capacity is around two times of the development capacities required in 2030. The required capacities in this study are to be estimated based on the overall concept mentioned in Section 6.3.

Based on the overall concept mentioned in Section 6.3, rural water supply systems are planned to be developed by LSRWSS and SSRWSS.

a) Development of LSRWSS: LSRWSS is proposed mainly for areas with high population density or areas with difficulties in groundwater use on a personal or community basis. LSRWSS is to be developed for 1.74 million residents in 16 counties of TCA.
b) Development of SSRWSS: The SSRWSS is proposed for 2.72 million residents in 16 counties of TCA, and it includes construction and improvement of boreholes, wells, and springs on a personal and community basis. As this type of works is to be implemented on a personal and community basis, only the water demand projection is carried out for SSRWSS in the master plan.

(3) Proposed Water Supply Development Plan

Based on the development strategy mentioned above, the proposed UWSS is presented in Table 11.3.1, and the proposed LSRWSS and SSRWSS are in Tables 11.3.2 and 11.3.3, respectively. Figure 7.3.1 shows urban centers subject to urban water supply system development.

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

[30] Refer to Sectoral Report (C), Section 2.4.

Proposed Water Supply Development Plan (TCA)

Type of Project		Target Area	Total Capacity (m^3/day)	Service Population (million persons)
Urban Water Supply	Rehabilitation	15 UCs	106,000	4.90
	Expansion	14 UCs	349,000	
	New Construction	8 UCs	88,000	
	Total	23 UCs	543,000	
Rural Water Supply	LSRWSS	16 Counties	211,000	4.96
	SSRWSS	16 Counties	145,000	
	Total	16 Counties	356,000	

Note: The water supply development plan of ACA includes Thika with 0.51 million population in 2030. Thika is located in TCA, but it has been covered by water supply system in ACA.
Source: JICA Study Team (Prepared based on Tables 11.3.1 to 11.3.3.)

Based on the above water supply development plan, the water supply situation of TCA in 2030 will be improved as follows:

Water Supply Situation in 2030 (TCA)

Items		Urban Water Supply	Large-scale Rural Water Supply	Small-scale Rural Water Supply	Total
Service Population (million)	2010	1.95		1.43	3.38
	2030	4.90	2.24	2.72	9.86
Water Supply Capacity (m^3/day)	2010	106,000	149,000	72,000	327,000
	2030	543,000	211,000	145,000	899,000
Operating Body		Registered WSPs	Registered WSPs	Individual, Community, etc.	--
Target Towns/ Areas		23 UCs	16 Counties		--

Source: JICA Study Team (Figures for 2010 were prepared by reference to Sectoral Report (C), Section 2.3. Figures for 2030 were prepared based on Tables 11.3.1 to 11.3.3.)

In order to ensure water sources required for the water supply systems mentioned above, it is proposed to construct four new dams and one intra-basin water transfer system and also expand two existing intra-basin water transfer systems presented in Tables 7.7.1 and 7.7.2, as the result of the water balance study.

11.4 Sanitation Development Plan

(1) Current Situation of Sanitation Development

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

Current Situation of Access to Sanitation Facilities (TCA)

Type	Sewerage System	Septic Tank, Pit Latrine, Cesspool (On-site Treatment Facilities)	Bush, etc (No Treatment)
Urban Population	7%	90%	3%
Rural Population	0%	87%	13%
Total Population	2%	87%	11%

Source: JICA Study Team, and Census 2009 data (Ref. Sectoral Report (D), Sub-section 2.3.6.)

Sewerage system has been developed in limited areas in TCA and current sewerage coverage ratio is only 2%. There are six small-scale wastewater treatment plants in six UCs such as Thika, Nyeri, Muranga, etc., with a total treatment capacity of about 32,343 m^3/day. Around 87% of the population use on-site treatment facilities such as septic tanks, etc. The on-site treatment facilities include

unimproved ones, but the ratio of the unimproved facilities is not known. Around 11% of the population does not have any treatment facilities and resort to unsanitary waste disposal.

(2) Development Strategy

Based on the overall concept and framework mentioned in Section 6.4, sewerage system development is planned for 18 UCs in TCA. The sewerage system development is conducted through the following three types of projects:

a) Rehabilitation of existing sewerage system: Rehabilitation includes the repair and replacement of mechanical and electrical equipment of wastewater treatment plants (WWTPs) and pumping stations, and replacement of corroded sewer pipes in six UCs, which have sewerage systems with a total capacity of 32,000 m^3/day.
b) Expansion of sewerage system: In order to cover the demand in 2030, capacities of existing sewerage systems of six UCs are to be expanded. This includes expansion and/or new construction of sewerage pipes, pumping stations, and WWTPs. The total capacity of expansion is 118,000 m^3/day.
c) Construction of New Sewerage System: There are no sewerage systems in 12 UCs. New sewerage systems are to be constructed in these UCs with total capacity of 248,000 m^3/day.
d) According to data from WSBs, there are 11 plans of sewerage development projects to cover 12 urban centres in TCA, which have 98,000 m^3/day of total treatment capacity[31]. These plans are to be taken into account for planning.

Outside the sewerage service area, improved on-site treatment facilities will be available for the remaining 5.13 million residents in 2030. Currently, 4.99 million residents (87% of the entire population) are using existing on-site treatment facilities, but unimproved ones are to be improved with new housing construction. Development of on-site treatment facilities is planned for 16 counties in TCA.

(3) Proposed Sanitation Development Plan

The sewerage development plan is shown in Table 11.4.1, and the on-site treatment development plan is shown in Table 11.4.2. The proposed sanitation development plan for TCA is outlined below.

Proposed Sanitation Development Plan (TCA)

Type of Project		Target Area	Total Capacity (m^3/day)	Service Population (million persons)
Sewerage System	Rehabilitation	6 UCs	32,000	5.24
	Expansion	6 UCs	118,000	
	New Construction	12 UCs	248,000	
	Total	18 UCs	398,000	
On-site Treatment Facilities		16 Counties	--	5.13

Source: JICA Study Team (Prepared based on Tables 11.4.1 and 11.4.2.)

Out of 6.34 million of the urban population in TCA, 82% is expected to be covered by the sewerage system. The ratio of TCA is higher than the national target of 80%, because there are only a few

[31] Refer to Sectoral Report (D), Section 2.4.

large-scale UCs which have high priority of sewerage system development. By the above sanitation development, the sanitation situation of TCA in 2030 will be as follows:

Sanitation Situation in 2030 (TCA)

Items		Sewerage System	Septic Tank, etc. (On-site Treatment Facilities)
Service Population (million)	2010	0.11	4.99
	2030	5.24	5.13
Required Treatment Capacity (m^3/day)	2010	32,000	--
	2030	398,000	--
Operating Body		Registered WSPs	Individual, Community, etc.
Target Towns/ Areas		18 UCs	16 Counties

Source: JICA Study Team (Figures for 2010 were prepared by reference to Sectoral Report (D), Section 2.3. Figures for 2030 were prepared based on Tables 11.4.1 and 11.4.2.)

11.5 Irrigation Development Plan

(1) Current Situation of Irrigation Development

The Tana River is the largest river in Kenya of which drainage area accounts for 76.1% of TCA. Upstream of the Tana River is densely populated highland. The lowland area in TCA is a huge unused flatland with an arid or semi-arid climate. The total cropping area in TCA in 2011 was 1.0 million ha. Major crops cultivating are horticultural crops and food crops such as maize and beans. The existing irrigation area in the TCA is 64,425 ha in 2010, consisting of 11,200 ha (17%) of large-scale schemes, 14,823 ha (23%) of small-scale schemes, and 38,402 ha (60%) of private schemes. The share of irrigation area against cropping area is 6.4%. Existing public irrigation systems, especially pumping schemes, have deteriorated due to lack of budget for repair and maintenance.

(2) Development Strategy

Following the overall concept and frameworks for irrigation development mentioned in Section 6.5, strategy for irrigation development in RVCA was set as follows:

a) Blessed with ample land and water resources available for irrigation in TCA, priority should be given to large dam irrigation in semi-arid lands to maximise irrigation area. Furthermore, weir irrigation, small-scale dam irrigation and groundwater irrigation should be developed as long as water resources are available;
b) To strengthen the agricultural sector in TCA, irrigation should be expanded in rainfed agricultural areas in arid and semi-arid lands to increase agricultural productivity and production; and
c) To utilise available water resources efficiently for the maximisation of irrigation development, water-saving irrigation methods to improve water productivity should be introduced for all irrigation areas.

(3) Proposed Irrigation Development Plan

As a result of the water balance study by sub-basins in TCA, possible irrigation development areas under application of the water-saving irrigation methods were estimated as summarised below.

Possible Irrigation Area in 2030 (TCA)

(Unit: ha)

Type of Irrigation	Existing Irrigation Area in 2010	New Irrigation Area						Total Irrigation Area in 2030
		Surface Irrigation Area			Groundwater Irrigation	Water Harvesting Irrigation	New Irrigation Total	
		River Water	Dam	Total				
Large Scale	11,200	4,961	131,000	135,961	0	0	135,961	147,161
Small Scale	14,823	0	0	0	10,054	5,730	15,784	30,607
Private	38,402	0	0	0	10,054	0	10,054	48,456
Total	64,425	4,961	131,000	135,961	20,108	5,730	161,799	226,224

Source: JICA Study Team (Ref. Main Report Part F, Sub-section 4.4.3.)

Against the provisional target of new irrigation development area of 482,450 ha (distributed to TCA for the national target of 1.2 million ha) mentioned in Section 6.5, the possible new irrigation development area comes to 161,799 ha (decrease of 320,651 ha) even with maximum water resources development presented in section 11.7 due to limitation of available water resources. Table 7.5.1 shows the maximum irrigation area by catchment area in 2030.

As for the large-scale irrigation projects (more than 500 ha), 15 projects proposed by the government authorities and one projects proposed in this study listed in Table 6.5.1 were taken up for the water balance study, and four projects listed in Table 7.5.2 (135,961 ha in total) were selected as the possible projects in TCA from a viewpoint of surface water resources availability for irrigation. The locations of the selected projects are shown in Figure 7.5.1. Among them, the large scale irrigation projects more than 5,000 ha are as follows.

a) High Grand Falls Irrigation Project (106,000 ha, High Grand Falls multipurpose dam)
b) Kora Dam Irrigation Project (25,000 ha, Kora dam)

The irrigation water demand necessary for the above new irrigation development and existing irrigation was estimated at 2,697 MCM/year as given in Table 7.2.1.

11.6 Hydropower Development Plan

(1) Current Situation of Hydropower Development

In TCA, there are five major hydropower stations in the upstream area of the Tana River, namely, Masinga (40 MW), Kamburu (94.2 MW), Gitaru (225 MW), Kindaruma (40 MW), and Kiambere (164 MW). Total installed capacity of these five power stations is 563.2 MW. Annual power generation of these power stations is 2313 GWh (average of 2005-2010), which contributes 36% of the total power supply in the country. Most of these power stations are old power stations that were constructed more than 30 years ago. Therefore, there are issues of reservoir sedimentation, deterioration of power generation equipment, etc. Furthermore, Karura hydropower development project, which is KenGen's development plan, will also be taken up in the plan as the project has a very high probability of being implemented.

(2) Development Strategy

Based on the overall concept and frameworks mentioned in Section 6.6, the proposed plans in Least Cost Power Development Plan (LCPDP) and the hydropower component of multipurpose type

development schemes on the Tana River are to be taken up for the hydropower development plan for TCA.

(3) Proposed Hydropower Development Plan

Based on the development strategy mentioned above, the proposed hydropower development plan consists of the following two plans. Locations of the proposed hydropower development sites are shown in Figure 11.6.

Proposed Hydropower Development Plan (TCA)

Plan	River	Installed Capacity	Purpose
High Grand Falls Multipurpose Dam Development Plan	Tana River	Stage 1: 500 MW Stage 2: +200 MW	Water Supply, Irrigation, Hydropower
Karura Hydropower Development Project	Tana River	90 MW	Hydropower
Total		790 MW	

Source: JICA Study Team based on information from MORDA, TARDA and KenGen. (Ref. Main Report Part F, Sub-section 4.5.3.)

As for Karura Hydropower Development Project, feasibility study by KenGen is ongoing as of January 2013.

11.7 Water Resources Development Plan

(1) Current Situation of Water Resources Development

TCA has a total catchment area of 126,026 km^2 (21.9% of the country), and an annual average rainfall of 840 mm which is between the rather heavy rainfall of around 1,300-1,400 mm in LVNCA and LVSCA and less rainfall of around 500 mm in RVCA and ENNCA. The annual rainfall differs spatially within the catchment area, ranging from around 500 mm in the middle reaches of the Tana River to 1,400 mm in the western mountainous area. The available water resources estimated in TCA for 2010 (present) are 5,858 MCM/year for surface water and 879 MCM/year for groundwater. The available surface water resources in 2030 were estimated to be 7,261 MCM/year considering the effect of climate change and the groundwater resources is 873 MCM/year, which is almost same as the amount of 2010.

The present (2010) water demands in TCA were estimated to be 891 MCM/year, which consist mainly of domestic water demands for the population of 5.73 million (14.9% of national population) and irrigation water demands for the irrigation area of 64,425 ha. Among 23 urban centres situated in the catchment area, 15 centres have water supply systems. About 24% of the population is supplied with groundwater.

The existing water resource structures/facilities except for direct intake facilities from the rivers to satisfy the present water demands are: i) seven dams (two for domestic water supply to Nairobi, five for hydropower generation, with total storage volume of 2,218 MCM almost all of which are for hydropower); ii) two intra-basin and two inter-basin water transfer facilities; iii) 622 small dams/water pans (for domestic, livestock and irrigation water supply , with total storage volume of 27 MCM); and iv) 1,587 boreholes (for mainly domestic water supply, with total abstraction volume of 68

MCM/year). The values of present water supply reliability in TCA were estimated by the water balance study to be 1/1 at the reference point of Tana Rukanga (4BE10) in the upper reach of Tana River, 1/7 at Thika (4CC03) in Thika River, and 1/2 at Garissa (4G01) in the lower reach of Tana River under the condition of existing water resource structures/facilities mentioned above. One dam is under construction (for domestic water supply, with storage volume of 1 MCM).

(2) Development Strategy

As mentioned in Sections 11.3 and 11.5, the projected 2030 water demand of 3,239 MCM/year show a large increase of about 3.6 times compared to the present demand due to considerable increase in population to 10.37 million and irrigation areas to 235,736 ha expected by the year 2030 in TCA. Judging from the estimated 2030 water deficits discussed in Section 11.2, it is certain that the existing water resource structures/facilities will not be able to satisfy the greatly increased 2030 water demands because of the uneven distribution of water resources both spatially and temporally. Therefore, new water resource structures/facilities are required to be developed.

Attention needs to be paid to develop the irrigation water supply for large-scale irrigation schemes planned in the downstream area of the Tana River and the water supply to the Lamu Port. It is also noted that TCA has an important function to transfer domestic water to Nairobi and its outskirt in ACA.

Strategies for the water resources development in TCA were enumerated below to formulate the well-balanced development plan between water resources and demands, following the overall concept and framework for the planning as stated in Section 6.7 and based on the current situation of the catchment area and future water demands.

a) Inter-basin water transfer facilities from dams located upstream of the catchment area to ACA are to be developed to supply domestic water to Nairobi and satellite towns where heavily concentrated domestic water demands are expected in 2030 but where both surface and groundwater resources are insufficient. The volume of water transferred from these dams to ACA is included in the water demands mentioned in Section 10.2 for ACA.
b) Dam development is essential and to be promoted in the western part of the catchment area where sharply increased future large water demands such as domestic, industrial and irrigation water demands are expected in 2030. Candidates of dam development for maximum surface water exploitation include, in principle: i) dams proposed by the NWMP (1992), and ii) dams under the design and/or planning stage by the government including the Kenya Vision 2030 flagship projects.
c) High Grand Falls Dam is to be included in the development plan to supply irrigation water for large-scale irrigation schemes located in the downstream area of the Tana River and domestic and industrial water to the Lamu Port.
d) Expansion of the existing domestic water supply system is to be included in the development plan for water supply to Kitui from Masinga Dam and to Mwingi from Kiambere Dam.
e) Small dams and/or water pans are to be constructed in small rivers throughout 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 possible for large dams but where surface water is available.

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

(3) Proposed Water Resources Development Plan

The water balance study was carried out for 2030 between the available water resources and water demands in TCA based on the overall concept and framework for the planning and development strategy. As a result of the water balance study, the required new water resource structures/facilities in addition to direct intake facilities from rivers are as follows:

Existing Structures/Facilities and Proposed Water Resources Development Plan (TCA)

Structure		No.	Purpose	Dimension/Capacity	Remarks
Dam	Existing	7	Domestic and hydropower	Total storage volume of 2,218 MCM	
	Proposed	11	Domestic, industrial, irrigation, hydropower and flood control	Total storage volume of 5,729 MCM	
Intra-basin Water Transfer	Existing	2	Domestic	Total transfer volume of 4 MCM/year from Masinga and Kiambere dams	
	Proposed	1	Domestic	Transfer volume of 23 MCM/year from Masinga Dam to Kitui	Expansion
	Proposed	1	Domestic	Transfer volume of 2 MCM/year from Kiambere Dam to Mwingi	Expansion
	Proposed	1	Domestic and industrial	Transfer volume of 69 MCM/year from High Grand Falls Dam to Lamu	
Inter-basin Water Transfer	Existing	2	Domestic	Total transfer volume of 181 MCM/year from Sasumua and Thika dams to Nairobi in ACA	
	Proposed	1	Domestic	Transfer volume of 168 MCM/year from TCA to Nairobi	Expansion
Small Dam/ Water Pan	Existing	622	Domestic, livestock and irrigation	Total storage volume of 27 MCM	
	Proposed	3,020	Rural domestic, livestock, irrigation, wildlife and fisheries	Total storage volume of 151 MCM	
Borehole	Existing	1,587	Domestic	Total abstraction of 68 MCM/year	
	Proposed	1,440	Domestic, industrial, and irrigation	Total abstraction of 144 MCM/year	

Note: The water supply reliability applied in the plan is 1/10 for domestic and industrial use and 1/5 for irrigation use.
Source: JICA Study Team (Ref. Main Report Part F, Sub-sections 4.6.1 and 4.6.3.)

A list of the proposed dams is represented in Table 7.7.1 and a list of the proposed water transfer facilities is shown in Table 7.7.2. Figure 7.7.1 illustrates locations of the dams and water transfer facilities.

The water demand and supply balance for 2030 in TCA under the condition of proposed water resources development structures mentioned above is summarised in Table 11.7.1.

The water supply reliabilities for 2010 and 2030 at the reference points proposed for water resources management in TCA are estimated as below:

Water Supply Reliability at Reference Point (TCA)

Reference Point	Present (2010) Water Supply Reliability (with Existing Facilities)	Future (2030) Water Supply Reliability (with Existing and Proposed Facilities)
Tana River, upper reach (4BE10), Tana Rukanga	1/1	1/10
Thika River (4CC03), Thika	1/7	1/10
Tana River, lower reach (4G01), Garissa	1/2	1/5

Source: JICA Study Team (Ref. Sectoral Report (G), Section 4.8)

The future water supply reliabilities in 2030 at Tana Rukanga in Upper Tana River and Thika in Thika River are estimated at 1/10 since water demand downstream of the reference points is domestic use only, while the future water supply reliability at Garissa in Lower Tana River is estimated at 1/5 as water demand downstream of the reference point is mainly irrigation use.

The naturalised flows, reserves, water demands, yields and water supply reliabilities at the reference points are presented in Table 7.7.4. Estimated river flows for 2010 and 2030 are illustrated in Figure 11.7.1 for the reference points in TCA.

The proposed water resources development plan listed above is a basis of the proposed water resources allocation plan for 2030 water demands stated in Section 11.2.

11.8 Water Resources Management Plan

(1) Current Situation of Water Resources Management

Water resources monitoring systems in TCA are established, covering the major river of Tana and its tributaries. However, monitoring stations are concentrated in the upper areas of Tana River that have much water resources and many water users. As for the current monitoring situation, the ratio of actual monitoring stations against the WRMA's target is 62% (28 stations) for surface water level, 34% (14 stations) for groundwater level and 71% (25 stations) for rainfall as presented in Table 6.8.1. The ratio of groundwater monitoring is low.

Water resources evaluation is not being properly done using the above monitored data, therefore it is necessary to establish a system to evaluate water resources in the catchment.

Water permit issuance and control is not well managed as the ratio of effective water permit/issued permit is the lowest among six regional offices of WRMA at 17% (surface water 15%, groundwater 47%). Further improvement is necessary.

For watershed conservation, Mt. Kenya and the Aberdare Range of the Five Water Towers, are major water sources of Tana River. Both Mt. Kenya and the Aberdare Range are relatively well-managed. However, decrease of forest areas is significant in the other gazetted small forest areas. According to the analysis conducted in this study[32], about 11% of forest area has disappeared in TCA since 1990. In addition, soil erosion control due to deforestation is an issue in this catchment area.

(2) Management Strategy

Based on the overall concept and frameworks mentioned in Section 6.8, strategies for water resources management in TCA is to be considered for four major aspects of: a) monitoring, b) water resources evaluation, c) water permit issuance and control, and d) watershed conservation, as described hereunder:

1) Monitoring

Monitoring items are surface water, groundwater and rainfall. For the surface water and groundwater, water quantity and quality are monitored. To make the current monitoring

[32] Refer to Sectoral Report (B), Section 8.3.

system more effective, review is to be made on surface water monitoring stations which are concentrated in the upper reaches of the Tana River. 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.

Rainfall monitoring stations are to be reviewed considering the climate division (arid area that covers most of the eastern part, semi-arid area in the central-western part and humid areas near Mt. Kenya and the Aberdare Range) of the catchment area and corresponding rainfall station densities to establish proper monitoring system.

Groundwater monitoring stations are to be set at areas where groundwater demand will increase in the future, namely, areas that have both a water supply development plan and a sewerage development plan. In such areas, groundwater is to be monitored using dedicated boreholes for monitoring.

2) Evaluation of Water Resources

As is mentioned in the overall concept and frameworks in Section 6.8, regional offices should enhance the capacity for evaluation of water resources in both quantity and quality so as to determine available water resources for water permit issuance based on the monitored data, and to judge necessity of water resources development.

3) Water Permit Issuance and Control

Based on the overall concept mentioned in Section 6.8, in preparation of increased water demand in the future, the latest version of the issued water permits is to be maintained to enable accurate control of issued water permits that reflect the current water use. In addition, revision of standards such as "Guidelines for Water Allocation (WRMA, First Edition, March 2010)" is to be considered to enable issuance of water permits that reflect the current water use and available water resources. Furthermore, in view of the current working conditions in the issuance of water permits in regional offices, water rights officers in charge of water permit issuance and control are to be increased for regional/subregional offices for smooth work.

4) Watershed Conservation

Based on the overall concept and frameworks as mentioned in Section 6.8, forest recovery is to be implemented through reforestation. Furthermore, preventive measures for soil erosion caused by deforestation in this catchment area should be considered.

(3) Proposed Water Resources Management Plan

Based on the management strategy mentioned above, the water resources management plan proposed for TCA is as follows:

1) Monitoring

Proposed layout of monitoring stations for surface water, groundwater, rainfall and reference point is shown in Figures 7.8.1 and 19.1.10. Water quantity and quality are monitored at

surface water monitoring and groundwater monitoring stations, while rainfall amount is monitored at rainfall monitoring stations. WRMA's target number and the proposed number of monitoring stations are shown in Table 6.8.1.

In view of covering representative locations of major rivers, lakes and springs, current layout of the surface water monitoring stations were reviewed. Proposed surface water monitoring stations are 16 stations in the upper reaches, eight stations in the middle reaches and two stations in the lower reaches of Tana River and its tributaries. In total, 26 stations are proposed against WRMA's target number of 45 for surface water monitoring network in TCA.

In addition, the reference points representing the flow conditions of major rivers were set at three representative surface water monitoring stations, two for the main stream of the Tana River and one for the Thika River as shown in Figure 19.1.10.

Based on the overall concept described in Section 6.8 (2), normal discharge values are set at the above three reference points as shown below. These normal discharge values are used for low water management of Tana and Thika rivers.

Normal Discharge at Reference Point (TCA)

(Unit: m^3/sec)

Reference Point	Normal Discharge (Reserve + Water Demand for the Downstream of Reference Point)	
	2010	2030
Tana River (upper) (4BE10)	14.2 (=13.5+0.7)	14.4 (=13.5+0.9)
Thika River (4CC03)	9.8 (=8.4+1.4)	10.1 (=8.4+1.7)
Tana River (lower) (4G01)	57.0 (=53.5+3.5)	153.2 (=53.5+99.7)

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

The above normal discharges are to be reviewed and revised as necessary in the "Evaluation of Water Resources" 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.

As a result of the review based on the overall concept mentioned in Section 6.8 (2), 47 rainfall monitoring stations are proposed against WRMA's target number of 35.

As for groundwater monitoring stations, 18 locations which are 18 urban centers having both a water supply development plan and a sewerage development plan in this study are proposed against WRMA's target number of 41 expecting increase of the groundwater demand toward future. Groundwater monitoring is to be conducted using dedicated boreholes.

2) Evaluation of Water Resources

As for the enhancement of water resource quantity evaluation system, an evaluation team is formed by assigning a chief hydrologist from Tana regional office in Embu as the leader and

assistant hydrologists from each subregional office of Muranga, Kerugoya, Meru, Kitui, and Garissa as members. The evaluation team will target the whole area of TCA to evaluate water resources of the catchment area once a year on the items mentioned in Section 6.8 (2) b).

For water resource quality evaluation, in addition to the existing water quality testing laboratory in Embu, one more laboratory is to be proposed in Garissa for timely analysis of monitored water quality data in the eastern part of the catchment area. For the existing and new laboratories, adequate number of water quality experts should be assigned to establish a system for proper evaluation of qualities of surface water and groundwater at a monitoring time.

3) Water Permit Issuance and Control

As for water permit issuance and control, the following activities are proposed:

a) To maintain the latest version of the issued water permits through periodic updating of the water permit database and establishment of a notification system for permit expiry;
b) To revise standards of WRMA such as "Guidelines for Water Allocation (WRMA, First Edition, March 2010)" based on future water demands and available water resources; and
c) To enable smooth water permit issuance and control, it is proposed to increase water rights officers of Tana regional office in Embu and Muranga, Kerugoya, Meru, Kitui, and Garissa subregional offices from the current seven to 15 by adding eight additional officers, two each in Muranga, Kerugoya, and Meru subregional offices, and one each in Kitui and Garissa subregional offices.

4) Watershed Conservation

For reforestation for forest recovery, about 1,370,000 ha of reforestation is proposed for TCA to achieve the target of the Kenya Vision 2030. Of the target, gazetted forest is supposed to be implemented by KFS.

As for control of soil erosion, it is proposed to conduct surveys for target locations first to formulate plans.

11.9 Flood and Drought Disaster Management Plan

(1) Current Situation of Flood Disaster Management

Within the middle to lower TCA, the areas along the Tana River are susceptible to flood. Flood damage in TCA is the largest in Kenya outside the Lake Victoria areas. In recent years, floods in 2006 and 2007 severely affected Garissa. Even at built-up areas 600-700 m away from the left bank of Tana River, houses were inundated under more than 1.0 m of flood water and the residents around these areas had to evacuate for 2-4 months. Meanwhile, although there are only a small number of densely-populated areas in the inundation area lower in elevation than Garissa, the inundation width extended up to 3-5 km from the banks of the Tana River. The residents in this area require accurate warning information for their evacuation activities.

Although an official document specifying flood disaster management has not been prepared in TCA, there are 43 river gauge stations under the management of WRMA Tana Regional Office. Out of the 43 stations, Garissa and Garsen stations have 3 steps of warning water levels, namely Alert, Alarm and Flood levels.

On the other hand, there are five units of hydropower dams along the Tana River. Warning information is to be provided by KenGen, the hydropower operator, to the public through TARDA, the owner of dams, and the local government offices before a large volume of water is released from the reservoirs.

Normally, residents living along the downstream reaches of the Tana River carry out evacuation activities on an empirical basis based on government information or their own judgement because enough lead time for evacuation is secured.

(2) Current Situation of Drought Disaster Management

Most of the TCA except for its most upstream parts in and around Embu and Muranga is categorised as arid land for the downstream parts and semi-arid land for the midstream parts. TCA is therefore vulnerable to both flood and drought disasters.

For drought disaster management at local government and community levels, Arid Land Resources Management Project II was completed in December 2010. The project formulated institutional arrangement for drought disaster management at local levels for all the arid and semi-arid land districts in the TCA.

As for water resources management during droughts, Garissa and Thika river gauge stations have two steps of water level warnings, namely Alert and Alarm levels. Once river water level reaches the warning level, WRMA Tana Regional Office carries out water use restriction by regulating water intake.

There are eight existing dams for hydropower and domestic water supply purposes. A drought disaster management program including water use restriction of the reservoirs has not been implemented.

(3) Flood Disaster Management Strategy

As explained in the overall concept e) mentioned in Section 6.9, the proposed examination areas in TCA are Lower Tana and Ijara. Since the extent of Lower Tana is not clearly defined in any documents, the examination area in NWMP 2030 shall be from Garissa to the mouth of Tana River. In this case, Ijara is included in Lower Tana and hence Ijara will be examined together with Lower Tana. Out of this area, Garissa is the only urban area.

In Garissa, where flood damage is severe, flood control measures shall be implemented by constructing river structures, taking particular note of the large number of people affected by long-term inundation. In addition, it is more effective to adopt a strategy of mitigating human damages since structural measures alone have limited effectivity against floods exceeding a design level. Hazard maps and an evacuation plan should be prepared.

In the lower part of Tana River except Garissa, it is intended to mitigate human damages by establishing a community-based disaster management system based on the gradual flooding in the

Tana River, the public's evacuation capacity based on their past experience, and the absence of large-scale settlements along the river. This system is assumed to adopt a simplified flood forecasting system based on water level observation in the upper reaches.

In addition, warning system for discharge release from the existing hydropower dam for this area shall be improved. It is considered important to accurately disseminate warning information to the public because they possess the ability to evacuate by themselves if information is given early.

(4) Drought Disaster Management Strategy

Based on the overall concepts mentioned in Section 6.9, drought disaster management strategy for TCA is to be: i) preparation of water use restriction rules for existing and proposed reservoir, ii) establishment of Basin Drought Conciliation councils, and iii) establishment of drought early warning system.

(5) Proposed Flood and Drought Disaster Management Plan

Based on the management strategy mentioned above, the flood disaster management plan for TCA is proposed as follows:

a) Implementation of flood control measures as well as preparing hazard map and evacuation plan in Garissa,
b) Establishment of CBDM system in the lower part of the Tana River except Garissa, and
c) Improvement of warning system for discharge release from the existing hydropower dam.

Based on the management strategy mentioned above, the drought disaster management plan for TCA is proposed as follows:

a) Preparation of water use restriction rules for reservoirs in the eight existing and ten proposed dams including setting of reference reservoir water level, and determination of reduction rate,
b) Monitoring of reference water levels which correspond to reserve or normal discharge (this work is to be implemented as a part of water resources management plan),
c) Establishment of a Basin Drought Conciliation Council with legal status on the basis of a river basin unit, and
d) Establishment of specialised drought early forecast system for water use restriction, that are linked to expected fluctuation of percentage of the above 18 reservoirs.

Figure 7.9.1 shows the flood disaster management plan and drought disaster management plan.

11.10 Environmental Management Plan

(1) Current Situation of Environmental Management

Tana River is main river of TCA. Many tributaries originating from the Aberdare Range and Mt. Kenya are flowing in upper reaches of the Tana River and abundant water resources have been maintained. There is fear that large-scale development projects such as High Grand Falls Multipurpose Development Project in the upper reaches affect the Kora National Park and the Mwingi National

Reserve which are situated directly below the projects. In addition, the Arawale National Reserve and the Tana River Primate National Reserve are located in the middle to the lower reaches of the Tana River. Environmental monitoring for natural resources is required in the middle reaches because of the expected negative impact from future population growth of Garissa Town as main city of the area. Tana Delta located near river mouth is not a national protected area, but it is receiving much attention regarding its importance to the wetland ecosystem of Kenya.

Most of Mt. Kenya and the Aberdare Range are located in TCA. Deforestation because of illegal logging in the Aberdare Range is significant. Urgent action is required from the aspect of water resource management.

(2) Management Strategy

Based on the overall concept mentioned in Chapter 6.10, it is proposed to set environmental flow rate and to conduct environmental monitoring in main rivers and lakes in TCA.

The water resource development projects in NWMP 2030 are mostly proposed for the upper reaches of the Tana River. Therefore, setting of environmental flow rate and environmental monitoring are proposed for the Tana River and the Chania River which is a tributary of Tana River and is proposed to have a water transfer plan to ACA.

(3) Proposed Environmental Management Plan

Based on the management strategy mentioned above, and point selection criteria mentioned in overall concept and framework, target points of environmental flow rate and environmental monitoring of environmental management plan for TCA are shown in the following table. Locations of target point are as shown Figure 11.10.1.

Environmental Flow Rate Setting Points and Environmental Monitoring Points (TCA)

Target	Setting Point			Proposed Major Development Projects
Tana River	Environmental flow rate	1	Reference point (Lower reaches of Garissa Town) : TCA-F1	Maragua 4, Thiba, and High Grand Falls dams, Masalani and Tana Delta irrigations
		2	Upper reaches of the Meru National Park : TCA-F2	
		3	Reference point (Upper reaches of Masinga Dam) : TCA-F3	
	Environmental monitoring	4	Tana Delta : TCA-M1	
		5	Upper reaches of the Tana River Primate National Reserve : TCA-M2	
		6	Reference point (Lower reaches of Garissa Town) : TCA-M3	
		7	Upper reaches of the Meru National Park : TCA-M4	
		8	Reference point(Upper reaches of Masinga Dam) : TCA-M5	
Chania River	Environmental flow rate	1	Reference point(Lower reaches of Thika Town) : TCA-F4	Ndiara, Karimenu 2, Thika 3A, Chania-B and Yatta dams
	Environmental monitoring	2	Reference point(Lower reaches of Thika Town): TCA-M6	

Source: JICA Study Team (Ref. Main Report Part F, Sub-section 4.9.3.)

In addition, environmental survey for setting of environmental flow rate (current river flow rate, water quality and river ecosystem) shall be conducted in the Tana and Chania rivers.

12. EWASO NG'IRO NORTH CATCHMENT AREA

12.1 Catchment Area Characteristics

ENNCA is located in the north-eastern part of the country as shown in Figure 1.3.1. ENNCA borders with Ethiopia in the north, Somalia in the east, Rift Valley Catchment Area in the west and Tana Catchment Area in the south.

Total area of ENNCA is 210,226 km^2 corresponding to 36.5% of the country's total land area. According to the Census 2009, population of ENNCA is 3.82 million, or 9.9% of the total population of Kenya. Population density is as low as 18 persons/km^2.

The topography of ENNCA varies, from the highest peak of Mt. Kenya at 5,199 m amsl to the Lorian swamp at 150 m amsl. Most of the area lies below 1,000 m amsl.

The Ewaso Ng'iro North River is the largest river in ENNCA and it originates from Mt. Kenya. It flows in the central part of the country eastward and flows underground before the Lorian Swamp. The underground flow pours into Somalia. The drainage area of the Ewaso Ng'iro North River is 81,749 km^2, or 39% of ENNCA.

ENNCA is classified as an arid land except the upstream area of the Ewaso Ng'iro North River which is classified as a semi-arid land. The mean annual rainfall ranges between 400 mm in the northern part to 1,000 mm in the upstream area of the Ewaso Ng'iro North River. The catchment area average mean annual rainfall is 510 mm. The renewable water resources, which is defined as precipitation minus evapotranspiration, is estimated at 7.38 BCM/year in 2010 for the Tana Catchment Area and the per capita renewable water resources is calculated at 1,933 m^3/year/capita.

12.2 Water Resources, Water Demands and Water Allocation

The available water resources were estimated in ENNCA for the years 2010 (present) and 2030 (future) as explained in Section 4.4 and summarised below. The estimate for 2030 includes the impacts of climate change.

Annual Available Water Resources (ENNCA)

(Unit: MCM/year)

	Surface Water	Groundwater	Total
2010	1,725	526	2,251
2030	2,536	475	3,011
Ratio of 2030 to 2010	147%	90%	134%

Source: JICA Study Team (Ref. Main Report Part G, Section 3.2.)

The annual water demands were estimated for the year 2010 and projected for 2030 in ENNCA as described in Section 5.2 and summarised below. The projection for 2030 followed the national development targets of Kenya Vision 2030 and socioeconomic framework, but without considering the available water resources.

Water Demands by Subsector (ENNCA)

Year	Water Demands (MCM/year)						
	Domestic	Industrial	Irrigation	Livestock	Wildlife	Fisheries	Total
2010	58	1	92	57	0	4	212
2030	125	2	2,644	79	0	7	2,857

Source: JICA Study Team (Ref. Main Report Part G, Section 3.3.)

In order to assess severity of water balance, ratios of available water resources and water demands presented above and those of water demands and water deficits discussed in Section 5.3 are tabulated for both 2010 and 2030 as follows:

Ratios of Water Demands/Available Water Resources and Water Deficits/Water Demands (ENNCA)

Description	2010	2030
Available Water Resources (MCM/year)	2,251	3,011
Water Demands (MCM/year)	212	2,857
Water Demands/Available Water Resources	9%	95%
Water Deficits (MCM/year)	68	2,442
Water Deficits/Water Demands	32%	85%

Source: JICA Study Team (Ref. Main Report Part G, Section 3.4 (1) and Sectoral Report (G), Sub-section 3.4.2.)

Although the present water demands in 2010 are estimated to be 9% of the available water resources (water stress ratio), the water demands for 2030 are expected to sharply increase to 95% of the available water resources in 2030. This ratio indicates ENNCA will be under severe water stress in the future as the ratio is over 40%. The above table also shows the estimated water deficits of 68 MCM/year in 2010 and increased deficits of 2,442 MCM/year in 2030. The irrigation water demand, representing about 93% of the total demand, needs to be reduced to attain the appropriate water balance as well as proper water resources development.

The water balance study was carried out based on the proposed water resources development plans of the related subsectors described in the following sections. The water demands that can be covered by the available water resources are presented in Table 7.2.1. The allocated amounts of the surface water and groundwater to satisfy the 2030 water demands are as follows:

Water Resources Allocation Plan for Water Demands in 2030 after Water Balance Study (ENNCA)

(Unit: MCM/year)

Subsector	Water Demand (2030)	Water Resources Allocation	
		Surface Water	Groundwater
Domestic	125	42	83
Industrial	2	1	1
Irrigation	539	432	107
Livestock	79	79	0
Wildlife	0	0	0
Fisheries	7	7	0
Total	752	561	191

Source: JICA Study Team (Ref. Main Report Part G, Section 3.4 (3) and Sectoral Report (G), Sub-section 4.9.3 (2).)

Because of limited water resources, it was concluded that interim target of new irrigation development area of 142,665 ha for 2030 needed to be reduced to 41,483 ha as stated in Sections 6.5 and 12.5.

The abovementioned water resources allocation plan should be the base data for future water resources management plan of the ENNCA.

12.3 Water Supply Development Plan

(1) Current Situation of Water Supply

Current population of ENNCA in 2010 is estimated to be 3.82 million including an urban population of 0.74 million and a rural population of 3.08 million. Based on the 2009 Census data, the current situation of water connection of ENNCA was estimated as shown below.

Current Situation of Water Connection (ENNCA)

Type	Piped by WSPs	Spring/Well/Borehole	Water Vendor	Stream/Lake/Pond/Others
Urban Population	48%	26%	13%	13%
Rural Population	20%	44%	7%	30%
Total Population	26%	40%	8%	26%

Source: JICA Study Team, based on data of "Census 2009" (Ref. Sectoral Report (C), Sub-section 2.3.8.)

The water provided by unregistered water vendors and water taken from streams, lakes, and ponds without proper treatment are categorised as an unimproved drinking water source. Around 34% of the population get drinking water from such unimproved drinking water source. Also, around 40% of the population get water from springs, wells or boreholes. Unprotected wells and springs are also categorised as an unimproved drinking water source, but the utilisation ratio of unprotected ones is not known.

It is projected that the urban population will increase by 1.02 million, the rural population will decrease by 0.43 million and the total population will be 4.40 million in 2030. Population growth is expected to be relatively low, due to the large proportion of arid area in ENNCA. Therefore, the scale of urban water supply system development is rather small compared to the other catchment areas.

(2) Development Strategy

ENNCA is divided into two areas: northern arid area and southern non-arid area for water supply systems planning considering the characteristics of the two areas.

Based on the overall concept mentioned in Section 6.3, UWSS are planned for 12 UCs in ENNCA. The water supply capacity required for UWSS in LNVCA in 2030 is 124,000 m^3/day compared to the current water supply capacity (including capacity under construction) of 32,000 m^3/day. Therefore, additional capacity of 92,000 m^3/day is to be developed by 2030. It is to be developed through the following three types of projects.

a) Rehabilitation of existing UWSS: In order to achieve 20% NRW ratio, water meters are to be installed for all households and old pipes of existing UWSS of the six UCs, which has a water supply capacity of 21,000 m^3/day, are to be replaced. In addition, the rehabilitation will include 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 above six UCs to meet the water demand in 2030. The total capacity of expansion is 61,000 m^3/day.

c) Construction of new UWSS: The construction of new UWSS is planned for the six UCs which have no UWSS. The total capacity of new construction is 31,000 m^3/day.

d) According to data from WSBs, there are six plans of water supply development projects to cover two UCs and surrounding areas in ENNCA[33], which have 22,000 m^3/day of total water supply capacity. (Refer to Sectoral Report (C), Section 2.4) These plans are to be taken into account for planning.

Based on the overall concept mentioned in Section 6.3, rural water supply systems are planned to be developed by LSRWSS and SSRWSS.

a) Development of LSRWSS: The LSRWSS is proposed mainly for areas with high population density or areas with difficulties in groundwater use on a personal or community basis. The LSRWSS is to be developed for 1.16 million residents in 14 counties of ENNCA.

b) Development of SSRWSS: The SSRWSS is proposed for 2.20 million residents in 14 counties of ENNCA, and it includes construction and improvement of boreholes, wells, and springs on a personal and community basis. As this type of works is to be implemented on a personal and community basis, only the water demand projection is carried out for SSRWSS in the master plan.

(3) Proposed Water Supply Development Plan

Based on the development strategy mentioned above, the proposed UWSS is presented in Table 12.3.1, and the proposed LSRWSS and SSRWSS are in Tables 12.3.2 and 12.3.3, respectively. Figure 7.3.1 shows urban centers subject to urban water supply system development.

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

Proposed Water Supply Development Plan (ENNCA)

Type of Project		Target Area	Total Capacity (m^3/day)	Service Population (million persons)
Urban Water Supply	Rehabilitation	6 UCs	21,000	1.04
	Expansion	6 UCs	61,000	
	New Construction	6 UCs	31,000	
	Total	12 UCs	124,000	
Rural Water Supply	LSRWSS	14 Counties	119,000	3.36
	SSRWSS	14 Counties	101,000	
	Total	14 Counties	220,000	

Source: JICA Study Team (Prepared based on Tables 12.3.1 to 12.3.3.)

Based on the above water supply development plan, the water supply situation of ENNCA in 2030 will be imploved as follows:

[33] Refer to Sectoral Report (C), Section 2.4.

Water Supply Situation in 2030 (ENNCA)

Items		Urban Water Supply	Large-scale Rural Water Supply	Small-scale Rural Water Supply	Total
Service Population (million)	2010	0.99		1.53	2.52
	2030	1.04	1.16	2.20	4.40
Water Supply Capacity (m^3/day)	2010	32,000	7,000	77,000	116,000
	2030	124,000	119,000	101,000	344,000
Operating Body		Registered WSPs	Registered WSPs	Individual, Community, etc.	--
Target Towns/ Areas		12 UCs	14 Counties		--

Source: JICA Study Team (Figures for 2010 were prepared by reference to Sectoral Report (C), Section 2.3. Figures for 2030 were prepared based on Tables 12.3.1 to 12.3.3.)

In order to ensure water sources required for the water supply systems mentioned above, it is proposed to construct four new dams in ENNCA presented in Tables 7.7.1 and 7.7.2, as the result of the water balance study.

12.4 Sanitation Development Plan

(1) Current Situation of Sanitation Development

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

Current Situation of Access to Sanitation Facilities (ENNCA)

Type	Sewerage System	Septic Tank, Pit Latrine, Cesspool (On-site Treatment Facilities)	Bush, etc (No Treatment)
Urban Population	9%	82%	10%
Rural Population	0%	57%	43%
Total Population	2%	62%	36%

Source: JICA Study Team based on Census 2009 data (Ref. Sectoral Report (D), Sub-section 2.3.7.)

Sewerage system has been developed in limited areas in ENNCA and current sewerage coverage ratio is only 2%. There is a small-scale waste water treatment plant in Nyahururu, of with a total treatment capacity of about 4,600 m^3/day. Around 62% of the population use on-site treatment facilities such as septic tanks, etc. The on-site treatment facilities include unimproved ones, but, the ratio of the unimproved facilities is not known. Around 36% of the population does not have any treatment facilities and resort to unsanitary waste disposal.

(2) Development Strategy

Based on the overall concept and framework mentioned in Section 6.4, sewerage system development is planned for five UCs in ENNCA. The sewerage system development is conducted through the following three types of projects:

a) Rehabilitation of existing sewerage system: Rehabilitation includes the repair and replacement of mechanical and electrical equipment of wastewater treatment plants (WWTPs) and pumping stations, and replacement of corroded sewer pipes in two UCs, which have sewerage systems with a total capacity of 5,000 m^3/day.

b) Expansion of sewerage system: In order to cover the demand in 2030, capacities of existing sewerage systems of two UCs are to be expanded. This includes expansion and/or

new construction of sewerage pipes, pumping stations, and WWTPs. The total capacity of expansion is 27,000 m^3/day.

c) Construction of New Sewerage System: There are no sewerage systems in three UCs. New sewerage systems are to be constructed in these UCs with total capacity of 30,000 m^3/day.

d) According to data from WSBs, there are two plans of sewerage development projects to cover two urban centres in ENNCA, which have 7,000 m^3/day of total treatment capacity in ENNCA[34]. These plans are to be taken into account for planning.

Outside the sewerage service area, improved on-site treatment facilities will be available for the remaining 3.58 million residents in 2030. Currently, 2.37 million residents (62% of the entire population) are using existing on-site treatment facilities, but unimproved ones are to be improved with new housing construction. Development of on-site treatment facilities is planned for 14 counties in ENNCA.

(3) Proposed Sanitation Development Plan

Based on the development strategy above, the sewerage development plan is shown in Table 12.4.1 and the on-site treatment development plan is shown in Table 12.4.2. The proposed sanitation development plan for ENNCA is outlined below.

Proposed Sanitation Development Plan (ENNCA)

Type of Project		Target Area	Total Capacity (m^3/day)	Service Population (million persons)
Sewerage System	Rehabilitation	2 UCs	5,000	0.82
	Expansion	2 UCs	27,000	
	New Construction	3 UCs	30,000	
	Total	5 UCs	62,000	
On-site Treatment Facilities		14 Counties	--	3.58

Source: JICA Study Team (Prepared based on Tables 12.4.1 and 12.4.2.)

Out of 1.76 million of the urban population in ENNCA, 47% is expected to be covered by the sewerage system. The ratio of ENNCA is much lower than the national target of 80%, because there are only a few large-scale urban centres, which have priority of sewerage development in ENNCA. Currently 36% of the population has no sanitation facilities, so that development of on-site treatment facilities is higher priority than sewerage development. By the above sanitation development, the sanitation situation of ENNCA in 2030 will be as follows:

[34] Refer to Sectoral Report (D), Section 2.4.

Sanitation Situation in 2030 (ENNCA)

Items		Sewerage System	Septic Tank, etc (On-site Treatment Facilities)
Service Population (million)	2010	0.07	2.37
	2030	0.82	3.58
Required Treatment Capacity (m^3/day)	2010	5,000	--
	2030	62,000	--
Operating Body		Registered WSPs	Individual, Community, etc.
Target Towns/ Area		5 UCs	14 Counties

Source: JICA Study Team (Figures for 2010 were prepared by reference to Sectoral Report (D), Section 2.3. Figures for 2030 were prepared based on Tables 12.4.1 and 12.4.2.)

12.5 Irrigation Development Plan

(1) Current Situation of Irrigation Development

ENNCA is the driest catchment area in Kenya. Except for highlands at the southwest corner of ENNCA, most of all the areas have an arid climate with annual rainfall of 200-400 mm. The largest river is the Ewaso Ng'iro North River originating at the highlands but in the downstream section it becomes a dry river. The cropping area in the ENNCA in 2011 was 194,123 ha. Major crops cultivated are horticultural crops and maize. The productivity of rainfed agricultural areas is quite low. The existing irrigation area is 7,896 ha in 2010, consisting of 6,233 ha (79%) of small-scale schemes, and 1,663 ha (21%) of private schemes. The share of irrigation area against cropping area is 4.1%.

(2) Development Strategy

Based on the overall concept and frameworks mentioned in Section 6.5, the strategy for irrigation development in ENNCA was set as follows:

a) To utilise limited water resources efficiently for the maximisation of irrigation area, water-saving irrigation methods to improve water productivity should be introduced for all irrigation areas;
b) To strengthen the agricultural sector in ENNCA, irrigation should be expanded in rainfed agricultural areas in arid and semi-arid lands to increase agricultural productivity and production; and
c) Due to quite limited river water resources for irrigation in ENNCA, priority should be given to large dam irrigation in arid and semi-arid lands to maximise irrigation area. Furthermore, small-scale dam irrigation and groundwater irrigation should be developed as long as water resources are available.

(3) Proposed Irrigation Development Plan

As a result of the water balance study by sub-basins in ENNCA, possible irrigation development areas under application of the water-saving irrigation methods were estimated as summarised below.

Possible Irrigation Area in 2030 (ENNCA)

(Unit: ha)

Type of Irrigation	Existing Irrigation Area in 2010	New Irrigation Area in 2030						Total Irrigation Area in 2030
		Surface Water Irrigation			Groundwater Irrigation	Water Harvesting Irrigation	New Irrigation Total	
		River Water	Dam	Total				
Large Scale	0	4,202	22,000	26,202	0	0	26,202	26,202
Small Scale	6,233	0	0	0	7,166	950	8,116	14,349
Private	1,663	0	0	0	7,165	0	7,165	8,828
Total	7,896	4,202	22,000	26,202	14,331	950	41,483	49,379

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

Against the provisional target of new irrigation development area of 142,665 ha (distributed to ENNCA for the national target of 1.2 million ha) mentioned in Section 6.5, the possible new irrigation development area comes to 41,483 ha (decrease of 101,182 ha) even with maximum water resources development presented in section 12.7 due to limitation of available water resources. Table 7.5.1 shows the maximum irrigation area by catchment area in 2030.

As for the large-scale irrigation projects (more than 500 ha), three projects proposed by the government authorities and one project proposed in this study listed in Table 6.5.1 were taken up for the water balance study, and three projects listed in Table 7.5.2 (26,202 ha in total) were selected as the possible projects in ENNCA from a viewpoint of surface water resources availability for irrigation. The locations of the selected projects are shown in Figure 7.5.1. Among them, the large scale irrigation projects more than 5,000 ha are as follows.

a) Kihoto Irrigation Project (18,000 ha, Kihoto multipurpose dam)

The irrigation water demand necessary for the above new irrigation development and existing irrigation was estimated at 539 MCM/year as given in Table 7.2.1.

12.6 Hydropower Development Plan

(1) Current Situation of Hydropower Development

In ENNCA, there is no existing hydropower station and also no development plan.

(2) Development Strategy

As there are no proposed plans in Least Cost Power Development Plan (LCPDP) and no multipurpose-type development schemes with hydropower component, no hydropower development plan is proposed for ENNCA.

(3) Proposed Hydropower Development Plan

As mentioned in the current situation and development strategy above, there is no hydropower development plan proposed in ENNCA.

12.7 Water Resources Development Plan

(1) Current Situation of Water Resources Development

ENNCA has a total catchment area of 210,226 km^2 (36.5% of the national territory) and an annual average rainfall of 510 mm which is similar to that of RVCA and the smallest among the six WRMA catchment areas. The annual rainfall differs spatially within the catchment area, ranging from around 200 mm in the northeastern and northwestern parts to 1,400 mm in the southwestern part near the Kenya water towers. The available water resources estimated in ENNCA for 2010 (present) are 1,725 MCM/year for surface water and 1,401 MCM/year for groundwater. The available surface water resources in 2030 were estimated to be 2,536 MCM/year considering the impacts of climate change and the groundwater resources is 1,391 MCM/year, which is same as the amount of 2010.

The present (2010) water demands in ENNCA were estimated to be 212 MCM/year, which consist mainly of domestic water demands for the population of 3.82 million (9.9% of national population), irrigation water demands for the irrigation area of 7,896 ha and livestock water demands. Among 12 urban centres situated in the catchment area, six centres have water supply systems. About 40% of the population is supplied with groundwater.

The existing water resource structures/facilities except for direct intake facilities from the rivers to satisfy the present water demands are: i) 615 small dams/water pans (for domestic and livestock water supply, with total storage volume of 10 MCM); and ii) 1,147 boreholes (mainly for domestic water supply, with total abstraction volume of 35 MCM/year). There are no existing dams and no water transfer facilities. The value of present water supply reliability in ENNCA was estimated by the water balance study to be 1/1 at the reference point of Archers' Post (5ED01) in Ewaso Ng'iro North River under the condition of existing water resource structures/facilities mentioned above. One new dam is under construction (for domestic water supply, with storage capacity of 4 MCM).

(2) Development Strategy

As mentioned in Sections 12.3 and 12.5, the projected 2030 water demand of 965 MCM/year shows a large increase of about 4.5 times compared to the present demand due to considerable increase in population to 4.4 million and irrigation areas to 77,148 ha expected by the year 2030 in ENNCA. Judging from the estimated 2030 water deficits discussed in Section 12.2, it is certain that the existing water resource structures/facilities will not be able to satisfy the greatly increased 2030 water demands because of the uneven distribution of water resources both spatially and temporally. Therefore, new water resource structures/facilities are required to be developed.

Strategies for water resources development in ENNCA were enumerated below to formulate the well balanced development plan between water resources and demands, following the overall concept and framework for the planning as stated in Section 6.7 and based on the current situation of the catchment area and future water demands.

a) Dam development is essential and to be promoted in the southwest part of the catchment area where increased future large water demands such as domestic, industrial and irrigation water demands are expected in 2030. Candidates for dam development for maximum surface water exploitation include, in principle: i) dams proposed by the NWMP (1992), and ii)

dams under design and/or planning stage by the government including the Kenya Vision 2030 flagship projects.

b) Small dams and/or water pans are to be constructed in small rivers over almost the entire catchment area except for the northwest and east part of the catchment area for small and scattered demands including rural domestic, livestock, small scale irrigation, wildlife and inland fisheries water supply purposes. The small dams and water pans are planned at locations where suitable dam sites are not possible for large dams but where surface water is available.

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

(3) Proposed Water Resources Development Plan

The water balance study was carried out for 2030 between the available water resources and water demands in ENNCA based on the overall concept and framework for the planning and development strategy. As a result of the water balance study, the required new water resource structures/facilities in addition to direct intake facilities from rivers are as follows:

Existing Structures/Facilities and Proposed Water Resources Development Plan (ENNCA)

Structure		No.	Purpose	Dimension/ Capacity	Remarks
Dam	Existing	0			
	Proposed	5	Domestic, industrial, irrigation and hydropower	Total storage volume of 522 MCM	
Small Dam/ Water Pan	Existing	615	Domestic and livestock	Total storage volume of 10 MCM	
	Proposed	1,820	Rural domestic, livestock, irrigation, wildlife and fisheries	Total storage volume of 91 MCM	
Borehole	Existing	1,147	Domestic	Total abstraction of 35 MCM/year	
	Proposed	1,560	Domestic, industrial, and irrigation	Total abstraction of 156 MCM/year	

Note: The water supply reliability applied in the plan is 1/10 for domestic and industrial use and 1/5 for irrigation use.
Source: JICA Study Team (Ref. Main Report Part G, Sub-sections 4.6.1 and 4.6.3.)

A list of the proposed dams is represented in Table 7.7.1. Figure 7.7.1 illustrates locations of the dams.

The water demand and supply balance for 2030 in ENNCA under the condition of proposed water resources development structures mentioned above is summarised in Table 12.7.1.

The water supply reliabilities for 2010 and 2030 at the reference point proposed for water resources management in ENNCA are estimated as below:

Water Supply Reliability at Reference Point (ENNCA)

Reference Point	Present (2010) Water Supply Reliability (with Existing Facilities)	Future (2030) Water Supply Reliability (with Existing and Proposed Facilities)
Ewaso Ng'iro North River (5ED01), Archers' Post	1/1	1/5

Source: JICA Study Team (Ref. Sectoral Report (G), Section 4.9)

The future water supply reliability in 2030 at Archers' Post in Ewaso Ng'iro North River is estimated at 1/5 as water demand downstream of the reference point is irrigation use only.

The naturalised flows, reserves, water demands, yields and water supply reliabilities at the reference points are presented in Table 7.7.4. Estimated river flows for 2010 and 2030 are illustrated in Figure 12.7.1 for the reference point in ENNCA.

The proposed water resources development plan listed above is a basis of the proposed water resources allocation plan for 2030 water demands stated in Section 12.2.

12.8 Water Resources Management Plan

(1) Current Situation of Water Resources Management

Water resources monitoring systems in ENNCA are established, focusing on the south-western part of the catchment area in the upper reaches of the Ewaso Ng'iro North River. As for the current monitoring situation, the ratio of actual monitoring stations against the WRMA's target is 60% (24 stations) for surface water level, 50% (five stations) for groundwater level and 31% (8 stations) for rainfall as presented in Table 6.8.1. The ratio of rainfall monitoring is low.

Water resources evaluation is not properly done using the above monitored data, therefore it is necessary to establish a system to evaluate water resources in the catchment.

Water permit issuance and control is not well managed as the ratio of effective water permit/issued permit is 28% (surface water 19%, groundwater 90%). Further improvement is necessary.

For watershed conservation, degradation of the forest areas is significant in the northern skirts of Mt. Kenya and gazetted forest in the west of Marsabit. According to the analysis conducted in this study[35], about 16% of forest area has disappeared in ENNCA since 1990. In addition, degradation of small water sources and soil erosion control caused by deforestation are issues in this catchment area.

(2) Management Strategy

Based on the overall concept and frameworks mentioned in Section 6.8, strategies for water resources management in ENNCA is to be considered for four major aspects of: a) monitoring, b) water resources evaluation, c) water permit issuance and control, and d) watershed conservation, as described hereunder:

1) Monitoring

Monitoring items are surface water, groundwater and rainfall. For the surface water and groundwater, water quantity and quality are monitored. To make the current monitoring system more effective, review is to be made on surface water monitoring stations which are concentrated in the upper reaches of the Ewaso Ng'iro North River. 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.

[35] Refer to Sectoral Report (B), Section 8.3.

Rainfall monitoring stations are to be reviewed considering the climate division (arid area that covers most of the catchment area, humid area near Mt. Kenya and the Aberdare Range, semi-arid area near the humid areas) of the catchment area and corresponding rainfall station densities to establish proper monitoring system.

Groundwater monitoring stations are to be set at areas where groundwater demand will increase in the future, namely, areas that have both a water supply development plan and a sewerage development plan. In such areas, groundwater is to be monitored using dedicated boreholes for monitoring.

2) Evaluation of Water Resources

As mentioned in the overall concept and frameworks in Section 6.8, regional offices should enhance the capacity for evaluation of water resources in both quantity and quality so as to determine available water resources for water permit issuance based on the monitored data, and to judge necessity of water resources development.

3) Water Permit Issuance and Control

Based on the overall concept mentioned in Section 6.8, in preparation of increased water demand in the future, the latest version of the issued water permits is to be maintained to enable accurate control of issued water permits that reflect the current water use. In addition, revision of standards such as "Guidelines for Water Allocation (WRMA, First Edition, March 2010)" is to be considered to enable issuance of water permits that reflect the current water use and available water resources. Furthermore, in view of the current working conditions in the issuance of water permits in regional offices, water rights officers in charge of water permit issuance and control are to be increased for regional/subregional offices for smooth work.

4) Watershed Conservation

Based on the overall concept and frameworks as mentioned in Section 6.8, forest recovery is to be implemented through reforestation focusing on Mt Kenya and gazetted forest in the west of Marsabit. Furthermore, preventive measures for soil erosion caused by deforestation in this catchment area are to be considered.

(3) Proposed Water Resources Management Plan

Based on the management strategy mentioned above, the water resources management plan proposed for ENNCA is as follows:

1) Monitoring

Proposed layout of monitoring stations for surface water, groundwater, rainfall and reference point is shown in Figures 7.8.1 and 19.1.12. Water quantity and quality are monitored at surface water monitoring and groundwater monitoring stations, while rainfall amount is monitored at rainfall monitoring stations. WRMA's target number and the proposed number of monitoring stations are shown in Table 6.8.1.

In view of covering representative locations of major rivers, lakes and springs, current layout of the surface water monitoring stations were reviewed. Proposed surface water monitoring stations are ten stations in the upper reaches of Ewaso Ng'iro North River and its tributaries, two stations in springs located in the central western part of the catchment area and one station in Daua international river. In total, 13 stations are proposed against WRMA's target number of 40 for surface water monitoring network in ENNCA.

In addition, the reference point representing the flow conditions of major rivers was set at one representative surface water monitoring station in the upper reaches of the Ewaso Ng'iro North River as shown in Figure 19.1.12.

Based on the overall concept described in Section 6.8 (2), normal discharge value is set at the above one reference point as shown below. The normal discharge value is used for low water management of Ewaso Ng'iro North River.

Normal Discharge at Reference Point (ENNCA)

(Unit: m^3/sec)

Reference Point	Normal Discharge (Reserve + Water Demand for the Downstream of Reference Point)	
	2010	2030
Ewaso Ng'iro North River (5ED01)	3.0 (=1.6+1.4)	6.5 (=1.6+4.9)

Source: JICA Study Team (Ref. Sectoral Report (H), Sub-section 3.8.2)

The above normal discharges are to be reviewed and revised as necessary in the "Evaluation of Water Resources" 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.

As a result of the review based on the overall concept mentioned in Section 6.8 (2), 34 rainfall monitoring stations are proposed against WRMA's target number of 26.

As for groundwater monitoring stations, five locations which are five urban centers having both a water supply development plan and a sewerage development plan in this study are proposed against WRMA's target number of ten expecting increase of the groundwater demand toward future. Groundwater monitoring is to be conducted using dedicated boreholes.

2) Evaluation of Water Resources

As for the enhancement of water resource quantity evaluation system, an evaluation team is to be formed by assigning a chief hydrologist from Ewaso Ng'iro North regional office in Nanyuki as the leader and assistant hydrologists from each subregional office of Nanyuki, Rumuruti, Isiolo, Marsabit, and Mandera as members. The evaluation team will target the

whole area of ENNCA to evaluate water resources of the catchment area once a year on the items mentioned in Section 6.8 (2) b).

For water resource quality evaluation, in addition to the existing water quality testing laboratory in Nyeri (in TCA), two more laboratories are to be proposed in Marsabit and Wajir for timely analysis of monitored water quality data in the northern part of the catchment area. For the existing and new laboratories, adequate number of water quality experts should be assigned to establish a system for proper evaluation of qualities of surface water and groundwater at a monitoring time.

3) Water Permit Issuance and Control

As for water permit issuance and control, the following activities are proposed:

a) To maintain the latest version of the issued water permits through periodic updating of the water permit database and establishment of a notification system for permit expiry;
b) To revise standards of WRMA such as "Guidelines for Water Allocation (WRMA, First Edition, March 2010)" based on future water demands and available water resources; and
c) To enable smooth water permit issuance and control, it is proposed to increase water rights officers of ENN regional office in Nanyuki and subregional offices in Nanyuki, Rumuruti, Isiolo, Marsabit, and Mandera from the current eight to 12 by adding four additional officers, two in Marsabit subregional office, and one each in Nanyuki and Mandera subregional offices.

4) Watershed Conservation

For reforestation for forest recovery, about 590,000 ha of reforestation is proposed for ENNCA to achieve the target of the Kenya Vision 2030. Of the target, gazetted forest is supposed to be implemented by Kenya Forest Service (KFS).

As for conservation of small water sources and control of soil erosion caused by deforestation in the catchment area, it is proposed to conduct surveys for target locations first to formulate plans.

12.9 Flood and Drought Disaster Management Plan

(1) Current Situation of Flood Disaster Management

Although most of ENNCA is defined as arid districts, severe flood damages have been reported in the various parts of the catchment area. Isiolo has both river-induced flood and urban drainage issue. In Mandera, there are two causes of flood. One is overflow from the Daua River which is the national boundary with Ethiopia, and another is the two tributaries flowing from Somalia into the Daua River through the built-up area of Mandera.

Flood control structural measures are underway even though only gradually, while construction of dykes along the Daua River have been implemented by NWCPC in recent years. However, it could not be said that systematic flood disaster management has been implemented in ENNCA because setting of warning water levels at major river gauge stations have not been confirmed.

(2) Current Situation of Drought Disaster Management

Most of ENNCA except for very limited parts in and around the major five water tower is categorised as arid lands, and drought damage in the catchment area is the most severe in Kenya.

As for drought disaster management at local government and community levels, Arid Land Resources Management Project II was completed in December 2010. The project formulated institutional arrangement for drought disaster management at local levels for all the arid and semi-arid land districts in ENNCA.

For water resources management during droughts, WRMA ENN Regional Office has formulated a three step system of warning water level, namely: Normal, Alert and Alarm levels at five river gauge stations. Once river water level reaches the warning level, WRMA ENN office carry out water use restriction by regulating water intake.

There is one existing dam for domestic water supply currently under construction.

(3) Flood Disaster Management Strategy

As explained in the overall concept e) mentioned in Section 6.9, the proposed examination areas in ENNCA are Middle/Lower Ewaso Ng'iro North, Wajir, Mandera, and Isiolo. Here, the southern boundary of Wajir County is along the Ewaso Ng'iro North River; hence, Wajir shall be treated as a part of the Ewaso Ng'iro North River basin. Out of these, urban areas are limited to Mandera and Isiolo. Middle/Lower Ewaso Ng'iro North including Wajir is to be excluded from NWMP 2030 because severe flood damage has rarely been reported while river-induced inundation was confirmed.

In consideration of the high population density of Isiolo, this area should be protected by river structural measures. In addition, it is more effective to adopt a strategy of mitigating human damages since structural measures alone have limited effectivity against floods exceeding a design level. Hazard maps and an evacuation plan should be prepared. Regarding urban drainage issue in Isiolo, the drainage system should also be improved in consideration of the high population density.

In Mandera, the abovementioned floods are caused by international rivers. Therefore, it is considered difficult to construct a flood control dam. In this regard, urban area of Mandera should be protected by river improvement works, retarding basins or a combination of them. In addition, it is also more effective to adopt a strategy of mitigating human damages since structural measures alone have limited effectivity against floods exceeding a design level. Hazard maps and an evacuation plan should be prepared.

(4) Drought Disaster Management Strategy

Based on the overall concepts mentioned in Section 6.9, drought disaster management strategy for ENNCA includes: i) preparation of water use restriction rules for existing and proposed reservoir, ii) establishment of basin drought conciliation councils and iii) establishment of drought early warning system.

(5) Proposed Flood and Drought Disaster Management Plan

Based on the management strategy mentioned above, the flood disaster management plan for ENNCA is proposed as follows:

a) Implementation of flood control measures as well as preparing hazard map and evacuation plan in Mandera,
b) Implementation of flood control measures as well as preparing hazard map and evacuation plan in Isiolo, and
c) Implementation of urban drainage measures in Isiolo.

Based on the management strategy mentioned above, the drought disaster management plan for ENNCA is proposed as follows:

a) Preparation of water use restriction rules for reservoirs in the one existing and five proposed dams including setting of reference reservoir water level, and determination of reduction rate,
b) Monitoring of reference water levels which correspond to reserve or normal discharge (this work is to be implemented as a part of water resources management plan),
c) Establishment of one Basin Drought Conciliation Council with legal status on the basis of a river basin unit, and
d) Establishment of specialised drought early forecast system for water use restriction, that linked to expected fluctuation of percentage of the above six reservoirs.

Figure 7.9.1 shows the flood disaster management plan and drought disaster management plan.

12.10 Environmental Management Plan

(1) Current Situation of Environmental Management

Most of ENNCA area belongs to ASAL area and ENNCA has the least water resources among six catchment areas. The main river of ENNCA is the Ewaso Ng'iro North River originating from Mt. Kenya. The river basin has four national protected areas such as the Lusai National Parks and three other protected areas. In addition, the Ewaso Ng'iro North River flows underground in the lower reaches. Wetlands and vegetation zones are located along groundwater veins of the river. They are important protected areas. Setting of adequate environmental flow rate and environmental monitoring for the Ewaso Ng'iro North River are required because the ecosystem of lower reaches is important in ASAL area.

In addition, relatively large gazetted forests other than Mt. Kenya of the Five Water Towers are located in the western area. These forests have been devastated by logging and cultivation and are losing their water retention capacity.

(2) Management Strategy

Based on overall concept mentioned in Chapter 6.10, it is proposed to set of environmental flow rate and environmental monitoring in main rivers in ENNCA.

The water resource development projects in NWMP 2030 are mostly proposed on the upper reaches of the Ewaso Ng'iro North River and its tributaries such as the Ewaso Narok River and the S.R.Uguoi River. Therefore, setting of environmental flow rate and environmental monitoring are proposed for the main stem of Ewaso Ng'iro North River.

(3) Proposed Environmental Management Plan

Based on the management strategy mentioned above, and point selection criteria mentioned in overall concept and framework, target points of environmental flow rate and environmental monitoring of environmental management plan for ENNCA are shown in the following table. Locations of target point are as shown Figure 12.10.1.

Environmental Flow Rate Setting Points and Environmental Monitoring Points (ENNCA)

Target	Setting Point			Proposed Major Development Projects
Ewaso Ng'iro North River	Environmental flow rate	1	Reference point (Archer's Post Town) : ENN-F1	Archer's Post, Isiolo, Kihoto, Rumuruti, and Nyahururu dams
		2	Lower reaches of confluence point of the Ewaso Narok River: ENN-F2	
	Environmental monitoring	3	Reference point (Archer's Post Town) : ENN-M1	
		4	Lower reaches of confluence point of the Ewaso Narok River: ENN-M2	

Source: JICA Study Team (Ref. Main Report Part G, Sub-section 4.9.3.)

In addition, environmental survey for setting of environmental flow rate (Current river flow rate, water quality and river ecosystem) shall be conducted in the Ewaso Ng'iro North River.

13. COST ESTIMATES

13.1 Basic Conditions for Cost Estimates

Costs were estimated for the proposed projects in the water supply, sanitation, irrigation, hydropower and water resources development plans and for the proposed water resources management, flood and drought disaster management, and environmental management plans. The estimated costs for the proposed projects include project investment costs, operations and maintenance (O&M) costs and replacement costs. The estimated costs for the proposed management plans include development costs and recurrent costs.

Purposes of the cost estimate are to know the total cost in general, to evaluate general economic viability (only for the projects, excluding the management plans) and to discuss the general idea of financing for implementation of the proposed projects and plans. As the estimated costs are preliminary, these costs should not be used for the specific purpose of financial arrangements of the projects and plans.

The cost estimates were carried out using the following methods:

a) The project costs were estimated by applying unit costs per water supply capacity, area or other related factors derived from the existing cost data, or based on the project costs previously estimated by the government with necessary adjustments.

b) The O&M costs for the projects were estimated by applying unit costs or percentages of the project costs, both were derived from existing data.

c) The replacement costs for the projects were estimated by applying percentages of the project costs derived from existing data.

d) The development costs for the management plans were estimated by applying unit costs based on the existing cost data obtained from the government or other related organisations.

e) The recurrent costs for the management plans were estimated by applying unit costs or percentages of the development costs, both based on existing cost data.

The cost estimate was based on the price level of November 1, 2012.

13.2 Cost Estimates for Proposed Plans

The project costs and O&M costs estimated for the proposed projects in the development plans are shown in Table 13.2.1 and summarised as follows:

Estimated Costs for Proposed Projects in Development Plans[36]

(Unit: KSh million)

Development Plan	Proposed Project	Type	Project Cost	Annual O&M Cost
Water Supply*	Urban Water Supply (137 UCs)	Rehabilitation	70,920	-
		New construction	1,018,098	41,991
		Sub-total	1,089,018	41,991
	Rural Water Supply (47 Counties)	Rehabilitation	9,087	-
		New construction	189,762	8,392
		Sub-total	198,849	8,392
	Sub-total		1,287,867	50,384
Sanitation*	Sewerage System (95 UCs)	Rehabilitation	17,502	-
		New construction	458,981	25,128
	Sub-total		476,483	25,128
Irrigation**	Large-scale Irrigation (432,235 ha)	New construction	725,567	2,178
	Small-scale Irrigation (109,278 ha)	New construction	70,617	353
	Private Irrigation (82,162 ha)	New construction	159,283	1,592
	Sub-total		955,467	4,123
Hydropower	14 Projects (1,381 MW)	New construction	290,464	1,453
Total			3,010,281	81,088

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. Table 13.2.1 and Main Report Part B~G, Section 5.2)

The construction costs and O&M costs of the proposed dam were allocated to the related projects of water supply, irrigation and hydropower development in proportion of the required storage volumes in principle. The construction costs and O&M costs of the proposed intra-basin and inter-basin water transfer facilities were allocated to the related water supply projects. The construction costs of the dams and water transfer facilities are shown in Tables 7.7.1 and 7.7.2 respectively.

The development and recurrent costs, including operation and maintenance costs, estimated for the proposed management plans are shown in Table 13.2.2 and they are summarised as follows:

[36] Methods of estimate for project and O&M costs are described in Chapter 5 of Sectoral Report (C) for water supply, Chapter 4 of Sectoral Report (D) for sanitation, Chapter 5 of Sectoral Report (E) for irrigation and Chapter 4 of Sectoral Report (F) for hydropower.

Estimated Costs for Proposed Management Plans[37]

Management Plan	Proposed Plans	Development Costs (KSh million)	Recurrent Costs* (KSh million/year)
Water Resources Management	Monitoring (Surface water: 135 sites, Groundwater: 95 sites, Rainfall 258 sites)	665	714
	Water Resources Evaluation (6 catchment areas)	293	-
	Water Permit Issuance and Control (Renewal of water permit database at 5 years interval)	144	-
	Watershed Conservation (4,478,000 ha)	353,762	-
	Operation of Catchment Forum (6 catchment areas, two times a year)	-	6
	Sub-total	354,864	720
Flood and Drought Disaster Management	Community-based Disaster Management (5 locations)	865	6
	Evacuation Plan (3 locations)	90	0.5
	Flood Forecasting and Warning System (2 locations)	1,512	8
	Flood Fighting Plan (2 locations)	60	0.3
	Hazard Map (6 locations)	180	0.9
	Hydropower Dam Warning (1 location)	30	0.2
	River Training Works (cost for F/S) (6 locations)	958	-
	Sub-total	3,695	15.9
Environmental Management	Setting of Environmental Flow Rate including Survey (36 locations)	325	-
	Environmental Monitoring (50 locations)	-	6.4
	Sub-total	325	6.4
Total		358,884	742.3

Note: Recurrent cost includes operation and maintenance costs.
Source: JICA Study Team (Ref. Table 13.2.2 and Main Report Part B~G, Section 5.2)

14. ECONOMIC EVALUATION

14.1 Basic Conditions for Economic Evaluation

The overall economic evaluation was conducted for the four subsectors of urban water supply (for 137 UCs, excluding rehabilitation works), sewerage (for 95 UCs, excluding rehabilitation works), large-scale irrigation (with 480,250 ha), and hydropower (with 14 dams) at the master plan level. The following assumptions were made for economic evaluation:

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.

[37] Methods of estimate for development and recurrent costs are described in Chapter 4 of Sectoral Report (H) for water resources management, Chapter 6 of Sectoral Report (J) for flood and drought disaster management and Chapter 4 of Sectoral Report (K) for environmental management.

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 is estimated by setting items of economic benefits.

Based on the basic conditions for economic evaluation mentioned above, economic cost and economic benefit were estimated as follows:

Summary of Economic Cost by Subsector

(Unit: KSh billion)

Subsector	LVNCA	LVSCA	RVCA	ACA	TCA	ENNCA
Water Supply	126.8	142.3	87.5	455.8	114.4	19.5
Sewerage	70.3	74.1	35.6	183.5	58.7	9.2
Irrigation	59.8	98.2	82.9	33.1	253.9	34.2
Hydropower	25.0	44.2	54.4	7.5	142.0	--

Source: JICA Study Team (Ref. Main Report Part B~G, Section 6.2)

Economic Benefit by Subsector

(Unit: KSh billion)

Subsector	Items of Economic Benefit	LVNCA	LVSCA	RVCA	ACA	TCA	ENNCA
Water Supply	- Cost saving for water user - Increase of water supply amount	194.2	205.9	88.2	454.0	127.3	29.8
Sanitation	- Cost saving for user - Affordability to pay - Improvement of public health	94.3	94.6	47.6	231.3	82.2	12.0
Irrigation	- Crop production increase	101.0	90.6	100.2	28.6	181.6	28.4
Hydropower	- Capacity increase - Energy increase	22.6	36.1	72.1	11.3	137.6	--

Source: JICA Study Team (Ref. Main Report Part B~G, Section 6.2)

14.2 Economic Evaluation for Proposed Projects

Based on the estimated economic costs and benefits, the economic internal rate of return (EIRR) was calculated as shown in the Table below. The evaluation period was 30 years for water supply and sewerage projects and 50 years for irrigation and hydropower projects based on the economic lives of the facilities.

Economic Internal Rate of Return by Subsector

(Unit: %)

Subsector	LVNCA	LVSCA	RVCA	ACA	TCA	ENNCA
Water Supply	14.0	13.3	9.3	7.7	10.2	14.1
Sewerage	11.3	10.6	11.3	10.4	11.9	11.1
Irrigation	17.2	10.7	13.5	10.2	8.3	9.9
Hydropower	10.9	10.3	15.3	16.9	11.8	--

Source: JICA Study Team (Ref. Main Report Part B~G, Section 6.2)

In terms of economic viability, projects with more than 10% EIRR are evaluated as economically feasible, and projects with less than 10% EIRR are to be implemented carefully considering the needs of the projects.

The following are some remarks for the result of economic evaluation.

(1) Water Supply Subsector

a) For LVNCA, LVSCA, TCA, and ENNCA, the proposed water supply projects do not include expensive structures for water source development, such as large-scale dams or water transmission systems, so that the water supply subsector could be economically feasible. EIRR of TCA is decreased because of the high cost of transmission system of Lamu Water Supply Project.

b) As for RVCA and ACA, water supply projects require expensive structures for water source development, such as large-scale dams and long water transmission systems for the Nairobi and its satellite towns, the Mombasa and surrounding coastal area, and Greater Nakuru area, so that their EIRRs are less than 10%. The water supply projects around these areas should be promoted with careful consideration from the viewpoint of basic human needs.

(2) Sewerage Subsector

a) EIRR of sewerage subsector is generally more than 10%. Sewerage projects should be promoted taking into consideration their contribution to environmental conservation, human health, and recycling of water.

(3) Irrigation Subsector

a) For LVNCA, LVSCA, RVCA, and ACA, EIRRs of the irrigation subsector are over 10% and economically feasible.

b) For TCA, the irrigation subsector has the potential of creating large benefits, but EIRR in this subsector is low mainly due to high cost of long diversion canal for the High Grand Falls dam irrigation project. The project design and costs should be reviewed carefully before implementation.

c) For ENNCA, the irrigation subsector is evaluated and determined as not economically feasible due to the high cost of dams, but the irrigation projects in this area are important for securing food security in this region. They should be promoted with careful consideration.

(4) Hydropower Subsector

a) Except for LVNCA, EIRRs of hydropower projects are over 10% and evaluated as economically feasible. The projects in RVCA and TCA, owing to topographic conditions, could gain sufficient head beneficial for power generation. Because of the high cost of Nandi forest multipurpose dam project, the EIRR for LVNCA is less than 10%.

15. IMPLEMENTATION PROGRAMMES

15.1 Criteria for Prioritisation for Implementation

Implementation programmes were prepared for the proposed projects in the water supply, sanitation, irrigation, hydropower and water resources development plans and for the proposed water resources management, flood and drought disaster management, and environmental management plans. The prepared implementation programmes will be a roadmap for the smooth realisation 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. The programmes of the proposed projects and plans were prepared for an implementation term of 18 years from fiscal year 2013/14 to 2030/31 by dividing the term into three, namely: short term (five years, from 2013/14 to 2017/18), medium term (five years, from 2018/19 to 2022/23), and long term (eight years, from 2023/24 to 2030/31) considering directions and targets of the implementation for each of three terms.

In order to prepare the implementation programmes, the proposed projects and management plans were ranked in accordance with prioritisation criteria. The criteria for the proposed projects are as follows:

a) Priority ranking is given to the projects according to their status. Rank 1 is given to projects with finance. Ranks 2 and 3 are given to projects with completed detailed designs completed and feasibility studies, respectively. National flagship projects and projects proposed by the organisations in charge are incorporated in the ranking study above.
b) For projects having the same project status as sorted in the abovementioned ranking study, rehabilitation projects which generally have rather short implementation periods and less costs, or projects having large number of beneficiaries and/or high economic viability are prioritised.
c) Water resources development projects including dams, water transfers stations, boreholes, and small dams/water pans are to be implemented according to the requirements of the water supply and irrigation subsectors. Hydropower projects are to be implemented following the dam projects.

The criteria for prioritisation of the proposed management plans were set as shown below.

a) For the water resources management plan, observation and data gathering activities for the meteo-hydrological data are prioritised considering the magnitude of contribution to stable and sustainable water resources management works.
b) For the flood disaster management plan, non-structural measures which generally costs less compared with structural measures and urgently required urban drainage projects having detailed designs are prioritised. Multipurpose dams including those for flood control purposes are to be implemented in coordination with other water use purposes. For drought disaster management plan, plans using the existing dams are prioritised.
c) For the environmental management plan, locations of surveys and studies for setting the environmental flow rates in rivers and environmental monitoring activities to monitor the set flow rates are decided prior to the implementation of the development projects.

15.2 Implementation Schedule of Proposed Plans

The implementation schedules were prepared under the following conditions as well as the criteria for prioritisation:

a) All the proposed projects and management plans should be realised by the target year of 2030.
b) The schedules follow the existing implementation schedules already prepared by the government.
c) The schedules of each water subsector should be prepared in close harmony with the requirements of other subsectors.
d) The schedules need to be prepared, in which annual disbursement costs are to be as even as possible.

The prepared implementation schedules for the proposed development projects are shown in Figures 15.2.1 - 15.2.5 and those of management plans are shown in Figures 15.2.6 - 15.2.8. The term-wise achievement rates by the proposed projects for each subsector are as shown below. Achievement rates were evaluated based on the projects which are to have been completed by respective terms. Prior to implementation of the development projects, environmental impact assessment (EIA) should be implemented including the issues of compensation.

Term-wise Achievement Rates by Proposed Projects for Each Subsector

Subsector	Indicator for Achievement Rate	Short Term		Medium Term		Long Term		Target for Development
		2013 -2017	Percen-tage	2018 -2022	Percen-tage	2023 -2030	Percen-tage	2013 -2030
Water Supply	Supply Capacity (m^3/day)	230,396	6.3%	1,613,236	44.1%	1,811,194	49.6%	3,654,826
	Accumulated (m^3/day)	230,396	6.3%	1,843,632	50.4%	3,654,826	100.0%	
Sanitation	Treatment Capacity (m^3/day)	218,987	8.1%	413,726	15.3%	2,062,769	76.5%	2,695,481
	Accumulated (m^3/day)	218,987	8.1%	632,712	23.5%	2,695,481	100.0%	
Irrigation	Irrigation (ha)	62,427	10.0%	150,626	24.2%	410,622	65.8%	623
	Accumulated (ha)	62,427	10.0%	213,053	34.2%	623,675	100.0%	
Hydro-power	Installed Capacity (MW)	615	44.5%	436	31.6%	330	23.9%	1,381
	Accumulated (MW)	615	44.5%	1,051	76.1%	1,381	100.0%	
Water Resources Development	Storage Capacity (MCM)	5,456	50.7%	2,052	19.1%	3,256	30.2%	10,764
	Accumulated (MCM)	5,456	50.7%	7,508	69.8%	10,764	100.0%	

Source: JICA Study Team (Prepared based on the implementation schedules presented in Figures 15.2.1 to 15.2.5.)

15.3 Points to Consider during Implementation of Proposed Plans

For the smooth implementation of the proposed projects, management plans and activities, it is indispensable to coordinate among related organisations and stakeholders. Major points to consider are as listed below. Detailed information is as described in the relevant sectoral reports as recommendations.

(1) Water Supply and Sanitation Development Plan

a) Confirmation on the Availability of Land for Treatment Plant

(2) Irrigation Development Plan

a) Incentives for Introduction of Water-saving Irrigation

b) Review of Existing Irrigation Development Plans whether they satisfy WRMA's guidelines for water allocation

(3) Water Resources Management Plan

a) Sharing of Long-term Forecast Information with Kenya Meteorological Department (KMD) for effective implementation of weather forecasting, flood and drought forecasting, as well as water resources management activities.

b) Clear Demarcation on Forestation Activities between KFS and WRMA for effective implementation of the proposed watershed conservation activities.

(4) Environmental Management Plan

a) Sharing of information among related ministries/organisations through establishment of database related to environment

16. FINANCING ASPECT

16.1 Government Budget

(1) Current Government Budget

The current government budget for water resources development is summarised in the table below. The water sector development budget consists of around 2.8% of the total government budget. In terms of GDP, water sector development expenditure accounts for less than 1% of GDP. On the other hand, external resources for the water sector are almost same as the government subsidies for the water sector, which is around 2.8% of the government budget.

Current Budget of Water Sector in 2012/13

Item	Amount (KSh billion)	% of GDP	% of GOK Budget
Government Budget	838.2	24.0%	-
MWI, Development Grants	16.9	0.5%	2.0%
MORDA, Development Grants	5.6	0.2%	0.7%
MOE, Development Grants (Hydropower)	1.3	0.0%	0.2%
Total Available Government Budget	23.8	0.7%	2.8%
MWI, External Resources	23.7	0.7%	2.8%

Note: * The GOK budget in the Ministry of Energy is estimated at 20% of development budget in hydropower projects.
** This category excludes external resources for water resource development.

Source: Budget Policy Statement 2012, Ministry of Finance; the data from the Ministry of Water and Irrigation; the data from KenGen.

(2) Estimate of Available Financial Resources up to 2030

The following assumptions are made for estimating available resources for the NWMP 2030.

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

b) The future government budget and expenditure are expected to increase in proportion to the projected GDP growth.

c) The government budget in the water sector is also projected to increase in proportion to the GDP growth rate[38]. Since the implementation of multipurpose dams is expected to commence from the 2013/14 financial year, the budget for regional development is considered to increase from 0.7% to 1.0% of the total GOK budget from fiscal year 2013/14.

The estimated available resources for development projects by subsectors up to 2030 are summarised in the following figure:

Available Budget for Water Sector up to 2030

(Unit: KSh billion)

Item	2030/31	2013/14-2030/31	% of GOK Budget
Government Budget	4,024.6	38,687.3	-
MWI, Development Grants	80.5	859.8	2.2%
MORDA, Development Grants	40.2	300.9	0.7%
MOE, Development Grants (Hydropower)	4.7	86.0	0.2%
Total Available Government Budget	125.4	1,246.7	3.2%

Source: Budget Policy Statement 2012, Ministry of Finance; the data from the Ministry of Water and Irrigation; the data from KenGen

16.2 Financing Analysis

The required investment costs (development costs) and the available government budget up to 2030 estimated by GDP growth rate as mentioned before are compared below. The estimated available government budget cannot cover the required investment costs in all subsectors.

Required Investment Costs and Available Budget

(Unit: KSh billion)

Subsector	Required Investment Cost	Available Government Budget	Coverage
Water Supply	1,287.9	561.5	43.6%
Sewerage	476.5	30.9	6.5%
Irrigation*	796.2	580.4	72.9%
Hydropower	290.5	74.0	25.5%
Total	2,851.1	1,246.7	43.7%

Note: * Private irrigations are excluded.
Source: JICA Study Team (Ref. Main Report Part A, Section 9.4)

Based on the above comparison, the following consideration can be made:

The government budget available for the water supply subsector covers around 44% of the required investment cost. The ratio of the government budget could be decreased gradually, with more private sector financing and financing sources other than the government budget such as ODA funds being actively introduced in this subsector.

Generally, sewerage development depends largely on the government budget. However, the government budget available for the sewerage subsector covers only 6.5% of the required investment cost. The government budget for sewerage should be increased more than the amount expected above.

[38] Refer to Section 5.1.

For the irrigation subsector, most of investment costs are usually provided by the government budget except for private irrigation schemes. The available government budget for the irrigation subsector covers 73% of its required investment costs. Financing sources such as ODA fund is considerable for large-scale irrigation schemes.

It is conceivable to gradually decrease the ratio of the government budget for the hydropower subsector by utilizing ODA funds and private sector financing, especially for financially viable hydropower projects.

Based on the above evaluation, it can be considered that:

a) Introduction of more private financing and ODA funds for development of hydropower and water supply sectors is to be promoted, to allocate more government budget to sewerage subsector. The possibility of private participation can be scrutinised during the course of individual project formulation;
b) Considering the fact that the current government budget for water sector is only 0.2-0.3% of GDP, and that the average government expenditures for water sector in other African countries against their GDP is 0.7%, GOK still has the space to increase the budget.

17. INSTITUTIONAL STRENGTHENING PLAN

17.1 Existing Representation of Institutional Framework of Water Sector

The existing representation of the institutional framework of the water sector under the MWI is illustrated in Figure 17.1.1. The roles and responsibilities of MWI include development of legislation, policy formulation, sector coordination and guidance, and monitoring and evaluation. WRMA, composed of the head office and the regional offices, is a regulatory body for the planning, regulation, and management of water resources and contribution to policy formulation at the national and regional levels. WRMA is under the jurisdiction of MWI. The Catchment Areas Advisory Committee (CAACs) is an advisory body to WRMA for the regulation of water resources issues at the regional level. The subregional offices of WRMA provide water resources management (WRM) services at subregional level under the regional offices of WRMA.

17.2 Base Documents

Aligning the Water Act 2002 with the Constitution of Kenya 2010 (CoK 2010) and New National Water Policy 2012 have not been completed yet as of end October 2012. The institutional strengthening to materialise NWMP 2030 is drafted based on the condition that Sessional Paper No.1 on National Policy on Water Resources Management and Development 1999 (NWRDP 1999) and Water Act 2002 are already effective as of end October 2012.

17.3 Proposed Actions

The following eight strategic actions[39] for the institutional strengthening were proposed at the national and regional level to resolve the prevailing and future issues identified by the study.

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

Regulation of irrigation water services is not included in the present sector framework of water resources management in Kenya. Regulatory functions stipulated in the Water Act, Land Act, Irrigation Act, Environmental Management and Coordination Act, etc. are also duplicated and inconsistent, and results in conflict in water resources management at the different sites. It is proposed to regulate irrigation water services and water supply services together as Integrated Water Resources Management being consistent with the Irrigation Act and other related acts.

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

It is necessary to establish a framework (law and institution) which prevents grant of water rights for development from regional water rights conflicts due to development of water resources including inter-basin and intra-basin water transfer crossing county boundaries in response to dramatic increase in future water use. Autonomous water rights regulatory organizations at regional level will not be able to regulate such water rights issues. It is proposed to establish monopolistic and unified regulatory power and functions of water resources management both at the national and regional levels. The present power and functions of the national apex body shall be strengthened for this. WRMA shall be equipped with strong competence to regulate and enforce all the water sector regulatory bodies and various water users for water rights allocation and regulation.

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

For provision to future water demand increase and climate change it is important to grant water rights appropriately from the stage of water resources development plan to ensure regional water supply security or confidence level. It is proposed to establish the unitary regulation and enforcement of water rights institution which links the grant of all water permits (water rights) with river basin water resources development plans. The new water permit system requires the registration of all water abstraction from the existing and new storage dams regardless of public or private ownership, and sectors of irrigation, domestic water supply, or hydropower generation.

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

In order to materialize Strategic Actions 2 and 3 it is necessary to establish scientific and quantitative management of water resources trusted by stakeholders which is credible, transparent and accountable. The proposed management system integrates the three components of grant of water use permits,

[39] Refer to Sectoral Report (L) for details.

monitoring of discharge and abstraction records, and regulation of water rights linked with the relevant basin water resources development plans.

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

Water demand required to achieve the Kenya Vision 2030 will not be fulfilled neither by present supply side management nor by the present demand side management working individually. As supply side management, it is proposed to enhance development of water resources, both surface water and groundwater legally, as specified by such laws as water resources promotion law to specify the support and incentives, and specific multipurpose dam law to specify cost and benefit allocation. As demand side management, it is proposed to enhance legally efficient and beneficial use of water resources for agricultural, domestic, and industrial water use such as water saving, recycling, reduction of loss, water rights transfer, and trading.

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

Present staffing and technical capacity of the WRMA regional offices are not sufficient to implement Strategic Actions 2 and 3. It is proposed to execute capacity development of the WRMA regional offices as a lower structure of water rights regulation. Technical capacity development of the WRMA regional offices shall be executed as an integrated program with Strategic Actions 2, 3, and 4.

(7) Strategic Action-7: Enhance Establishment of and Strengthen Water Resources Users Associations (WRUAs)

Embodiment and capacity of the present Water Resources Users Associations (WRUAs) are not sufficient to participate effectively in conflict resolution and cooperative management of water resources in catchment areas. It is proposed to enhance establishment of WRUAs and to strengthen the capacity of WRUAs. WRUAs shall keep their position as water users or service providers, but not as regulators.

(8) Strategic Action-8: Improvement of Financial Capacity for the Water Resources Management Institution at National and Regional Level[40]

MWI guides the WRMA and the WRMA regional offices in operating the present and future water resources management mainly through the use of the revenue from water use permit fees and charges. Regulatory and management activities by the WRMA are not sufficient due to insufficient financial and technical capacities. It is proposed to improve the financial capacity for water resources management institution to secure smooth implementation of water resources management activities through effective government financing.

The study recommends the implementation of the eight strategic actions as soon as possible to avoid current water rights conflicts and significant environmental impacts, in particular to execute a trial study of Strategic Actions 3 and 4 as part of institutional strengthening of the WRMA and the priority

[40] Refer to Main Report Part A, Sub-section 8.3.2 (8) for detail.

WRMA regional offices. The trial can be started through the use of the relevant catchment water resources development and management plan of NWMP 2030.

18. ACTION PLAN FOR WRMA REGIONAL OFFICES TOWARD 2022

18.1 Current Issues on Water Resources Management for WRMA Regional Offices

For smooth implementation of the proposed water resources management plan in this study, it is necessary to strengthen the capacity and system for water resources management in WRMA regional offices that are in charge of the actual management works. In this study, pilot activities were conducted in WRMA-Tana Catchment Area for: i) assistance for establishment and operation of catchment forum for improvement of river basin governance, ii) assistance for strengthening of hydro-meteorological information management, iii) assistance for improvement of water permit database management, and iv) assistance for improvement of flood and drought disaster management. Based on the results of the pilot activities, action plans were prepared for WRMA regional offices toward 2022.

Issues on water resources management extracted from the pilot activities in WRMA-Tana and through this study are as follows:

(1) Issues on Establishment and Operation of Catchment Forum for Strengthening of River Basin Governance:

a) Establishment of legal status of the Catchment Forum.
b) Promotion of establishment of Water Resources Users Association (WRUAs) in the catchment area to strengthen the organisational power in the catchment area as a whole, and promotion of participation of WRUAs to catchment forum.

(2) Issues on Strengthening of Hydro-meteorological Information Management:

a) Issues on hydro-meteorological observation (lack of measured discharge data for floods, lack of dedicated boreholes for groundwater monitoring, lack of technical capacity of gauge readers etc.).
b) Lack of system resources for management of observed hydro-meteorological data such as computers and peripherals.

(3) Issues on Water Permit Database Management:

The rules for issuance of water permit are stipulated in Water Act 2002 and also Water Resources Management Rules 2007, however there are issues on operation of the rules such as insufficient familiarisation of issuance procedures, lack of resources, etc. The specific issues are as follows:

a) Lack of system resources for water permit issuance and control such as computers, and insufficient network resources and environment.
b) Capacity building for WRMA staff on water permit issuance and control especially on familiarisation with the procedures and operational skills on the system.

(4) Issues on Improvement of Flood and Drought Disaster Management:

(Flood Disaster Management)

a) Lack of information sharing and coordination among related organisations.

b) Lack of flood information propagation.

c) Lack of survey and analysis on floods.

(Drought Disaster Management)

a) Lack of system to coordinate water use during droughts.

b) Lack of information on past drought damages.

18.2 Proposed Action Plans Toward 2022

Based on the results of pilot activities in WRMA-Tana as mentioned in the previous section, survey was conducted for other regional offices of WRMA using questionnaire sheets on the current issues on water resources management. Although there were slight differences in issues of water resources management, the survey results indicated the same tendency as the results derived from pilot activities in WRMA-Tana. In this connection, it is considered that proposed action plans in this section can be applied to all the six regional offices of WRMA.

Action plans for WRMA regional offices toward 2022[41] are proposed as follows:

(1) Actions for establishment and operation of Catchment Forum for strengthening of river basin governance

a) Establish a "Catchment Forum" in the six regional offices of WRMA. Ministry of Water and Irrigation (MWI) and WRMA headquarters are to take actions on establishment of legal status of the forum.

b) Secure budget for operation of "Catchment Forum" in each regional office and continue holding the forum periodically (twice a year).

c) Promote establishment of WRUAs in each catchment area and promote participation of WRUAs to the forum[42].

(2) Actions for strengthening of hydro-meteorological information management

a) Improvement of operation of monitoring stations

i) Replace present iron post for river gauging with concrete post to prevent vandalism.

ii) Upgrade existing manual gauging into automatic gauging (surface and groundwater level and rainfall).

iii) Periodically patrol gauging stations at least once a year.

iv) Introduce flood discharge measurement equipment to prepare accurate rating curve.

v) Involve members of WRUAs as gauge readers for more responsible gauging.

vi) Install dedicated boreholes for groundwater monitoring.

[41] The year of 2022 is an interim goal of mid-term development plan under the frameworks of Kenya Vision 2030.

[42] It is expected that active participation to water resources management activities at community levels will be strengthened through promotion of establishment of WRUAs.

b) Improvement of water quality monitoring and pollution control system

i) Publish a guideline for water quality monitoring

ii) Enforce preparation of Effluent Discharge Control Plan (EDCP) by industries for pollution control.

iii) Establish water resources quality objectives for major water bodies.

c) Improvement of hydrometeorological database management

i) Enhance system resources (computers and related equipment) based on assessment of the current situation.

ii) Renew/update Hydro-meteorological Database System (every five years).

d) Establishment of training courses

i) Training course on discharge measurement.

ii) Training course on water quality analysis in the laboratory for both surface and groundwater.

iii) Training course on operation of Hydro-meteorological Database.

(3) Actions for improvement of Water Permit Database (PDB) management:

a) Improvement of permit control

i) Enhance system resources (computers and related equipment) based on assessment of the current situation.

ii) Enhance data communication environment (internet/intranet environment) based on assessment of the current situation.

iii) Establish a map-based permit information management system using GPS.

iv) Renewal/updating of PDB system (every five years).

b) Establishment of training courses

i) Training course on operation of Water Permit Database.

ii) Training course on procedures for water permit issuance and control.

(4) Actions for improvement of flood and drought disaster management

a) Improvement of flood information management

i) Establish a flood information sharing system among related organisations such as Kenya Meteorological Department (KMD), the Ministry of Regional Development Authorities (MORDA), Kenya Electricity Generating Company (KenGen), National Irrigation Board (NIB), local governments, communities with clear demarcation and flow of information.

ii) Prepare flood hazard maps based on numerical analysis for major urban centres.

iii) Prepare flood damage database to accumulate past flood damages.

iv) Install color-coded staff gauges for flood risk indications.

v) Guide WRUAs to include flood aspects in Sub-catchment Management Plan (SCMP).

vi) Conduct flood survey and analysis for flood prone areas.

b) Improvement of drought information management

i) Establish a basin drought conciliation council.

ii) Establish water use restriction rules of reservoirs.

iii) Prepare drought damage database to accumulate past drought records.

iv) Guide WRUAs to include drought aspects in Sub-catchment Management Plan (SCMP).

Implementation schedules of the proposed action plans are shown in Figure 18.2.1.

19. SUMMARY OF PROPOSED PLANS BY SUBSECTOR

In Chapter 7 to Chapter 12, the proposed water allocation plans, development plans (water supply, sanitation, irrigation, hydropower and water resources development plans) and management plans (water resources, flood and drought disaster and environmental management plans) are described by catchment area for six catchment areas. In this chapter, the proposed development plans and management plans are summarised by subsector together with summary of water allocation plans.

Table 19.1.1 presents the summary of water allocation plans. The proposed development plans are summarised in Tables 19.1.2 – 19.1.6 and the proposed management plans are summarised in Tables 19.1.7 – 19.1.9. Also, the locations of the proposed development and management plans are shown in Figures 19.1.1 – 19.1.14.

20. RECOMMENDATIONS

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

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

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

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

Through preparation of the NWMP 2030, it was revealed that the basic information and data required for formulation of the national water master plan were insufficient. It is recommended to establish a database to accumulate the basic information and data continuously toward the next update of the national water master plan. In concrete, necessary information includes the followings but not limited to:

1) Data related to the current water use (accurate amount of water supply for each subsector, existing irrigation area, irrigation efficiency, cropping intensity etc.)
2) Information required for appropriate planning (amount of water resources, total amount of issued water permits, information on water resource development, information related to siltation of dams, environmental flow, reserve etc.)
3) Basic socio-economic information for water demand projection (population projection by administrative boundary, basic industrial information related to industrial water demand projection, numbers of livestock and required daily water for feeding, areas of fishpond for inland fisheries etc.)

(2) Early Implementation of Required Surveys for Planning

During the course of the master plan study, formulation of the master plan was rather difficult in the following areas due to lack of related data. Early implementation of the required surveys and accumulation of the data are recommended.

1) Detailed flood survey[43] for formulation of flood management plan
2) Survey on the current situation of soil erosion[44] and degradation of small water sources[45]

(3) Continuous Monitoring and Evaluation of Water Resources

The monitoring and evaluation of water resources are basis for the water resources management and they should be continuously conducted. The reliable water resources data will realise the proper water resources management.

The NWMP 2030 presents the basic information and data for water resources management such as available water resources, present and future water demands, water resources monitoring networks, water allocation plans based on water balance study, change of flow regime at reference points, etc. However, it is recommended to realise equitable water allocation and proper water right issuance based on the latest data obtained from the continuous monitoring and evaluation of water resources.

The future water demand to achieve the Kenya Vision 2030 will increase to about four times of the present water demand in total. This indicates that it will be quite severe to keep the balance between water supply and demand in the future. It is recommended to steadily develop water resources to meet the water demands; to manage the water resources so as to promote efficient water use and water saving; and to attain equitable water allocation. Strengthening of capability of the water resources management is therefore essential, which requires institutional strengthening of WRMA such as maintenance and expansion of the observation stations and increase of workforces.

As for groundwater potential, a potential map was prepared during the master plan as general information. Detailed information on groundwater potential should be rectified through survey and further studies.

(4) Actions on Institutional Strengthening for Water Resources Management

The institutional strengthening plan in the NWMP 2030 proposed eight strategic actions on institutional strengthening of water resources management. It is recommended to take those actions as early as possible to avoid conflicts on water rights caused by increased the water demands toward future and to attain proper water resources management.

[43] Survey items for planning should include location, depth, area and time of flooding, flood discharge, river conditions, topographic maps, etc. (Refer to Sectoral (J) Flood and Drought Disaster Management 7.4 (1)).
[44] Survey items for planning should include location, scale, current situation, and the required countermeasures. (Refer to Sectoral (H) Water Resources Management 3.2 (4)3)).
[45] Survey items for planning should include location, scale, water use, water quality, vegetation condition, management method, and major issues. (Refer to Sectoral (H) Water Resources Management 3.2 (4)2)).

(5) Financing Aspect

According to rough analysis on financing aspect, the government budget allocated to water sector cover only around 44% of the required total investment cost to implement the proposed plans assuming that the water sector budget increases in proportion to a growth rate of GDP. Currently the water sector budget accounts for 0.7% of GDP. It is recommended to increase this ratio of 0.7% to around 1.0% and also to make use of the private funds and ODA funds to cover the required investment cost.

(6) Revision of National Water Policy and Water Act

The present national water policy was established in 1999 and the present water act in 2002. They are presently effective and the NWMP 2030 is based on them. However, they are under process of revision to align with new Constitution of Kenya established in 2010. It is recommended to review the relevant parts of NWMP 2030 after enactment of the revised national water policy and water act.

(7) Formulation of Development Master Plans of Subsectors

The NWMP 2030 was formulated based on the national development targets presented in the Kenya Vision 2030, but no concrete development master plans for respective subsectors are presented. It is recommended to prepare the development master plans of subsectors such as water and sanitation master plan, irrigation master plan, hydropower master plan, urban development master plan, regional development master plan, etc. to quantify the future water demands more clearly.

(8) Water Resources Management for International Rivers

There is no international treaties on the transboundary water with related countries so far. Therefore, no consideration was made for international water allocation in the NWMP 2030. The NWMP 2030 includes development of transboundary water as an input to achieve the Kenya Vision 2030. However, it is necessary to build consensus prior to implementation of water resources development projects in international river basins. The NWMP 2030 assumes that international agreements and treaties with neighboring countries will be made in line with the Transboundary Water Policy which is currently under formulation by MWI. It is recommended to have the Transboundary Water Policy completed promptly as the policy is important for implementation of NWMP 2030.

Tables

Table 6.3.1 Target 137 Urban Centres for Urban Water Supply Development

No.	LVNCA	LVSCA	RVCA	ACA	TCA	ENNCA
1	Eldoret	Kisumu	Nakuru	Nairobi	Lamu	Isiolo
2	Vihiga	Rongo	Naivasha	Mombasa	Nyeri	Nanyuki
3	Kitale	Kericho	Ol Kalou	Ruiru	Kitui	Nyahururu
4	Mumias	Bomet	Molo	Kikuyu	Thika	Mandera
5	Kimilili	Kisii	Narok	Kangundo-Tala	Embu	Wajir
6	Kakamega	Migori	Gilgil	Machakos	Meru	Rumuruti
7	Kapsabet	Suneka	Njoro	Mavoko	Matuu	Moyale
8	Bungoma	Ahero	Eldama Ravine	Malindi	Makuyu	Rhamu
9	Busia	Kipkelion	Lodwar	Karuri	Chuka	Elwak
10	Luanda	Homa Bay	Mai Mahiu	Ngong	Muranga	Takaba
11	Item/Tambach	Londiani	Kakuma	Kiambu	Garissa	Maralal
12	Webuye	Nyamira	Kabarnet	Limuru	Chogoria	Marsabit
13	Kapenguria	Keroka	Lokichogio	Ukunda	Maragua	
14	Bondo	Oyugis		Kitengela	Wanguru	
15	Siaya	Muhoroni		Wundanyi	Runyenjes	
16	Yala	Awasi		Kilifi	Kerugoya/Kutus	
17	Malaba	Kehancha		Mtwapa	Maua	
18	Malakisi	Awendo		Juja	Mwingi	
19	Chwele	Kendu Bay		Ongata Rongai	Sagana	
20	Butere	Mbita Point		Taveta	Karatina	
21	Kiminini	Tabaka		Mariakani	Othaya	
22	Usenge	Litein		Voi	Madogo	
23	Moi's Bridge	Sotik		Kajiado	Msalani	
24	Nandi Hills	Nyansiongo		Kwale	Hola	
25	Lumakanda	Ogembo		Kiserian		
26	Matunda			Loitokitok		
27	Ugunja			Githunguri		
28	Port Victoria			Wote		
29	Ukwala			Watamu		
30	Nambale			Mitto Andei		
31	Burnt Forest			Masambweni		
32	Malava					
Total	32 UCs	25 UCs	13 UCs	31 UCs	24 UCs	12 UCs

Source: JICA Study Team, based on Census 2009

Table 6.4.1 Target 95 Urban Centres for Sewerage System Development

No.	LVNCA	LVSCA	RVCA	ACA	TCA	ENNCA
1	Eldoret	Kisumu	Nakuru	Nairobi	Lamu	Isiolo
2	Vihiga	Rongo	Naivasha	Mombasa	Nyeri	Nanyuki
3	Kitale	Kericho	Ol Kalou	Ruiru	Kitui	Nyahururu
4	Mumias	Bomet	Molo	Kikuyu	Thika	Mandera
5	Kimilili	Kisii	Narok	Kangundo-Tala	Embu	Wajir
6	Kakamega	Migori	Gilgil	Machakos	Meru	
7	Kapsabet	Suneka	Njoro	Mavoko	Matuu	
8	Bungoma	Ahero	Eldama Ravine	Malindi	Makuyu	
9	Busia	Kipkelion	Kabarnet	Karuri	Chuka	
10	Luanda	Homa Bay		Ngong	Muranga	
11	Item/Tambach	Londiani		Kiambu	Garissa	
12	Webuye	Nyamira		Limuru	Chogoria	
13	Kapenguria	Keroka		Ukunda	Maragua	
14	Bondo	Oyugis		Kitengela	Wanguru	
15	Siaya	Muhoroni		Wundanyi	Runyenjes	
16	Malaba	Awasi		Kilifi	Kerugoya/Kutus	
17	Malakisi	Kehancha		Mtwapa	Maua	
18	Moi's Bridge	Awendo		Juja	Mwingi	
19	Matunda	Kendu Bay		Ongata Rongai		
20				Taveta		
21				Mariakani		
22				Voi		
23				Kajiado		
24				Kwale		
25				Kiserian		
Total	19 UCs	19 UCs	9 UCs	25 UCs	18 UCs	5 UCs

Source: JICA Study Team, based on Census 2009

Table 6.5.1 Large Scale Irrigation Projects Proposed by Government Authorities and This Study (1/3)

a) Projects Proposed by Government Authorities

No	Name of Project	County	Irrigation Area (ha)	Type of Project*[1]	Water Source Facility*[2]	Project Status as of Oct. 2012*[3]	Executing Agency
LVNCA							
1.	Lower Nzoia Irrigation	Busia & Siaya	10,470	New	Weir	On-going	NIB
2.	Lower Sio Irrigation	Busia	6,600	New	Weir	On-going	NIB
3.	Nandikinya-Magombe-Makunda Irri.	Busia	600	New	Pumping	Proposed	LBDA
4.	Sabwani-Kapsitwet-Namanjalala Irri.	Trans Nzoia	800	Reh+Ext	Weir	Proposed	LBDA
5.	Yala Swamp Drainage & Irrigation	Siaya	4,600	New	Weir	F/S done	LBDA
	Total		23,070				
LVSCA							
1.	Ahero and West Kano Irrigation	Kisumu	1,800	Reh+Ext	Pump/Weir	F/S done	NIB
2.	Kano Plain Irrigation (Magwagwa Multi-dam)	Nyamira/Kericho	15,000	New	Multi-dam	F/S done	LBDA
3.	Kimira-Oluch Irrigation	Homa Bay	1,474	New	Weir	On-going	LBDA
4.	Lower Kuja Irrigation	Migori	7,800	New	Weir	D/D done	NIB
5.	Nandi Irrigation (Nandi Forest Multi-dam)	Vihiga/Nandi	7,272	New	Multi-dam	D/D on-going	LBDA
6.	Nyando Irrigation (Nyando Multi-dam)	Kericho	3,000	New	Multi-Dam	Proposed	LBDA
7.	South West Kano Irrigation	Kisumu	1,200	Reh	Weir	On-going	NIB
	Total		37,546				
RVCA							
1.	Ainabkoi Kamwosor Irrigation	Elgeyo Marakwet	500	New	Dam	Proposed	KVDA
2.	Arror Irrigation (Arror Multi-dam)	Elgeyo Marakwet	10,000	New+Ext	Multi-dam	F/S done	KVDA
3.	Chebaram-Kimose Irrigation	Baringo	650	New	Dam	Proposed	KVDA
4.	Chesegon Irrigation	Elgeyo Marakwet	500	New	Dam	Proposed	KVDA
5.	Chesongoch Irrigation	Elgeyo Marakwet	1,000	New	Dam	Proposed	KVDA
6.	Embobut Irrigation	Elgeyo Marakwet	2,000	Ext	Multi-dam	Proposed	KVDA
7.	Embolot Irrigation	Elgeyo Marakwet	500	New	Dam	Proposed	KVDA
8.	Embomon Irrigation	Elgeyo Marakwet	800	New	Dam	Proposed	KVDA
9.	Kakuma Irrigation	Turkana	700	New	Dam	Proposed	KVDA
10.	Katilu Irrigation	Turkana	5,060	Reh+Ext	Weir	Proposed	NIB
11.	Kimwarer Irrigation	Baringo	2,000	New	Multi-Dam	Proposed	KVDA
12.	Kipkukutia Irrigation	Baringo	600	New	Dam	Proposed	KVDA
13.	Lomut Irrigation	West Pokot	850	New	Dam	Proposed	KVDA
14.	Lower Ewaso Ng'iro Irrigation (Oletukat/Oldorko Multi-dam)	Kajiado	15,000	New	Multi-dam	F/S on-going	ENSDA
15.	Mogil Kiptunos Irrigation	Elgeyo Marakwet	500	New	Dam	Proposed	KVDA
16.	Muringa Banana Irrigation	Turkana	1,446	New	Weir	Proposed	KVDA
17.	Murung-Sebit Irrigation	West Pokot	850	New	Dam	Proposed	KVDA
18.	Namerit Irrigation	Turkana	2,000	New	Dam	Proposed	KVDA
19.	Nauwia Irrigation	Elgeyo Marakwet	500	New	Dam	Proposed	KVDA
20.	Norera Irrigation	Narok	2,000	New	Dam	F/S on-going	ENSDA
21.	Oke-Kipsaa Dam Irrigation	Baringo	1,080	New	Dam	Proposed	KVDA
22.	Oldekesi Irrigation	Narok	2,000	New	Weir	Proposed	ENSDA
23.	Olkejuado Dry Land Irrigation	Kajiado	3,000	New	Dam	Proposed	ENSDA
24.	Perkera Irrigation Extension	Baringo	3,000	Reh+Ext	Weir/Dam	F/S on-going	NIB
25.	Suswa Flood Mitigation Irrigation	Narok	4,000	New	Weir	Proposed	ENSDA
26.	Todonyang-Omo Irrigation (Gibe 3 Multi-dam in Ethiopia)	Turkana	35,000	New	Multi-dam	Proposed	KVDA
27.	Torok Irrigation	Elgeyo Marakwet	500	New	Dam	Proposed	KVDA
28.	Tunyo Irrigation	Elgeyo Marakwet	500	New	Dam	Proposed	KVDA
29.	Turkwel Irrigation	West Pokot	5,000	New	Dam (E)	F/S done	KVDA
30.	Turkwel & Kerio Valley Irrigation	Elgeyo Marakwet	30,000	New	Weir/Dam	F/S on-going	NIB
	Total		131,536				

Note: *[1]: Reh = Rehabilitation, Ext = Extension; *[2]: Multi = Multipurpose, E = Existing

*[3]: On-going = projects financed for construction, Proposed = projects having no detailed information for evaluation.

Table 6.5.1 Large Scale Irrigation Projects Proposed by Government Authorities and This Study (2/3)

a) Projects Proposed by Government Authorities (contd.)

No	Name of Project	County	Irrigation Area (ha)	Type of Project*[1]	Water Source Facility*[2]	Project Status as of Oct. 2012*[3]	Executing Agency
ACA							
1.	Burangi Irrigation	Kilifi	1,200	New	Weir	Proposed	CDA
2.	Ilchilal Irrigation	Kajiado	600	Ext	Weir	Proposed	ENSDA
3.	Kanzal Irrigation Extension	Makueni	3,500	Ext	Weir	Proposed	NIB
4.	Kavunyalalo Irrigation	Kilifi	8,240	New	Weir	F/S on-going	NIB
5.	Kayatta Irrigation Extension	Machakos	3,500	Ext	Weir	Proposed	NIB
6.	Kibwezi Irrigation Extension (Munyu Multi-dam)	Makueni	15,000	Ext	Multi-Dam	Proposed	TARDA
7.	Kibwezi Irrigation Extension (Munyu Multi-dam)	Makueni	15,000	Ext	Multi-Dam	Proposed	TARDA
8.	Kibwezi Greater Irrigation Extension (Thwake Multi-dam)	Makueni	42,000	Ext	Multi-Dam	Proposed	NIB
9.	Mt. Kilimanjaro Irrigation	Kajiado	1,500	Reh+Ext	Springs	Proposed	ENSDA
10.	Olkishunki Irrigation	Kajiado	2,000	New	Multi-Dam	Proposed	ENSDA
11.	Raare Irrigation	Kilifi	700	New	Dam	F/S on-going	CDA
12.	Rwabura Irrigation Extension	Kiambu	4,360	Ext	Weir/Dam	D/D on-going	NIB
13.	Sabaki Irrigation Extension	Kilifi	3,000	Ext	Weir	F/S on-going	NIB
14.	Sabaki Umba River Basins Integrated Irrigation	Kilifi, Kwale	80,000	New	Weir/Dam	F/S on-going	CDA
15.	Taita Taveta Irrigation	Taita Taveta	3,780	Reh+Ext	Weir	F/S on-going	TARDA
	Total		184,380				
TCA							
1.	Bura Pump Irrigation Extension	Tana river	800	Ext	Weir	On-going	NIB
2.	Bura West Irrigation Extension	Tana river	5,500	Reh+Ext	Weir	D/D done	NIB
3.	High Grand Falls Irrigation (High Grand Falls Multi-dam)	Garissa/ Tana River	106,000	New	Multi-dam	F/S done	TARDA/ NIB
4.	Hola Pump Irrigation Extension	Tana River	800	Ext	Pump	On-going	NIB
5.	Hola Irrigation Greater Extension	Tana River	3,500	Reh+Ext	Weir	D/D on-going	NIB
6.	Kaggari-Gaturi-Keini Irrigation	Embu	6,600	Ext	Dam	D/D done	NIB
7.	Kanzalu Irrigation	Machakos	4,055	New	Weir/Dam	Proposed	TARDA
8.	Kiambere Irrigation	Embu	10,000	Ext	Weir/Dam	F/S on-going	TARDA
9.	Kunati Irrigation	Meru	1,050	New	Weir	Proposed	NIB
10.	Masinga Irrigation	Machakos	10,000	New+Ext	Weir/Dam	F/S on-going	TARDA
11.	Mitunguu Irrigation Extension	Meru	10,000	Reh+Ext	Weir/Dam	F/S done	NIB
12.	Mwea Irrigation Extension (Thiba Dam)	Kirinyaga	9,485	Ext	Weir/Dam	On-going	NIB
13.	Tana Delta Irrigated Sugar	Tana River	20,000	New	Weir	D/D done	TARDA
14.	Tana Delta Irrigation Extension (Rice)	Tana River	10,000	Reh+Ext	Weir	D/D done	TARDA
15.	Thanantu Irrigation	Meru	2,500	New	Weir/Dam	Proposed	TARDA
	Total		200,290				
ENNCA							
1.	Kieni Irrigation	Nyeri	3,500	New	Weir	F/S on-going	NIB
2.	Kom (Wajir) Irrigation (Archer's Post Multi-dam)	Isiolo/Samburu	2,146	New	Multi-dam	F/S on-going	ENNDA
3.	Lorian Swamp Cotton Irrigation	Wajir	1,800	New	Weir/Dam	F/S on-going	ENNDA
	Total		7,446				

Note: *[1]: Reh = Rehabilitation, Ext = Extension; *[2]: Multi = Multipurpose, E = Existing

*[3]: On-going = projects financed for construction, Proposed = projects having no detailed information for evaluation.

Source: Information from government authorities

Table 6.5.1 Large Scale Irrigation Projects Proposed by Government Authorities and This Study (3/3)

b) Projects Proposed in This Study

No	Name of Project	County	Irrigation Area (ha)	Type of Project*[1]	Water Source Facility*[2]	Project Status as of Oct. 2012*[3]	Executing Agency
LVNCA							
1.	Upper Nzoia Irrigation (Nzoia 34B Multi-dam)	Bungoma	24,000	New	Multi-dam	Proposed	
2.	Moi's Bridge Irrigation (Moi's Bridge Multi-dam)	Bungoma	19,800	New	Multi-dam	Proposed	
3.	Kibolo Irrigation (Kibolo Multi-dam)	Kakamega	11,500	New	Multi-dam	Proposed	
	Total		55,300				
LVSCA							
1.	Lower Kuja Irrigation (Stage-2) (Katieno Multi-dam)	Migori	32,700	New	Multi-dam	Proposed	
2.	Amala Irrigation (Amala Multi-dam)	Bomet	5,000	New	Multi-dam	Proposed	
3.	Ilooiterre Irrigation (Ilooiterre Multi-dam)	Narok	3,000	New	Multi-dam	Proposed	
	Total		40,700				
TCA							
1.	Kora Irrigation (Kora Multi-dam)	Tana river	25,000	New	Multi-dam	Proposed	
	Total		25,000				
ENNCA							
1.	Kihoto Irrigation (Kihoto Multi-dam)	Laikipia	18,000	New	Multi-dam	Proposed	
	Total		18,000				

Source: JICA Study Team based on Information from government authorities

Table 6.8.1 Number of Target, Operational and Proposed Monitoring Stations of WRMA

a) Surface Water Level

Catchment Area	Target	Operational	% of Operational	Proposed Number in NWMP 2030	Difference between Target and Proposed
LVNCA	28	21	75%	24	-4
LVSCA	38	30	79%	23	-15
RVCA	41	25	61%	23	-18
ACA	31	18	58%	26	-5
TCA	45	28	62%	26	-19
ENNCA	40	24	60%	13	-27
Total	223	146	65%	135	-88

b) Surface Water Quality

Catchment Area	Target	Operational	% of Operational	Proposed Number in NWMP 2030	Difference between Target and Proposed
LVNCA	24	24	100%	24	0
LVSCA	61	47	77%	23	-38
RVCA	20	18	90%	23	3
ACA	31	26	84%	26	-5
TCA	45	18	40%	26	-19
ENNCA	40	24	60%	13	-27
Total	221	157	71%	135	-86

c) Groundwater Level

Catchment Area	Target	Operational	% of Operational	Proposed Number in NWMP 2030	Difference between Target and Proposed
LVNCA	13	9	69%	19	6
LVSCA	30	15	50%	19	-11
RVCA	37	24	65%	10	-27
ACA	71	25	35%	24	-47
TCA	41	14	34%	18	-23
ENNCA	10	5	50%	5	-5
Total	202	92	46%	95	-107

d) Groundwater Quality

Catchment Area	Target	Operational	% of Operational	Proposed Number in NWMP 2030	Difference between Target and Proposed
LVNCA	11	10	91%	19	8
LVSCA	17	13	76%	19	2
RVCA	8	8	100%	10	2
ACA	18	18	100%	24	6
TCA	41	14	34%	18	-23
ENNCA	10	3	30%	5	-5
Total	105	66	63%	95	-10

e) Rainfall

Catchment Area	Target	Operational	% of Operational	Proposed Number in NWMP 2030	Difference between Target and Proposed
LVNCA	65	52	80%	42	-23
LVSCA	65	53	82%	50	-15
RVCA	60	45	75%	47	-13
ACA	50	33	66%	38	-12
TCA	35	25	71%	47	12
ENNCA	26	8	31%	34	8
Total	301	216	72%	258	-43

Source: WRMA Performance Report No. 1 (July 2010), JICA Study Team

Table 7.2.1 Satisfiable Water Demands in 2030

a) Present Water Demand

(Unit: MCM/year)

Catchment Area	2010						
	Domestic	Industrial	Irrigation	Livestock	Wildlife	Fisheries	Total
LVNCA	169	6	18	26	0	9	228
LVSCA	165	10	155	43	3	9	385
RVCA	129	10	143	70	1	4	357
ACA	519	93	498	25	3	7	1,145
TCA	146	5	696	34	1	9	891
ENNCA	58	1	92	57	0	4	212
Total	1,186	125	1,602	255	8	42	3,218

b) Future Water Demand before Water Balance Study

(Unit: MCM/year)

Catchment Area	2030						
	Domestic	Industrial	Irrigation	Livestock	Wildlife	Fisheries	Total
LVNCA	424	19	817	61	0	16	1,337
LVSCA	464	41	2,324	106	3	15	2,953
RVCA	264	23	1,075	123	1	8	1,494
ACA	941	153	3,418	59	3	12	4,586
TCA	343	42	7,770	69	1	16	8,241
ENNCA	125	2	2,644	79	0	7	2,857
Total	2,561	280	18,048	497	8	74	21,468

c) Satisfiable Future Water Demand after Water Balance Study

(Unit: MCM/year)

Catchment Area	2030						
	Domestic	Industrial	Irrigation	Livestock	Wildlife	Fisheries	Total
LVNCA	424	19	1,359	61	0	16	1,879
LVSCA	464	41	1,158	106	3	15	1,787
RVCA	264	23	1,393	123	1	8	1,812
ACA	941	153	917	59	3	12	2,085
TCA	343	42	2,697	69	1	16	3,168
ENNCA	125	2	539	79	0	7	752
Total	2,561	280	8,063	497	8	74	11,483

Note: Future water demand includes present water demand.
Source: JICA Study Team

Table 7.3.1 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 7.3.2 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 7.3.3 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 7.4.1 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 7.4.2 Users and Required Units of On-Site Sanitation 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 7.5.1 Possible Irrigation Area by Catchment Area in 2030

(Unit: ha)

Category	Existing Irrigation Area in 2010	New Irrigation Area in 2030						Total Irrigation Area in 2030
		Surface Water Irrigation			Ground water Irrigation	Water Harvesting Irrigation*2	Total New Irrigation Area	
		Weir*1	Dam	Total				
LVNCA								
Large Scale Irrigation	363	12,600	65,770	78,370	0	0	78,370	78,733
Small Scale Irrigation	1,327	41,638	0	41,638	1,784	3,700	47,122	48,449
Private Irrigation	186	41,637	0	41,637	1,784	0	43,421	43,607
Total	1,876	95,875	65,770	161,645	3,568	3,700	168,913	170,789
LVSCA								
Large Scale Irrigation	1,800	1,800	73,772	75,572	0	0	75,572	77,372
Small Scale Irrigation	10,225	14,477	0	14,477	3,434	4,590	22,501	32,726
Private Irrigation	1,193	11,700	0	11,700	3,433	0	15,133	16,326
Total	13,218	27,977	73,772	101,749	6,867	4,590	113,206	126,424
RVCA*3								
Large Scale Irrigation	774	7,000	71,850	78,850	0	0	78,850	79,624
Small Scale Irrigation	5,791	5,335	0	5,335	1,046	2,890	9,271	15,062
Private Irrigation	3,022	3,000	0	3,000	1,045	0	4,045	7,067
Total	9,587	15,335	71,850	87,185	2,091	2,890	92,166	101,753
ACA*4								
Large Scale Irrigation	0	5,280	32,000	37,280	0	0	37,280	37,280
Small Scale Irrigation	13,524	35	0	35	2,309	4,140	6,484	20,008
Private Irrigation	31,374	35	0	35	2,309	0	2,344	33,718
Total	44,898	5,350	32,000	37,350	4,618	4,140	46,108	91,006
TCA								
Large Scale Irrigation	11,200	4,961	131,000	135,961	0	0	135,961	147,161
Small Scale Irrigation	14,823	0	0	0	10,054	5,730	15,784	30,607
Private Irrigation	38,402	0	0	0	10,054	0	10,054	48,456
Total	64,425	4,961	131,000	135,961	20,108	5,730	161,799	226,224
ENNCA								
Large Scale Irrigation	0	4,202	22,000	26,202	0	0	26,202	26,202
Small Scale Irrigation	6,233	0	0	0	7,166	950	8,116	14,349
Private Irrigation	1,663	0	0	0	7,165	0	7,165	8,828
Total	7,896	4,202	22,000	26,202	14,331	950	41,483	49,379
TOTAL								
Large Scale Irrigation	14,137	35,843	396,392	432,235	0	0	432,235	446,372
Small Scale Irrigation	51,923	61,485	0	61,485	25,793	22,000	109,278	161,201
Private Irrigation	75,840	56,372	0	56,372	25,790	0	82,162	158,002
Grand Total	141,900	153,700	396,392	550,092	51,583	22,000	623,675	765,575

Note: *1 = including weir irrigation, pump irrigation and spring irrigation.
*2 = by small dam and water pan
*3 = including the Todonyang-Omo irrigation project (35,000 ha) to be supplied water by a dam in Ethiopia.
*4 = including existing irrigation areas (11,339 ha) and proposed irrigation areas (5,280 ha) to be supplied water from the outside of the Athi river basin.

Source: JICA Study Team

Table 7.5.2 Large Scale Irrigation Projects Selected (1/2)

No	Name of Project	County	Sub-basin Code	Irrigation Area (ha)	Project Type*[1]	Water Source Facilities*[2]		Present Status*[3] (Oct. 2012)	Estimated Cost*[4] (KSh mil.)	Executing Agency
						Type	Name of Dam			
LVNCA										
1.	Kibolo Irrigation	Kakamega	1CE	11,500	New	Dam	Kibolo	Proposed	6,435	LBDA
2.	Lower Nzoia Irrigation	Busia & Siaya	1EF	10,470	New	Weir/M-dam	Nzoia 42A	D/D done	6,334	NIB
3.	Lower Sio Irrigation	Busia	1AH	6,600	New	Weir	-	D/D done	5,566	NIB
4.	Moi's Bridge Irrigation	Bungoma	1BE	19,800	New	Multi-dam	Moi's Bridge	Proposed	13,585	LBDA
5.	Upper Nzoia Irrigation	Bungoma	1BG	24,000	New	Multi-dam	Nzoia 34B	Proposed	13,728	NIB
6.	Yala Swamp Drainage & Irrigation	Siaya	1FG	4,600	New	Weir	-	F/S done	2,317	LBDA
	Weir Irrigation under construction			1,400	Reh+Ext	Weir	-	On-going	560	
Total				78,370					48,525	
LVSCA										
1.	Ahero and West Kano Irrigation	Kisumu	1HD	1,800	Reh+Ext	Weir	-	F/S done	871	NIB
2.	Amala Irrigation	Bomet	1LB1	5,000	New	Multi-dam	Amala	Proposed	2,860	LBDA
3.	Ilooiterre Irrigation	Narok	1KC	3,000	New	Multi-dam	Ilooiterre	Proposed	1,716	LBDA
4.	Kano Plain Irrigation	Nyamira/Kisumu	1JG1	15,000	New	Multi-dam	Magwagwa	D/D on-going	14,300	LBDA
5.	Lower Kuja Irrigation (Stage-1)	Migori	1KB	7,800	New	Weir	-	D/D done	6,578	NIB
6.	Lower Kuja Irrigation (Stage-2)	Migori	1KB	32,700	New	Multi-dam	Katieno	Proposed	17,160	NIB
7.	Nandi Forest Irrigation	Nyando/Kisumu	1HA2	7,272	New	Multi-dam	Nandi Forest	F/S done	15,730	LBDA
8.	Nyando Irrigation	Kericho	1GD	3,000	New	Multi-dam	Nyando	Proposed	1,716	LBDA
Total				75,572					60,931	
RVCA										
1.	Arror Irrigation	Elgeyo Marakwet	2CC	10,850	New+Ext	Multi-dam	Arror	F/S done	7,865	KVDA
2.	Embobut Irrigation	Elgeyo Marakwet	2BB	2,000	Ext	Dam	Embobut	Proposed	1,001	KVDA
3.	Kimwarer Irrigation	Baringo	2CB	2,000	New	Multi-dam	Kimwarer	Proposed	1,144	KVDA
4.	Lower Ewaso Ng'iro Irrigation	Kajiado	2KB	15,000	New	Multi-dam	Oletukat	F/S on-going	8,580	NIB/ENSDA
5.	Norera Irrigation	Narok	2KA	2,000	New	Dam	Upper Narok	F/S on-going	1,144	ENSDA
6.	Oldekesi Irrigation	Narok	3KA	2,000	New	Weir	-	Proposed	1,373	ENSDA
7.	Perkera Irrigation Extension	Baringo	2EE	3,000	Reh+Ext	Weir/Dam	Perkera (E)	F/S on-going	2,217	NIB
8.	Todonyang-Omo Irrigation	Turkana	2AB	35,000	New	Multi-dam	Gibe 3 in Ethiopia	Proposed	24,310	KVDA
9.	Turkwel Irrigation	West Pokot	2BD	5,000	New	Dam (E)	Turkwel (E)	F/S done	3,575	KVDA
	Weir Irrigation under construction			2,000	Reh+Ext	Weir	-	On-going	800	KVDA
Total				78,850					52,009	

Table 7.5.2 Large Scale Irrigation Projects Selected (2/2)

No	Name of Project	County	Sub-basin Code	Irrigation Area (ha)	Project Type*[1]	Water Source Facilities*[2]		Present Status*[3] (Oct. 2012)	Estimated Cost*[4] (KSh mil.)	Executing Agency
						Type	Name of Dam			
ACA										
1.	Kanzalu Irrigation Extension	Makueni	3DA	15,000	Ext	Multi-dam	Munyu	Proposed	6,050	NIB
2.	Kibwezi Irrigation Extension	Makueni	3FA	17,000	New+Ext	Multi-dam	Thwake	Proposed	6,800	NIB/TARDA
3.	Mt. Kilimanjaro Irrigation	Kajiado	3G	1,500	Reh+Ext	Spring	-	Proposed	484	ENSDA
4.	Taita Taveta Irrigation	Taita Taveta	3J	3,780	Reh+Ext	Weir	-	F/S on-going	1,815	TARDA
Total				37,280					15,149	
TCA										
1.	High Grand Falls Irrigation	Garissa/Tana River	4EB	106,000	New	Multi-dam	High Grand Falls	F/S done	242,000	TARDA
2.	Hola Irrigation Expansion	Tana River	4GF	800	Reh+Ext	Pump	-	On-going	402	NIB
3.	Hola Irrigation Greater Extension	Tana River	4GF	4,161	Reh+Ext	Weir	-	F/S on-going	3,146	NIB
4.	Kora Irrigation	Tana River	4GB	25,000	New	Dam	Kora	Proposed	12,870	TARDA
Total				135,961					258,418	
ENNCA										
1.	Kieni Irrigation	Nyeri	5BC	4,202	New	Weir	-	F/S on-going	2,200	NIB
2.	Kihoto Irrigation	Laikipia	5BC	18,000	New	Multi-dam	Kihoto	Proposed	7,700	ENNDA
3.	Kom (Wajir) Irrigation	Isiolo/Samburu	5DA	4,000	New	Multi-dam	Archer's Post	F/S on-going	2,000	ENNDA
Total				26,202					11,900	
Grand Total				432,235					446,932	

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

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

Table 7.7.1 Proposed Dams

Catch-ment Area		Name of Dam	Sub-basin	Relevant County	Purpose [1]	Effective Storage (MCM)	Yield (m^3/s)	Study Stage [2]	Estimated Cost (KSh million)
LVNCA	1	Siyoi	1BC	Trans-Nzoia, West Pokot	W (Kapenguria)	4.1	4.7	D/D to be completed in 2013	2,898
	2	Moi's Bridge	1BE	Trans-Nzoia	W (Moi's Bridge, Matunda), I (19,800 ha)	214.0	11.4	NWMP 2030	5,114
	3	Nzoia (34B)	1BG	Bungoma,	I (24,000 ha), P (16 MW), F	203.7	33.4	D/D to be completed in 2013	4,006
	4	Kibolo	1CE	Uasin Gishu	W (Lumakanda), I (11,500 ha)	40.0	21.7	NWMP 2030	5,455
	5	Teremi	1DB	Bungoma	W (Kimilili, Bungoma, Chwele)	3.0	36.2	NWMP 2030	3,580
	6	Nzoia (42A)	1EE	Siaya	I (10,470 ha), P (25 MW), F	395.0	93.1	D/D to be completed in 2013	8,694
	7	Nandi Forest	1FD	Nandi	W (Yala, Kisumu in LVSCA), I (7,272 ha in LVSCA), P (50 MW)	220.0	74.1	D/D completed	17,474
	Total					1,079.8	274.7		47,221
LVSCA	8	Londiani	1GC	Kericho	W (Londiani, Kipkerion and RVCA)	25.0	2.6	Pre-F/S done in 2012	6,137
	9	Nyando (Koru)	1GD1	Kisumu, Kericho	W (Muhoroni, Awasi, Ahero, Kisumu), I (3,000 ha), F	86.6	4.6	Preliminary Design ongoing	19,179
	10	Kibos	1HA	Nandi	W (Kisumu), F	26.0	1.0	NWMP 2030	8,950
	11	Itare	1JA	Nakuru	W (Litein and RVCA)	20.0	0.0	NWMP 2030	5,114
	12	Magwagwa	1JG	Bomet, Nyamira	W, I (15,000 ha), P (115 MW), F	445.0	20.2	D/D completed	20,202
	13	Bunyunyu	1KB	Kisii	W (Rongo, Tabaka, Suneka, Kisii, Awendo, Ogembo, Keroko)	6.3	0.1	Final Design completed	2,046
	14	Katieno	1KB	Migori	I (40,500ha)	201.0	21.5	Pre-F/S done	5,455
	15	Ilooiterre	1KC	Narok	W, I (3,000 ha)	13.6	2.6	Proposed by ENSDA	1,449
	16	Sand River (Naikara)	1LA3	Narok	W, F	20.0	0.1	NWMP 2030	5,711
	17	Amala	1LB1	Bomet, Narok	W, I (5,000 ha and RVCA)	175.0	4.8	NWMP 2030	20,031
	Total					1,018.5	57.5		94,274
RVCA	18	Murung-Sebit	2BB	West Pokot	I (850 ha), F	40.0	10.1	Proposed by KVDA	6,819
	19	Kimwarer	2CB	Elgiyo Marakwet	W, I (2,000 ha), P (20 MW)	107.0	4.3	Pre-F/S done	13,638
	20	Arror	2CC	Elgiyo Marakwet	W, I (10,850 ha), P (80 MW), F	62.0	3.0	D/D completed	11,422
	21	Embobut	2CC	West Pokot	W, I (2,000 ha), P (45 MW)	30.0	10.1	Pre-F/S done	3,239
	22	Waseges	2EB	Baringo	W	4.0	0.2	NWMP 2030	3,239
	23	Malewa	2GB	Nyandarua	W (Naivasha)	34.0	1.4	NWMP 2030	4,262
	24	Upper Narok	2KA	Narok	W (Narok), I (2,000 ha), F	29.0	2.2	NWMP 2030	5,967
	25	Oletukat	2KA	Narok	W, P (36 MW)	300.0	4.7	F/S, D/D to be completed in 2013	38,784
	26	Leshota	2KB	Narok	W, P (54 MW)	33.0	1.6	F/S, D/D to be completed in 2013	7,842
	27	Oldorko	2KB	Narok	W, I (15,000 ha with Oletukat Dam), P (90 MW)	20.0	6.4	F/S, D/D to be completed in 2013	2,898
	Total					659.0			98,110
ACA	28	Upper Athi	3AA	Machakos	W (Nairobi)	24.0	0.2	NWMP 2030	2,813
	29	Stony Athi	3AB	Machakos	W (Nairobi)	23.0	0.2	F/S and M/P ongoing	4,006
	30	Kikuyu	3BA	Nairobi	W (Nairobi)	31.0	1.3	NWMP 2030	4,092
	31	Ruaka (Kiambaa)	3BA	Nairobi	W (Nairobi)	4.0	0.9	D/D completed	1,961
	32	Kamiti 1	3BB	Kiambu	W (Nairobi)	16.0	0.1	F/S and M/P ongoing	6,308
	33	Ruiru-A (Ruiru 2)	3BC	Kiambu	W (Nairobi)	18.0	0.9	NWMP 2030	6,990
	34	Ndarugu	3CB	Kiambu	W (Nairobi)	300.0	0.3	F/S and M/P ongoing	5,029
	35	Munyu	3DA	Machakos	I (15,000 ha), P (40 MW)	575.0	8.8	F/S done	10,229
	36	Mbuuni	3EA	Machakos	W (Machakos, Kangundo Tala)	10.0	0.4	NWMP 2030	2,557
	37	Kiteta	3EB	Makueni	W	16.0	0.2	Pre-F/S done	2,983
	38	Thwake	3FA	Makueni, Kitui	W, I (17,000 ha), P (20 MW)	594.0	29.5	Final Design completed	8,439
	39	Olkishunki	3FA	Kajiado	W	1.2	0.1	Proposed by ENSDA	1,364
	40	Pemba	3HC	Kwale	W (Kwale)	19.0	0.5	NWMP 2030	5,455
	41	Lake Chala	3J	Taita Taveta	W (Taveta), F	6.0	0.0	D/D ongoing	1,534
	42	Rare	3LA	Kilifi	W (Mombasa)	36.0	0.1	D/D to be completed in 2013	3,580
	43	Mwachi	3MA	Kwale	W (Mombasa, Mtwapa)	16.0	0.2	Preliminary Design completed	4,262
	Total					1,689.2	43.6		71,602
TCA	44	Maragua 4	4BE	Muranga	W (Nairobi in ACA)	33.0	3.1	F/S and M/P ongoing	6,990
	45	Ndiara	4CA	Kiambu	W (Nairobi in ACA)	12.0	2.5	NWMP 2030	6,990
	46	Chania-B	4CA	Kiambu	W (Nairobi in ACA)	49.0	0.0	NWMP 2030	14,065
	47	Karimenu 2	4CA	Kiambu	W (Nairobi in ACA)	14.0	8.4	F/S and M/P ongoing	3,665
	48	Thika 3A	4CC	Kiambu	W (Nairobi in ACA)	13.0	2.3	F/S and M/P ongoing	3,239
	49	Yatta	4CC	Kiambu,	W (Matuu)	35.0	0.7	D/D completed	1,364
	50	Thiba	4DA	Kirinyaga, Embu	I (9,485 ha)	11.2	4.5	D/D completed	7,416
	51	High Grand Falls	4FB	Kitui, Tharaka	W (Garissa, Madogo, Hola, Masalani, Lamu), I (106,000 ha), P (700 MW), F	5,000.0	81.5	D/D completed	89,161
	52	Kora	4GA	Tana River, Isiolo	I (25,000 ha)	537.0	165.5	NWMP 2030	13,127
	53	Mutuni	4HA	Kitui	W (Kitui)	17.0	0.4	NWMP 2030	3,239
	54	Kitimui	4HA	Kitui, Machakos	W (Kitui)	8.0	0.3	NWMP 2030	4,859
	Total					5,729.2	269.3		154,115
ENNCA	55	Nyahururu	5AA	Nyandarua	W (Nyahururu, Rumuruti)	11.0	0.4	NWMP 2030	852
	56	Rumuruti	5AA	Laikipia	W (Rumuruti)	1.0	0.3	NWMP 2030	938
	57	Kihoto	5BC	Laikipia	I (18,000 ha)	389.0	16.4	NWMP 2030	13,894
	58	Isiolo	5DA	Isiolo	W (Isiolo)	21.0	0.0	F/S ongoing	2,642
	59	Archers' Post	5DA	Isiolo, Samburu	W, I (4,000 ha)	100.0	36.2	NWMP 2030	17,900
	Total					522.0	53.2		36,226
	Grand Total					10,697.7	698.3		501,548

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 data from MWI, NWCPC, NIB, MORDA, RDAs, WSBs

Table 7.7.2 Proposed Water Transfer Facilities

Catchment Area	Water Transfer Scheme		Relevant County	Purpose	Capacity, Dimensions	Estimated Cost (KSh million)	Data Sources
LVNCA	1	Moiben Dam to Eldoret/Iten (Expansion)	Elgiyo Marakwet, Uasin Gishu	W	Capacity of 10 MCM/year, Pipeline of 600 mm dia, 60 km long	3,069	NWMP 2030
	2	Nandi Forest Dam to LVSCA	Nandi, Kisumu	W, I, P	Capacity of 173 MCM/year	(Included in dam cost)	MORDA
	Total					3,069	
LVSCA	3	Itare and Londiani Dams to RVCA	Nakuru	W	Capacity of 41 MCM/year, Tunnel of 14.5 km long, Pipeline of 120 km long	25,742	RVWSB
	4	Amala Transfer from Amala Dam to RVCA	Narok	W, I, P	Capacity of 82 MCM/year, Tunnel of 3.8 km long	2,301	ENSDA
	Total					28,043	
ACA	5	Second Mzima Pipeline from Mzima Springs to Mombasa (Expansion)	Taita Taveta, Kwale	W	Capacity of 100,000 m^3/day (37 MCM/year), Pipeline	35,289	CWSB
	6	Sabaki Scheme (Expansion)	Kilifi	W	Capacity of 85,000 m^3/day (31 MCM/year), Pipeline	15,002	CWSB
	Total					50,291	
TCA	7	TCA to Nairobi in ACA (Expansion)	Muranga, Kiambu, Nairobi	W	Capacity of 168 MCM/year, Tunnels and pipelines	74,244	AWSB
	8	Tana River (High Grand Falls Dam) to Lamu Port	Garissa, Lamu	W	Capacity of 69 MCM/year, Pipeline	26,936	CWSB
	9	Masinga Dam to Kitui (Expansion)	Machakos, Kitui	W	Capacity of 23 MCM/year, Pipeline of 300 mm dia, 70 km long	1,790	NWMP 2030
	10	Kiambere Dam to Mwingi (Expansion)	Kitui	W	Capacity of 2 MCM/year, Pipeline of 300 mm dia, 30 km long	767	NWMP 2030
	Total					103,737	
Grand Total						185,140	

Note: W=Domestic and industrial water supply, I=Irrigation, P=Hydropower
Source: JICA Study Team based on the data collected from MORDA, RDAs and WSBs.

Table 7.7.3 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 7.7.4 Naturalised Surface Water, Reserve, Water Demand, Yield and Water Supply Reliability at Reference Points

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
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
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
ACA	3DB01	Athi (Middle)	6,813	8.1	8.6	13.1	0.1	23.3	0.1	10.2	1/2	1/5
	3HA12	Athi (Lower)	25,203	8.7	8.9	19.1	0.1	38.5	0.1	19.4	1/1	1/10
TCA	4BE10	Tana (Upper)	3,915	13.4	13.5	5	0.1	6.7	0.5	2.1	1/1	1/10
	4CC03	Thika	1,321	8.5	8.5	1.5	0.7	1.6	1.0	0.5	1/7	1/10
	4G01	Tana (Lower)	32,892	53.2	53.5	30.7	0.1	148.7	10.3	128.2	1/2	1/5
ENNCA	5ED01	Ewaso Ng'iro North	14,300	1.5	1.6	3.2	1.7	24.4	5.5	25.0	1/1	1/5

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 8.3.1 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 is 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 is counted as service population.

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

Table 8.3.2 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 8.3.3 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 8.4.1 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 8.4.2 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 8.7.1 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 9.3.1 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 Nakuru								
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 is 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 is counted as service population.

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

Table 9.3.2 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 9.3.3 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 9.4.1 Proposed Sewerage Development Plan (RVCA)

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	Nakuru	1,155,789	88,071	16,200	0	16,200	71,871	0
2	Naivasha	851,433	64,879	933	0	933	63,946	0
3	Ol Kalou	332,309	25,322	0	0	0	0	25,322
4	Molo	204,630	15,593	1,260	0	1,260	14,333	0
5	Narok	194,573	14,826	0	0	0	0	14,826
6	Gilgil	177,659	13,538	0	0	0	0	13,538
7	Njoro	118,552	9,034	0	0	0	0	9,034
8	Eldama Ravine	89,965	6,855	0	0	0	0	6,855
9	Kabarnet	31,236	2,380	0	0	0	0	2,380
	Total	3,156,144	240,498	18,393	0	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 9.4.2 Users and Required Units of On-Site Sanitation Facilities (RVCA)

Counties	Users in 2010	Users in 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 9.7.1 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 10.3.1 Proposed Water Supply Development Plan for UWSS (ACA)

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 Nairobi								
1	Nairobi	6,085,297	888,453					
2	Ruiru	896,358	106,667					
3	Kikuyu	875,242	104,154					
4	Kangundo-Tala	820,175	97,601					
5	Mavoko	514,909	61,274					
6	Thika	513,806	61,143					
7	Karuri	404,224	48,103					
8	Ngong	402,242	47,867	570,263	33,420	603,683	961,207	0
9	Kiambu	315,807	37,581					
10	Limuru	298,455	35,516					
11	Kitengela	218,282	25,976					
12	Juja	151,781	18,062					
13	Ongata Rongai	150,775	17,942					
14	Kiserian	71,913	8,558					
15	Githunguri	50,374	5,994					
16	Machakos	755,281	89,878	3,373	0	3,373	86,505	0
	sub-total	12,524,922	1,654,769	573,636	33,420	607,056	1,047,713	0
Mombasa Area								
1	Mombasa	2,644,591	386,110					
2	Malindi	443,811	52,814					
3	Ukunda	234,651	27,924					
4	Kilifi	183,228	21,804					
5	Mtwapa	182,474	21,714	86,620	0	86,620	449,919	0
6	Mariakani	90,271	10,742					
7	Kwale	74,303	8,842					
8	Watamu	37,639	4,479					
9	Masambweni	17,731	2,110					
	sub-total	3,908,701	536,539	86,620	0	86,620	449,919	0
Other Area								
1	Wundanyi	185,136	22,031	1,400	0	1,400	30,906	0
2	Voi	86,340	10,274					
3	Taveta	99,997	11,900	0	0	0	0	11,900
4	Kajiado	74,803	8,902	0	1,000	1,000	7,902	0
5	Loitoktok	56,530	6,727	0	0	0	0	6,727
6	Wote	49,709	5,915	225	300	525	5,690	0
7	Mitto Andei	22,753	2,708	2,708	0	2,708	0	0
	sub-total	575,268	68,457	4,333	1,300	5,633	44,498	18,627
	Grand-total	17,008,891	2,259,765	664,589	34,720	699,309	1,542,130	18,627
						1,560,756		

Note: Water demand in Thika, which is in Tana Catchment with 61,143 m^3/day, is satisfied with water supply system of Athi Catchment. The service population of piped water supply (UWSS+LSRWSS) in 2010 is estimated at 5.29 million. The service population for each urban centre in 2010 is not clear. 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 10.3.2 Proposed Water Supply Development Plan for LSRWSS (ACA)

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.	1.23	137,000	37,000	37,000	155,000
Rural Pop.	0.81	62,000			
Total	2.04	209,000			

Note: The service population of piped water supply (UWSS+LSRWSS) in 2010 is estimated at 5.29 million.

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

Table 10.3.3 Proposed Water Supply Development Plan for SSRWSS (ACA)

Counties	Service Population in 2010	Service Population in 2030	Difference (2010-2030)	Required Water Supply Amount in 2030 (m^3/day)
10	1,126,000	2,001,856	875,856	110,102

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

Table 10.4.1 Proposed Sewerage Development Plan (ACA)

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	Nairobi	6,085,297	568,367	152,000	40,000	192,000	376,367	0
2	Mombasa	2,644,591	247,005	17,100	0	17,100	229,905	0
3	Ruiru	896,358	68,302	0	0	0	0	79,868
4	Juja	151,781	11,566	0	0			
5	Kikuyu	875,242	66,693	0	0	0	0	66,693
6	Kangundo-Tala	820,175	62,497	0	0	0	0	62,497
7	Machakos	755,281	57,552	2,000	0	2,000	55,552	0
8	Mavoko	514,909	39,236	12,960	0	12,960	26,276	0
9	Malindi	443,811	33,818	0	0	0	0	33,818
10	Karuri	404,224	30,802	0	0	0	0	30,802
11	Ngong	402,242	30,651	0	0	0	0	36,131
12	Kiserian	71,913	5,480	0	0			
13	Kiambu	315,807	24,064	10,000	0	10,000	14,064	0
14	Limuru	298,455	22,742	10,000	0	10,000	12,742	0
15	Ukunda	234,651	17,880	0	0	0	0	17,880
16	Kitengela	218,282	16,633	0	0	0	0	16,633
17	Wundanyi	185,136	14,107	0	0	0	0	14,107
18	Kilifi	183,228	13,962	0	0	0	0	13,962
19	Mtwapa	182,474	13,905	0	0	0	0	13,905
20	Ongata Rongai	150,775	11,489	0	0	0	0	11,489
21	Taveta	99,997	7,620	0	0	0	0	7,620
22	Mariakani	90,271	6,879	0	0	0	0	6,879
23	Voi	86,340	6,579	0	0	0	0	6,579
24	Kajiado	74,803	5,700	0	0	0	0	5,700
25	Kwale	74,303	5,662	0	0	0	0	5,662
	Total	16,260,348	1,389,193	204,060	40,000	244,060	714,906	430,225

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 10.4.2 Users and Required Units of On-Site Sanitation Facilities (ACA)

Counties	Users in 2010	Users in 2030	Difference (2010-2030)	Required Units of On-site Facilities*
10	6,950,000	4,280,000	-2,670,000	856,000

Note: * 5 users/facilities
Source: JICA Study Team, based on data from Census 2009

Table 10.7.1 Balance between Water Resources and Water Demands in 2030 (ACA)

(Unit: MCM/year)

No.	Sub basin	CA (km²)	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	Desalination	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	Desalination	Groundwater	Balance
1	3AA	724	Kiserian, Ngong, Ongata Rongai, Mavoko, Kiteng	65.0	59.7	5.2	-52.4	12.4							13.4	0.0	13.1	0.0	0.0	0.3	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	79.5	25.5						
2	3AB	1,790		1.6	1.6	0.1	-0.1	0.4							13.8	0.0	13.0	0.0	0.0	0.8	0.0	0.0	2.1	2.1	0.0	0.1	0.1	0.0	0.4	0.4	0.0	18.0	13.4						
3	3AC	843		1.4	1.3	0.1	-0.4	0.4							3.1	0.0	2.7	0.0	0.0	0.4	0.0	0.0	2.0	2.0	0.0	0.0	0.0	0.0	0.2	0.2	0.0	6.8	3.1						
4	3BA	889	Karuri, Nairobi, Kikuyu, Limuru	487.6	399.6	88.0	-447.6	68.2	72.7	300.3	0.0	0.0	37.3	142.0	13.5	0.0	12.7	0.0	0.0	0.8	0.0	0.0	2.7	2.7	0.0	0.0	0.0	0.0	1.4	1.4	0.0	505.2	80.9						
5	3BB	258	Kiambu	19.7	17.3	2.4	-10.6	6.6							7.1	0.0	6.9	0.0	0.0	0.2	0.0	0.0	1.1	1.1	0.0	0.0	0.0	0.0	0.3	0.3	0.0	28.3	13.5	162.4	300.3	27.3	0.0	37.3	142.0
6	3BC	491	Ruiru, Githunguri	48.3	46.2	2.2	-27.2	15.9							13.7	0.0	13.3	0.0	0.0	0.4	0.0	0.0	2.2	2.2	0.0	0.0	0.0	0.0	0.6	0.6	0.0	64.8	29.2						
7	3BD	306	Juja	10.3	9.2	1.1	-5.4	4.5							6.4	0.0	6.2	0.0	0.0	0.3	0.0	0.0	0.9	0.9	0.0	0.0	0.0	0.0	0.6	0.6	0.0	18.3	10.7						
8	3CB	394	Thika	30.3	26.6	3.7	-18.7	13.0							13.6	0.0	11.7	0.0	0.0	1.9	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.6	0.6	0.0	45.5	24.7						
9	3DA	775	Kangundo Tala	40.1	38.2	1.9	-9.7	30.7							131.5	-89.7	39.7	89.7	0.0	2.1	0.0	0.0	1.9	1.9	0.0	0.0	0.0	0.0	0.7	0.7	0.0	174.2	70.3						
11	3DB	822		2.4	2.4	0.0	-1.8	0.4	0.0	0.0	0.0	0.0	2.0	0.0	6.8	0.0	2.0	0.0	0.0	2.3	2.5	0.0	1.3	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.5	2.4	0.0	0.0	3.6	0.0	4.5	0.0
10	3EA	867	Machakos	38.5	33.5	4.9	-36.4	8.8							5.6	0.0	3.8	0.0	0.0	1.7	0.1	0.0	2.0	2.0	0.0	0.0	0.0	0.0	0.9	0.9	0.0	47.0	12.6						
11	3EB	829		3.0	3.0	0.0	-4.3	0.5	33.6	0.0	0.0	0.0	7.6	0.0	5.1	0.0	3.4	0.0	0.0	1.6	0.1	0.0	1.7	1.7	0.0	0.0	0.0	0.0	0.2	0.2	0.0	10.1	3.9	33.6	0.0	13.9	0.0	8.0	0.0
12	3EC	702	Wote	7.6	7.3	0.3	-4.2	1.7							5.0	0.0	3.6	0.0	0.0	1.4	0.1	0.0	1.3	1.3	0.0	0.0	0.0	0.0	0.8	0.8	0.0	14.7	5.2						
13	3ED	545		3.3	3.3	0.1	-3.5	0.3							4.2	0.0	3.1	0.0	0.0	1.1	0.1	0.0	1.1	1.1	0.0	0.0	0.0	0.0	0.1	0.1	0.0	8.7	3.3						
14	3K	3,234	Msambweni, Ukunda	21.4	20.7	0.8	-9.0	7.2							5.1	0.0	2.0	0.0	0.0	3.1	0.0	0.0	5.0	5.0	0.0	0.1	0.1	0.0	0.6	0.6	0.0	32.2	9.2						
15	3LA	7,625	Wundanyi, Voi	21.8	21.1	0.7	-13.8	0.0							61.6	0.0	59.3	0.0	0.0	2.3	0.0	0.0	3.5	3.5	0.0	0.3	0.3	0.0	0.5	0.5	0.0	87.7	59.3						
16	3LB	781	Kilifi, Watamu, Malindi	33.6	30.0	3.6	-29.7	0.0	5.1	76.3	0.0	93.0	105.7	0.0	9.4	0.0	9.1	0.0	0.0	0.2	0.0	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.6	0.6	0.0	43.9	9.1	5.1	76.3	20.5	93.0	105.7	0.0
17	3MC	763	Kwale	4.7	4.5	0.2	-3.4	0.0							0.6	0.0	0.5	0.0	0.0	0.2	0.0	0.0	0.7	0.7	0.0	0.0	0.0	0.0	0.3	0.3	0.0	6.3	0.5						
18	3MD1	1,347	Mtwapa, Mombasa, Mariakani	194.9	158.9	36.0	-211.9	0.3							1.6	0.0	1.3	0.0	0.0	0.3	0.0	0.0	2.1	2.1	0.0	0.1	0.1	0.0	0.4	0.4	0.0	199.1	1.7						
	Reference Point (3DB01)																																						
20	3FA	9,924	Kajiado	25.1	24.3	0.8	-14.5	2.2	12.1	0.0	0.0	0.0	10.8	0.0	234.7	-206.8	12.7	206.8	0.0	3.5	11.7	0.0	9.1	9.1	0.0	0.4	0.4	0.0	0.2	0.2	0.0	269.5	14.9	218.8	0.0	13.2	0.0	22.6	0.0
21	3FB	4,181	Mtito Andei	7.7	7.5	0.2	-2.9	1.4	2.1	0.0	0.0	0.0	4.1	0.0	28.8	0.0	23.9	0.0	0.0	1.5	3.4	0.0	2.4	2.4	0.0	0.2	0.2	0.0	0.4	0.4	0.0	39.4	25.3	2.1	0.0	4.4	0.0	7.5	0.0
22	3G	6,543	Loitoktok	4.9	4.8	0.1	-3.1	0.0	0.0	0.0	0.0	0.0	4.9	0.0	5.2	0.0	3.0	0.0	0.0	0.4	1.7	0.0	3.7	3.7	0.0	0.2	0.2	0.0	0.5	0.5	0.0	14.6	3.0	0.0	0.0	4.9	0.0	6.7	0.0
23	3HA	916		0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	14.8	0.0	13.9	0.0	0.0	0.4	0.5	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.1	0.1	0.0	15.4	13.9	0.0	0.0	0.7	0.0	0.7	0.0
	Reference Point (3HA12)																																						
24	3HB	2,317		1.2	1.1	0.0	-0.4	0.1	0.1	0.0	0.0	0.0	1.0	0.0	24.0	0.0	20.1	0.0	0.0	1.0	2.9	0.0	0.6	0.6	0.0	0.1	0.1	0.0	0.0	0.0	0.0	25.9	20.2	0.1	0.0	1.7	0.0	3.9	0.0
25	3HC	2,979		2.9	2.8	0.1	-1.3	0.0	0.0	0.0	0.0	0.0	2.9	0.0	21.8	0.0	17.6	0.0	0.0	1.3	2.9	0.0	0.9	0.9	0.0	0.1	0.1	0.0	0.1	0.1	0.0	25.8	17.6	0.0	0.0	2.4	0.0	5.8	0.0
26	3HD1	654		0.8	0.7	0.0	-0.3	0.1	0.0	0.0	0.0	0.0	0.7	0.0	12.0	0.0	7.3	0.0	0.0	0.3	4.4	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.1	0.1	0.0	13.1	7.4	0.0	0.0	0.7	0.0	5.1	0.0
27	3HD2	393		0.4	0.4	0.0	-0.2	0.0	0.0	0.0	0.0	0.0	0.4	0.0	7.8	0.0	7.4	0.0	0.0	0.2	0.2	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.2	0.2	0.0	8.5	7.4	0.0	0.0	0.5	0.0	0.6	0.0
28	3J	2,804	Taveta	5.3	5.0	0.2	-4.3	0.0	0.7	0.0	0.0	0.0	4.5	0.0	4.0	0.0	1.7	0.0	0.0	1.0	1.3	0.0	1.1	1.1	0.0	0.1	0.1	0.0	0.4	0.4	0.0	10.9	1.7	0.7	0.0	2.6	0.0	5.8	0.0
29	3MA-1	3,997		1.8	1.7	0.0	-0.7	0.0	0.0	0.0	0.0	0.0	1.8	0.0	29.1	0.0	28.3	0.0	0.0	0.8	0.0	0.0	1.4	1.4	0.0	0.2	0.2	0.0	0.2	0.2	0.0	32.6	28.3	0.0	0.0	2.5	0.0	1.8	0.0
30	3MA-2	2,199		2.3	2.3	0.0	-0.6	0.0	0.0	0.0	0.0	0.0	2.3	0.0	42.2	0.0	41.8	0.0	0.0	0.4	0.0	0.0	1.4	1.4	0.0	0.1	0.1	0.0	0.0	0.0	0.0	46.0	41.8	0.0	0.0	1.9	0.0	2.3	0.0
31	3MB	1,676		3.5	3.5	0.1	-0.8	0.3	0.8	0.0	0.0	0.0	2.4	0.0	2.2	0.0	1.8	0.0	0.0	0.3	0.0	0.0	1.6	1.6	0.0	0.1	0.1	0.0	0.0	0.0	0.0	7.4	2.1	0.8	0.0	2.1	0.0	2.4	0.0
32	3MD2	212		0.5	0.5	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.3	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.1	0.1	0.0	1.3	0.3	0.0	0.0	0.5	0.0	0.5	0.0
33	3N	3,155		2.0	2.0	0.0	-1.2	0.0	0.0	0.0	0.0	0.0	2.0	0.0	4.2	0.0	1.0	0.0	0.0	0.5	2.6	0.0	2.4	2.4	0.0	0.1	0.1	0.0	0.1	0.1	0.0	8.9	1.0	0.0	0.0	3.2	0.0	4.7	0.0
				1094.1	941.2	152.9	-920.3	175.4	127.2	376.6	0.0	93.0	191.0	130.9	752.5	-296.5	388.2	296.5	0.0	33.1	34.6	0.0	59.5	59.5	0.0	2.5	2.5	0.0	11.6	11.6	0.0	1920.2	563.7	423.7	376.6	106.7	93.0	225.6	142.0

Note: Irrigation Demand: Excluding existing irrigation area (11,339 ha, 125MCM/year) to be supplied water from Mt. Kirimanjaro basin in Tanzania and the proposed irrigation area (5,280 ha, 40MCM/year) to be supplied water from outside of the Athi river basin
Groundwater of 3LA is Independent
Greater Nairobi:Upper Athi Dam, Stony Athi Dam,Kikuyu Dam, Ruaka (Kiambaa) Dam, Kamiti 1 Dam, Ruiru-A (Ruiru 2) Dam, Ndarugu Dam
Mombasa Area: Pemba Dam, Lake Chala Dam, Rare Dam, Mwachi Dam
3EA: Mbuuni Dam, 3EB: Kiteta Dam, 3DA: Munyu Dam, 3FA: Olkishunki Dam and Thwake Dam
Water Deficit of 152 MCM/year was estimated for the area of Nairobi and satellite towns by the water balance study applying the new water resources development structures as proposed in "F/S and M/P for Developing New Water Sources for Nairobi and Satellite Towns" studied by AWSB.
This F/S and M/P has been carried out for the specific area on the basis of more detailed studies than those of NWMP2030 including hydrological analyses and studies on possible structures, and results of which as of November 2012 indicated that future water demand will be satisfied by the proposed structures.
Therefore, NWMP2030 proposed the same structures for the targeted demands of the F/S and M/P as those mentioned above, regardless of the water deficit.

Source: JICA Study Team

Table 11.3.1 Proposed Water Supply Development Plan for UWSS (TCA)

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)
Upstream of Tana Catchment								
1	Nyeri	600,803	71,496	27,000	0	27,000	44,496	0
2	Embu	305,362	36,338	12,000	0	12,000	24,338	0
3	Meru	269,949	32,124	4,500	0	4,500	27,624	0
4	Chuka	218,821	26,040	2,700	0	2,700	23,340	0
5	Chogoria	143,036	17,021	600	0	600	16,421	0
6	Maua	86,713	10,319	0	0	0	0	10,319
7	Makuyu	221,524	26,361	0	0	0	0	26,361
8	Muranga	144,849	17,237	4,848	10,000	14,848	2,389	0
9	Maragua	132,762	15,799	0	0	0	0	15,799
10	Wanguru	120,726	14,366	0	0	0	0	14,366
11	Runyenjes	98,401	11,710	0	0	0	0	11,710
12	Kerugoya/Kutus	97,767	11,634	11,634	0	11,634	0	0
13	Sagana	53,112	6,320	2,358	0	2,358	3,962	0
14	Karatina	42,783	5,091	0	0	0	0	5,091
15	Othaya	25,859	3,077	3,077	0	3,077	0	0
	Sub-total	2,562,468	304,934	68,717	10,000	78,717	142,570	83,646
Arid Area								
1	Garissa	143,348	17,058	12,640	0	12,640	4,418	0
2	Madogo	19,308	2,298	0	0	0	0	2,298
3	Msalani	18,371	2,186	0	0	0	0	2,186
4	Hola	17,553	2,089	1,400	0	1,400	689	0
	Sub-total	198,580	23,631	14,040	0	14,040	5,107	4,484
Other Area								
1	Lamu	1,250,000	108,750	3,400	0	3,400	105,350	0
2	Kitui	551,547	65,634	7,750	0	7,750	57,884	0
3	Matuu	255,467	30,401	702	0	702	29,699	0
4	Mwingi	80,390	9,566	1,417	0	1,417	8,149	0
	Sub-total	2,137,404	214,351	13,269	0	13,269	201,082	0
	Total	4,898,453	542,916	96,026	10,000	106,026	348,759	88,130
							436,889	

Note: It is supplied from ACA in THIKA, which is in Tana catchment with 61,143 m^3/day of water demand.

The service population of piped water supply (UWSS+LSRWSS) in 2010 is estimated at 1.95 million. The service population for each urban centre in 2010 is not clear. 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 11.3.2 Proposed Water Supply Development Plan for LSRWSS (TCA)

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.	0.93	111,000	149,000	149,000	24,000
Rural Pop.	0.81	62,000			
Total	1.74	173,000			

Note: The service population of piped water supply (UWSS+LSRWSS) in 2010 is estimated at 1.95 million.

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

Table 11.3.3 Proposed Water Supply Development Plan for SSRWSS (TCA)

Counties	Service Population in 2010	Service Population in 2030	Difference (2010-2030)	Required Water Supply Amount in 2030 (m^3/day)
16	1,287,000	2,717,272	1,439,382	144,913

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

Table 11.4.1 Proposed Sewerage Development Plan (TCA)

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	Lamu	1,250,000	95,250	0	0	0	0	95,250
2	Nyeri	600,803	45,781	8,100	0	8,100	37,681	0
3	Kitui	551,547	42,028	0	0	0	0	42,028
4	Thika	513,806	39,152	20,000	0	20,000	19,152	0
5	Embu	305,362	23,269	682	0	682	22,587	0
6	Meru	269,949	20,570	1,000	0	1,000	19,570	0
7	Matuu	255,467	19,467	0	0	0	0	19,467
8	Makuyu	221,524	16,880	0	0	0	0	16,880
9	Chuka	218,821	16,674	0	0	0	0	16,674
10	Muranga	144,849	11,037	1,561	0	1,561	9,476	0
11	Garissa	143,348	10,923	1,000	0	1,000	9,923	0
12	Chogoria	143,036	10,899	0	0	0	0	10,899
13	Maragua	132,762	10,116	0	0	0	0	10,116
14	Wanguru	120,726	9,199	0	0	0	0	9,199
15	Runyenjes	98,401	7,498	0	0	0	0	7,498
16	Kerugoya/Kutus	97,767	7,450	0	0	0	0	7,450
17	Maua	86,713	6,608	0	0	0	0	6,608
18	Mwingi	80,390	6,126	0	0	0	0	6,126
	Total	5,235,273	398,928	32,343	0	32,343	118,389	248,195

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 11.4.2 Users and Required Units of On-Site Sanitation Facilities (TCA)

Counties	Users in 2010	Users in 2030	Difference (2010-2030)	Required Units of On-site Facilities*
16	4,990,000	5,130,000	140,000	1,026,000

Note: * 5 users/facilities
Source: JICA Study Team, based on data from Census 2009

Table 11.7.1 Balance between Water Resources and Water Demands in 2030 (TCA)

(Unit: MCM/year)

No.	Sub basin	CA (km²)	Major Domestic Demand Centre	Domestic										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	4AA	497		1.7	1.7	0.1	-0.6	1.1	0.0	0.0	0.0	0.6	0.0	7.6	0.0	7.1	0.0	0.0	0.5	0.0	0.0	0.9	0.9	0.0	0.0	0.0	0.0	0.9	0.9	0.0	11.2	8.2	0.0	0.0	2.4	0.6	0.0
2	4AB	672		3.1	2.9	0.2	-0.6	2.2	0.0	0.0	0.3	0.6	0.0	7.2	0.0	6.5	0.0	0.0	0.7	0.0	0.0	1.3	1.3	0.0	0.0	0.0	0.0	0.9	0.9	0.0	12.5	8.7	0.0	0.0	3.2	0.6	0.0
3	4AC	417	Nyeri	34.2	29.9	4.2	-0.4	28.4	0.0	0.0	5.4	0.4	0.0	5.8	0.0	5.4	0.0	0.0	0.4	0.0	0.0	1.1	1.1	0.0	0.0	0.0	0.0	0.5	0.5	0.0	41.6	33.7	0.0	0.0	7.4	0.4	0.0
4	4AD	457	Othaya	6.4	5.9	0.6	-0.5	5.1	0.0	0.0	0.9	0.5	0.0	11.3	0.0	10.9	0.0	0.0	0.5	0.0	0.0	1.3	1.3	0.0	0.0	0.0	0.0	0.5	0.5	0.0	19.6	16.0	0.0	0.0	3.2	0.5	0.0
5	4BA	299	Karatina	4.7	4.3	0.4	-0.3	3.5	0.0	0.0	0.9	0.3	0.0	5.4	0.0	5.1	0.0	0.0	0.4	0.0	0.0	0.9	0.9	0.0	0.0	0.0	0.0	0.7	0.7	0.0	11.6	8.6	0.0	0.0	2.8	0.3	0.0
6	4BB	256		1.3	1.3	0.0	-0.3	0.9	0.0	0.0	0.1	0.3	0.0	12.1	0.0	11.8	0.0	0.0	0.3	0.0	0.0	0.6	0.6	0.0	0.0	0.0	0.0	0.3	0.3	0.0	14.3	12.7	0.0	0.0	1.2	0.3	0.0
7	4BC	209	Sagana	4.5	4.3	0.2	-0.2	2.8	0.0	0.0	1.5	0.2	0.0	29.9	0.0	29.7	0.0	0.0	0.3	0.0	0.0	0.6	0.6	0.0	0.0	0.0	0.0	0.4	0.4	0.0	35.4	32.4	0.0	0.0	2.8	0.2	0.0
8	4BD	539	Muranga	10.3	10.0	0.3	-1.5	7.4	0.9	0.0	1.4	0.5	0.0	12.4	0.0	11.7	0.0	0.0	0.7	0.0	0.0	1.9	1.9	0.0	0.0	0.0	0.0	0.8	0.8	0.0	25.3	19.1	0.9	0.0	4.8	0.5	0.0
9	4BE	611	Maragua	12.2	11.7	0.4	-0.7	8.4	0.0	0.0	3.1	0.7	0.0	14.9	0.0	14.1	0.0	0.0	0.7	0.0	0.0	2.0	2.0	0.0	0.0	0.0	0.0	0.6	0.6	0.0	29.7	22.5	0.0	0.0	6.5	0.7	0.0
10	4BF	382	Makuyu	15.3	14.7	0.6	-0.2	5.0	0.0	0.0	10.1	0.2	0.0	4.9	0.0	4.4	0.0	0.0	0.5	0.0	0.0	1.3	1.3	0.0	0.0	0.0	0.0	0.4	0.4	0.0	21.9	9.4	0.0	0.0	12.2	0.2	0.0
	Reference Point (4BE10																																				
11	4BG	450		2.2	2.2	0.1	-0.2	1.1	0.0	0.0	0.9	0.2	0.0	5.2	0.0	4.7	0.0	0.0	0.6	0.0	0.0	0.8	0.8	0.0	0.0	0.0	0.0	0.2	0.2	0.0	8.6	5.8	0.0	0.0	2.5	0.2	0.0
12	4CA	530		4.6	4.5	0.1	-0.8	2.8	0.0	0.0	1.0	0.8	0.0	10.0	0.0	9.3	0.0	0.0	0.8	0.0	0.0	1.5	1.5	0.0	0.0	0.0	0.0	0.2	0.2	0.0	16.4	12.1	0.0	0.0	3.5	0.8	0.0
13	4CB	326		3.3	3.2	0.1	-0.5	1.9	0.0	0.0	0.8	0.5	0.0	7.3	0.0	6.8	0.0	0.0	0.5	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.4	0.4	0.0	12.0	8.8	0.0	0.0	2.7	0.5	0.0
	Reference Point (4CC03)															0.0																					
14	4CC	1,010	Matuu	17.7	16.9	0.8	-1.4	14.5	0.9	0.0	1.8	0.5	0.0	30.6	0.0	29.1	0.0	0.0	1.5	0.0	0.0	2.0	2.0	0.0	0.0	0.0	0.0	0.5	0.5	0.0	50.8	43.6	0.9	0.0	5.8	0.5	0.0
15	4DA	778	Wanguru, Kerugoya/Kutus	17.0	16.4	0.6	-0.7	14.2	0.0	0.0	2.2	0.7	0.0	93.9	0.0	92.7	0.0	0.0	1.2	0.0	0.0	2.2	2.2	0.0	0.0	0.0	0.0	0.9	0.9	0.0	114.1	106.9	0.0	0.0	6.5	0.7	0.0
16	4DB	435		4.5	4.4	0.1	-0.5	3.2	0.0	0.0	0.7	0.5	0.0	63.2	0.0	62.5	0.0	0.0	0.7	0.0	0.0	1.3	1.3	0.0	0.0	0.0	0.0	0.3	0.3	0.0	69.3	65.7	0.0	0.0	3.1	0.5	0.0
17	4DC	345	Embu	16.2	15.5	0.7	-0.5	14.4	0.0	0.0	1.3	0.5	0.0	18.3	0.0	17.8	0.0	0.0	0.5	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	35.7	32.2	0.0	0.0	3.0	0.5	0.0
18	4DD	456		1.2	1.2	0.0	-0.3	0.7	0.0	0.0	0.2	0.3	0.0	6.2	0.0	5.5	0.0	0.0	0.7	0.0	0.0	0.7	0.7	0.0	0.0	0.0	0.0	0.3	0.3	0.0	8.4	6.1	0.0	0.0	2.0	0.3	0.0
19	4DE	731		1.4	1.4	0.0	-0.3	0.4	0.0	0.0	0.7	0.3	0.0	3.5	0.0	2.4	0.0	0.0	1.1	0.0	0.0	1.1	1.1	0.0	0.0	0.0	0.0	0.3	0.3	0.0	6.2	2.8	0.0	0.0	3.2	0.3	0.0
20	4EA	765		5.2	5.1	0.1	-1.3	3.7	0.0	0.0	0.1	1.3	0.0	28.8	0.0	27.8	0.0	0.0	1.0	0.0	0.0	1.8	1.8	0.0	0.0	0.0	0.0	0.3	0.3	0.0	36.1	31.5	0.0	0.0	3.2	1.3	0.0
21	4EB	1,169	Chogoria, Chuka	21.2	20.3	0.8	-2.3	18.3	0.0	0.0	0.5	2.3	0.0	20.3	0.0	18.8	0.0	0.0	1.5	0.0	0.0	2.6	2.6	0.0	0.0	0.0	0.0	0.4	0.4	0.0	44.5	37.1	0.0	0.0	5.0	2.3	0.0
22	4EC	653	Runyenjes	7.0	6.8	0.2	-0.8	1.7	0.0	0.0	4.5	0.8	0.0	14.2	0.0	13.3	0.0	0.0	0.8	0.0	0.0	1.3	1.3	0.0	0.0	0.0	0.0	0.6	0.6	0.0	23.1	15.0	0.0	0.0	7.3	0.8	0.0
23	4ED	3,208	Mwingi	8.1	7.9	0.2	-3.5	3.0	0.4	2.0	1.6	1.0	0.0	34.8	0.0	30.6	0.0	0.0	4.1	0.0	0.0	3.1	3.1	0.0	0.0	0.0	0.0	0.5	0.5	0.0	46.4	33.6	0.4	2.0	9.3	1.0	0.0
24	4FA	2,187	Meru	20.5	19.8	0.7	-4.1	16.4	0.0	0.0	0.0	4.1	0.0	1,497.6	-555.7	931.5	555.7	0.0	2.6	7.8	0.0	4.1	4.1	0.0	0.0	0.0	0.0	0.7	0.7	0.0	1,522.9	947.9	555.7	0.0	7.4	11.9	0.0
25	4FB	3,999	Maua	13.1	12.8	0.3	-7.8	5.4	0.0	0.0	0.0	7.8	0.0	99.2	0.0	66.4	0.0	0.0	4.7	28.2	0.0	4.1	4.1	0.0	0.0	0.0	0.0	1.2	1.2	0.0	117.7	71.7	0.0	0.0	10.1	35.9	0.0
26	4GA	3,903		2.2	2.2	0.0	-1.4	0.9	0.0	0.0	0.0	1.4	0.0	30.1	0.0	21.7	0.0	0.0	0.4	8.0	0.0	1.2	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.6	22.6	0.0	0.0	1.6	9.4	0.0
27	4GB	5,530		1.1	1.1	0.0	-0.8	0.3	0.0	0.0	0.0	0.8	0.0	351.9	-208.3	137.7	208.3	0.0	0.5	5.4	0.0	2.1	2.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	355.2	138.0	208.3	0.0	2.7	6.2	0.0
	Reference Point (4G01)																																				
28	4GC	1,931	Garissa, Madogo	7.4	7.4	0.0	-1.9	5.5	0.0	0.0	0.0	1.9	0.0	10.0	0.0	6.7	0.0	0.0	0.2	3.1	0.0	0.8	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.2	12.2	0.0	0.0	1.0	5.0	0.0
29	4GD	7,499		1.4	1.4	0.0	-1.1	0.3	0.0	0.0	0.0	1.1	0.0	34.1	0.0	21.2	0.0	0.0	0.7	12.3	0.0	1.3	1.3	0.0	0.0	0.1	0.1	0.0	0.2	0.2	0.0	37.1	21.5	0.0	0.0	2.3	13.4	0.0
30	4GE	11,752		6.2	6.1	0.0	-5.3	0.8	0.0	0.0	0.0	5.3	0.0	38.6	0.0	17.9	0.0	0.0	1.1	19.6	0.0	4.3	4.3	0.0	0.0	0.1	0.1	0.0	0.5	0.5	0.0	49.7	18.8	0.0	0.0	6.0	24.9	0.0
31	4GF	15,582	Hola, Masalani	6.8	6.7	0.0	-4.6	2.2	0.0	0.0	0.0	4.6	0.0	61.4	0.0	35.9	0.0	0.0	1.5	24.0	0.0	3.8	3.8	0.0	0.0	0.2	0.2	0.0	0.9	0.9	0.0	73.0	38.1	0.0	0.0	6.3	28.6	0.0
32	4GG	7,235		2.7	2.6	0.1	-2.1	0.7	0.0	0.0	0.0	2.1	0.0	46.5	0.0	23.4	0.0	0.0	0.7	22.5	0.0	1.7	1.7	0.0	0.0	0.1	0.1	0.0	0.2	0.2	0.0	51.3	24.0	0.0	0.0	2.7	24.5	0.0
33	4HA	5,477	Kitui	28.9	27.7	1.2	-10.5	0.5	1.3	22.7	0.0	4.4	0.0	12.7	0.0	2.0	0.0	0.0	2.1	8.6	0.0	2.6	2.6	0.0	0.0	0.1	0.1	0.0	0.9	0.9	0.0	45.1	2.5	1.3	22.7	5.6	13.1	0.0
34	4HB	8,579		1.7	1.7	0.0	-1.7	0.0	0.0	0.0	0.0	1.7	0.0	21.1	0.0	11.2	0.0	0.0	3.2	6.7	0.0	1.4	1.4	0.0	0.0	0.1	0.1	0.0	0.2	0.2	0.0	24.4	11.2	0.0	0.0	4.9	8.3	0.0
35	4HC	7,010		1.4	1.4	0.0	-1.4	0.0	0.0	0.0	0.0	1.4	0.0	13.6	0.0	9.8	0.0	0.0	2.6	1.2	0.0	1.1	1.1	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.0	16.2	9.8	0.0	0.0	3.8	2.6	0.0
36	4JA	9,553		1.7	1.7	0.0	-1.6	0.1	0.0	0.0	0.0	1.6	0.0	10.7	0.0	9.4	0.0	0.0	0.0	1.2	0.0	1.9	1.9	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	14.3	9.5	0.0	0.0	2.0	2.9	0.0
37	4JB	3,728		0.5	0.5	0.0	-0.5	0.0	0.0	0.0	0.0	0.5	0.0	3.7	0.0	2.6	0.0	0.0	0.0	1.1	0.0	1.2	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5	2.7	0.0	0.0	1.3	1.6	0.0
38	4KA	6,011		0.9	0.9	0.0	-0.9	0.0	0.0	0.0	0.0	0.9	0.0	7.0	0.0	3.7	0.0	0.0	2.1	1.2	0.0	1.7	1.7	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.0	9.9	3.8	0.0	0.0	4.0	2.1	0.0
39	4KB	10,174	Lamu	85.2	56.0	29.2	-68.7	3.5	0.0	69.0	5.2	7.5	0.0	10.5	0.0	6.8	0.0	0.0	3.7	0.0	0.0	3.3	3.3	0.0	0.0	0.1	0.1	0.0	0.2	0.2	0.0	99.3	10.4	0.0	69.0	12.4	7.5	0.0
				385.0	342.7	42.4	-132.7	181.3	3.6	93.7	45.3	61.1	0.0	2,696.5	-764.0	1,735.8	764.0	0.0	45.8	150.8	0.0	69.0	69.0	0.0	1.2	1.2	0.0	16.4	16.4	0.0	3,168.2	1,917.2	767.6	93.7	177.8	211.9	0.0

Note: 4CC: Yatta Dam, 4DA: Thiba Dam, 4FA: High Grand Falls Dam, 4GB: Kora Dam, 4HA: Mutuni Dam and Kitimui Dam
Transfer to Nairobi:Maragua 4 Dam, Chania-B Dam,Karimenu 2 Dam, and Thika 3A Dam, Ndiara Dam

Source: JICA Study Team

Table 12.3.1 Proposed Water Supply Development Plan for UWSS (ENNCA)

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	Isiolo	231,501	27,549	3,220	10,528	13,748	13,801	0
2	Nanyuki	192,282	22,882	10,610	0	10,610	12,272	0
3	Nyahururu	183,483	21,835	4,552	0	4,552	17,283	0
4	Rumuruti	50,661	6,029	0	0	0	0	6,029
5	Mandera	108,071	12,860	1,672	0	1,672	11,188	0
6	Wajir	102,042	12,143	0	0	0	0	12,143
7	Moyale	46,075	5,483	67	1,020	1,087	4,396	0
8	Rhamu	32,494	3,867	0	0	0	0	3,867
9	Elwak	30,031	3,574	0	0	0	0	3,574
10	Takaba	27,305	3,249	0	0	0	0	3,249
11	Maralal	19,546	2,326	798	0	798	1,528	0
12	Marsabit	16,317	1,942	0	0	0	0	1,942
	Total	1,039,808	123,737	20,919	11,548	32,467	60,467	30,803
							91,270	

Note: The service population of piped water supply (UWSS+LSRWSS) in 2010 is estimated at 0.99 million. The service population for each urban centre in 2010 is not clear. 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 12.3.2 Proposed Water Supply Development Plan for LSRWSS (ENNCA)

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.	0.72	86,000	7,000	7,000	112,000
Rural Pop.	0.45	33,000			
Total	1.16	119,000			

Note: The service population of piped water supply (UWSS+LSRWSS) in 2010 is estimated at 0.99 million.

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

Table 12.3.3 Proposed Water Supply Development Plan for SSRWSS (ENNCA)

Counties	Service Population in 2010	Service Population in 2030	Difference (2010-2030)	Required Water Supply Amount in 2030 (m^3/day)
14	1,386,000	2,199,200	813,200	100,943

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

Table 12.4.1 Proposed Sewerage Development Plan (ENNCA)

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	Isiolo	231,501	17,640	2,000	0	2,000	15,640	0
2	Nanyuki	192,282	14,652	0	0	0	0	14,652
3	Nyahururu	183,483	13,981	2,617	0	2,617	11,364	0
4	Mandera	108,071	8,235	0	0	0	0	8,235
5	Wajir	102,042	7,776	0	0	0	0	7,776
	Total	817,380	62,284	4,617	0	4,617	27,004	30,663

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 12.4.2 Users and Required Units of On-Site Sanitation Facilities (ENNCA)

Counties	Users in 2010	Users in 2030	Difference (2010-2030)	Required Units of On-site Facilities*
14	2,370,000	3,580,000	1,210,000	716,000

Note: * 5 users/facilities

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

Table 12.7.1 Balance between Water Resources and Water Demands in 2030 (ENNCA)

(Unit: MCM/year)

No.	Sub basin	CA (km²)	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	5AA	1,314	Rumuruti, Nyahururu	15.0	14.3	0.6	-5.1	7.2	5.1	0.0	0.0	2.6	0.0	3.3	0.0	1.1	0.0	0.0	0.8	1.4	0.0	2.1	2.1	0.0	0.0	0.0	0.0	0.5	0.5	0.0	20.8	8.3	5.1	0.0	3.4	4.0	0.0
2	5AB	557		1.9	1.9	0.1	-0.3	0.8	0.0	0.0	0.0	1.1	0.0	1.3	0.0	0.4	0.0	0.0	0.3	0.6	0.0	0.9	0.9	0.0	0.0	0.0	0.0	0.8	0.8	0.0	5.0	1.2	0.0	0.0	2.1	1.7	0.0
3	5AD	511		0.6	0.6	0.0	0.0	0.3	0.0	0.0	0.0	0.3	0.0	4.9	0.0	4.4	0.0	0.0	0.3	0.1	0.0	0.4	0.4	0.0	0.0	0.0	0.0	0.8	0.8	0.0	6.7	4.7	0.0	0.0	1.6	0.4	0.0
4	5AC	1,031		1.0	1.0	0.0	0.0	0.3	0.0	0.0	0.0	0.7	0.0	3.4	0.0	1.8	0.0	0.0	0.6	0.9	0.0	0.9	0.9	0.0	0.0	0.0	0.0	0.4	0.4	0.0	5.7	2.1	0.0	0.0	1.9	1.6	0.0
5	5BA	260		0.5	0.5	0.0	0.0	0.2	0.0	0.0	0.0	0.3	0.0	2.4	0.0	1.7	0.0	0.0	0.1	0.6	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.1	0.1	0.0	3.4	2.0	0.0	0.0	0.6	0.8	0.0
6	5BB	433		1.3	1.2	0.0	0.0	0.5	0.0	0.0	0.0	0.7	0.0	6.0	0.0	5.6	0.0	0.0	0.2	0.2	0.0	0.7	0.7	0.0	0.0	0.0	0.0	0.3	0.3	0.0	8.3	6.2	0.0	0.0	1.2	0.9	0.0
7	5BC-1	1,472		3.1	3.0	0.1	0.0	1.5	0.0	0.0	0.0	1.5	0.0	7.8	0.0	4.2	0.0	0.0	0.7	2.9	0.0	1.7	1.7	0.0	0.0	0.0	0.0	1.1	1.1	0.0	13.6	5.8	0.0	0.0	3.4	4.4	0.0
8	5BC-2	144		0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	4.2	0.0	4.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	4.1	0.0	0.0	0.2	0.2	0.0
9	5BD	710		1.4	1.3	0.0	0.0	0.8	0.0	0.0	0.0	0.6	0.0	1.1	0.0	0.8	0.0	0.0	0.3	0.0	0.0	0.7	0.7	0.0	0.0	0.0	0.0	0.4	0.4	0.0	3.6	1.6	0.0	0.0	1.5	0.6	0.0
10	5BE	1,220	Nyanyuki	11.9	11.4	0.5	-3.9	6.0	0.0	0.0	0.0	5.9	0.0	14.8	0.0	12.5	0.0	0.0	0.6	1.8	0.0	1.5	1.5	0.0	0.0	0.0	0.0	0.3	0.3	0.0	28.5	18.5	0.0	0.0	2.4	7.6	0.0
11	5DC	1,277		0.5	0.5	0.0	-0.1	0.1	0.0	0.0	0.0	0.4	0.0	255.1	-163.8	7.0	247.0	0.0	0.3	0.8	0.0	0.9	0.9	0.0	0.0	0.0	0.0	0.5	0.5	0.0	257.0	7.1	247.0	0.0	1.7	1.2	0.0
12	5DD	1,920		0.5	0.5	0.0	-0.2	0.2	0.0	0.0	0.0	0.3	0.0	28.1	0.0	27.3	0.0	0.0	0.4	0.4	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.7	27.5	0.0	0.0	0.6	0.7	0.0
13	5DB	1,260		0.8	0.7	0.0	-0.3	0.1	0.0	0.0	0.0	0.6	0.0	4.0	0.0	2.9	0.0	0.0	0.3	0.9	0.0	0.7	0.7	0.0	0.0	0.0	0.0	0.1	0.1	0.0	5.6	3.0	0.0	0.0	1.1	1.5	0.0
14	5DA	2,192	Isiolo	14.3	13.8	0.6	-5.7	6.1	5.7	0.0	0.0	2.5	0.0	89.9	-46.3	25.4	55.2	0.0	0.5	8.8	0.0	1.9	1.9	0.0	0.0	0.0	0.0	0.1	0.1	0.0	106.2	31.6	60.9	0.0	2.5	11.3	0.0
	Reference Point (5ED01)																																								
15	5CA	2,374	Maralal	2.3	2.3	0.0	-0.8	0.5	0.0	0.0	0.0	1.9	0.0	3.3	0.0	2.2	0.0	0.0	0.5	0.6	0.0	1.3	1.3	0.0	0.0	0.0	0.0	0.8	0.8	0.0	7.7	2.7	0.0	0.0	2.6	2.5	0.0
16	5CB	2,267		0.8	0.8	0.0	-0.4	0.1	0.0	0.0	0.0	0.7	0.0	0.5	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.1	0.0	0.0	0.8	0.8	0.0
17	5CC	2,983		1.1	1.1	0.0	-0.6	0.1	0.0	0.0	0.1	0.9	0.0	0.6	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.1	0.0	0.0	1.3	0.9	0.0
18	5EC	21,938	Marsabit	3.9	3.9	0.0	-2.8	0.0	0.0	0.0	0.0	3.9	0.0	15.1	0.0	4.9	0.0	0.0	0.0	10.2	0.0	2.2	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.3	4.9	0.0	0.0	2.2	14.1	0.0
19	5ED	20,602		13.3	13.1	0.1	-5.3	0.5	0.0	0.0	0.0	12.8	0.0	35.8	0.0	0.0	0.0	0.0	0.0	35.8	0.0	6.3	6.3	0.0	0.0	0.0	0.0	0.7	0.7	0.0	56.1	0.5	0.0	0.0	7.0	48.6	0.0
20	5FA	17,286		6.1	6.1	0.0	-2.9	0.0	0.0	0.0	0.0	6.1	0.0	14.7	0.0	0.0	0.0	0.0	0.0	14.7	0.0	6.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26.9	0.0	0.0	0.0	6.1	20.8	0.0
21	5EA	26,938	Moyale, Wajir	11.3	11.3	0.0	-7.5	0.0	0.0	0.0	0.0	11.3	0.0	5.5	0.0	1.6	0.0	0.0	0.0	3.9	0.0	8.6	8.6	0.0	0.1	0.1	0.0	0.0	0.0	0.0	25.5	1.6	0.0	0.0	8.7	15.2	0.0
22	5EB	26,049		5.3	5.3	0.0	-2.3	0.0	0.0	0.0	0.0	5.3	0.0	12.3	0.0	2.6	0.0	0.0	0.0	9.6	0.0	6.2	6.2	0.0	0.1	0.1	0.0	0.0	0.0	0.0	23.8	2.6	0.0	0.0	6.3	14.9	0.0
23	5G	20,461	Takaba, Elwak	14.0	14.0	0.0	-6.5	0.0	0.0	0.0	0.0	14.0	0.0	3.7	0.0	0.0	0.0	0.0	0.0	3.7	0.0	17.7	17.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.5	0.0	0.0	0.0	17.8	17.7	0.0
24	5HA	3,272	Mandera	9.4	9.4	0.0	-6.2	0.0	0.0	0.0	7.6	1.8	0.0	11.8	0.0	11.8	0.0	0.0	0.0	0.0	0.0	4.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.2	11.8	0.0	0.0	11.6	1.8	0.0
25	5HB	6,946	Mandera	2.9	2.9	0.0	-1.5	0.0	0.0	0.0	0.0	2.9	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.5	0.0	7.2	7.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.6	0.0	0.0	0.0	7.2	3.4	0.0
26	5J	37,169		2.9	2.9	0.0	-1.4	0.0	0.0	0.0	0.0	2.9	0.0	8.1	0.0	0.0	0.0	0.0	0.0	8.1	0.0	4.1	4.1	0.0	0.1	0.1	0.0	0.0	0.0	0.0	15.2	0.0	0.0	0.0	4.2	11.0	0.0
27	5FB	8,000		1.3	1.3	0.0	-0.7	0.0	0.0	0.0	0.0	1.3	0.0	1.5	0.0	0.5	0.0	0.0	0.0	1.0	0.0	1.8	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	0.5	0.0	0.0	1.8	2.3	0.0
				127.6	125.4	2.1	-54.4	25.4	11.9	0.0	7.8	83.6	0.0	539.7	-210.1	122.9	302.2	0.0	7.1	107.5	0.0	79.2	79.2	0.0	0.4	0.4	0.0	7.0	7.0	0.0	753.9	148.3	313.0	0.0	101.5	191.1	0.0

Note: 5AA: Nyahururu Dam and Rumuruti Dam. 5DC, 5DD: Kihoto . 5DA: Isiolo Dam and Archers' Post Dam
Source: JICA Study Team

Table 13.2.1 Estimated Costs for Proposed Development Plans

Catchment Area	Development Plan	Proposed Project	Project Cost (KSh million)	O&M Cost (KSh million/ year)
LVNCA	Water Supply	Urban Water Supply for 32 UCs	144,158	6,101
		Rural Water Supply for 11 Counties	33,082	1,584
	Sanitation	Sewerage (off-site treatment) for 19 UCs	75,855	4,094
	Irrigation	Large Scale Irrigation (78,370 ha)	82,194	247
		Small Scale Irrigation (47,122 ha)	30,451	152
		Private Irrigation (43,421 ha)	84,178	842
	Hydropower	3 projects	26,442	132
	Total		476,360	13,152
LVSCA	Water Supply	Urban Water Supply for 25 UCs	159,868	6,289
		Rural Water Supply for 14 Counties	49,780	2,259
	Sanitation	Sewerage (off-site treatment) for 19 UCs	79,895	4,313
	Irrigation	Large Scale Irrigation (75,572 ha)	128,257	385
		Small Scale Irrigation (22,501 ha)	14,540	73
		Private Irrigation (15,133 ha)	29,338	293
	Hydropower	1 project	46,055	230
	Total		507,733	13,842
RVCA	Water Supply	Urban Water Supply for 13 UCs	101,393	2,721
		Rural Water Supply for 18 Counties	43,847	1,645
	Sanitation	Sewerage (off-site treatment) for 9 UCs	38,810	2,073
	Irrigation	Large Scale Irrigation (78,850 ha)	109,959	330
		Small Scale Irrigation (9,271 ha)	5,991	30
		Private Irrigation (4,045 ha)	7,842	78
	Hydropower	6 projects	57,120	286
	Total		364,962	7,163
ACA	Water Supply	Urban Water Supply for 32 UCs	531,130	21,865
		Rural Water Supply for 10 Counties	39,543	1,637
	Sanitation	Sewerage (off-site treatment) for 25 UCs	207,704	10,688
	Irrigation	Large Scale Irrigation (37,280 ha)	33,977	102
		Small Scale Irrigation (6,484 ha)	4,190	21
		Private Irrigation (2,344 ha)	4,544	45
	Hydropower	2 projects	7,961	40
	Total		829,049	34,398
TCA	Water Supply	Urban Water Supply for 23 UCs	129,488	4,145
		Rural Water Supply for 16 Counties	10,723	217
	Sanitation	Sewerage (off-site treatment) for 18 UCs	64,152	3,422
	Irrigation	Large Scale Irrigation (135,961 ha)	324,875	975
		Small Scale Irrigation (15,784 ha)	10,200	51
		Private Irrigation (10,054 ha)	19,491	195
	Hydropower	2 projects	152,886	765
	Total		711,815	9,770
ENNCA	Water Supply	Urban Water Supply for 12 UCs	22,981	870
		Rural Water Supply for 14 Counties	21,874	1,051
	Sanitation	Sewerage (off-site treatment) for 5 UCs	10,067	538
	Irrigation	Large Scale Irrigation (26,202 ha)	46,305	139
		Small Scale Irrigation (8,116 ha)	5,245	26
		Private Irrigation (7,165 ha)	13,890	139
	Hydropower	No project	0	0
	Total		120,362	2,763
Total	Water Supply	Urban Water Supply for 137 UCs	1,089,018	41,991
		Rural Water Supply for 47 Counties	198,849	8,393
	Sanitation	Sewerage (off-site treatment) for 95 UCs	476,483	25,128
	Irrigation	Large Scale Irrigation (432,235 ha)	725,567	2,178
		Small Scale Irrigation (109,837 ha)	70,617	353
		Private Irrigation (82,721 ha)	159,283	1,592
	Hydropower	14 projects	290,464	1,453
	Grand Total		3,010,281	81,088

Source: JICA Study Team

Table 13.2.2 Estimated Costs for Proposed Management Plans

Catchment Area	Management Plan	Proposed Plans	Development Cost (KSh million)	Recurrent Cost* (KSh million/ year)
LVNCA	Water Resources Management	Monitoring	117	127
		Evaluation	30	-
		Permitting	18	-
		Watershed Conservation (234,000 ha)	18,486	-
		Operation of Catchment Forum	-	1
	Flood and Drought Disaster Management	FFWS (1 location)	30	0.2
		Flood Fighting (1 location)	30	0.2
	Environmental Management	Setting of Environmental Flow Rate including Survey (5 locations)	35	-
		Environmental Monitoring (5 locations)	-	0.8
	Total		18,746	129
LVSCA	Water Resources Management	Monitoring	124	123
		Evaluation	30	-
		Permitting	18	-
		Watershed Conservation (412,000 ha)	32,548	-
		Operation of Catchment Forum	-	1
	Flood and Drought Disaster Management	FFWS (1 location)	1,482	7
		CBDM (2 locations)	311	2
		Flood Fighting (1 location)	30	0.2
	Environmental Management	Setting of Environmental Flow Rate including Survey (8 locations)	49	-
		Environmental Monitoring (13 locations)	-	2.4
	Total		34,592	136
RVCA	Water Resources Management	Monitoring	103	120
		Evaluation	63	-
		Permitting	27	-
		Watershed Conservation (1,006,000 ha)	79,474	-
		Operation of Catchment Forum	-	1
	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	-
	Environmental Management	Setting of Environmental Flow Rate including Survey (11 locations)	98	-
		Environmental Monitoring (14 locations)	-	1.6
	Total		80,175	123
ACA	Water Resources Management	Monitoring	128	137
		Evaluation	54	-
		Permitting	27	-
		Watershed Conservation (868,000 ha)	68,572	-
		Operation of Catchment Forum	-	1
	Flood and Drought Disaster Management	Hazard Map (1 location)	30	0.2
		CBDM (2 locations)	309	2
		River Training Works (cost for F/S) (1 location)	156	-
	Environmental Management	Setting of Environmental Flow Rate including Survey (6 locations)	61	-
		Environmental Monitoring (10 locations)	-	1.6
	Total		69,337	142
TCA	Water Resources Management	Monitoring	125	137
		Evaluation	54	-
		Permitting	27	-
		Watershed Conservation (1,366,000 ha)	107,914	-
		Operation of Catchment Forum	-	1
	Flood and Drought Disaster Management	Hazard Map (1 location)	30	0.2
		Evacuation Plan (1 location)	30	0.2
		CBDM (1 location)	457	2
		Hydropower Dam Warning (1 location)	30	0.2
		River Training Works (cost for F/S) (1 location)	154	-
	Environmental Management	Setting of Environmental Flow Rate including Survey (4 locations)	62	-
		Environmental Monitoring (6 locations)	-	0
	Total		108,883	141
ENNCA	Water Resources Management	Monitoring	67	69
		Evaluation	63	-
		Permitting	27	-
		Watershed Conservation (592,000 ha)	46,768	-
		Operation of Catchment Forum	-	1
	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)	328	-
	Environmental Management	Setting of Environmental Flow Rate including Survey (2 locations)	14	-
		Environmental Monitoring (2 locations)	-	0
	Total		47,357	71
Total	Water Resources Management	Monitoring	665	714
		Evaluation	293	-
		Permitting	144	-
		Watershed Conservation (4,478,000 ha)	353,762	-
		Operation of Catchment Forum	-	6
	Flood and Drought Disaster Management	CBDM (5 locations)	1,077	6
		Evacuation Plan (3 locations)	90	0.5
		FFWS (2 locations)	1,512	7
		Flood Fighting (2 locations)	60	0.3
		Hazard Map (6 location)	180	0.9
		Hydropower Dam Warning (1 location)	30	0.2
		River Training Works (cost for F/S) (6 locations)	958	-
	Environmental Management	Setting of Environmental Flow Rate including Survey (36 locations)	325	-
		Environmental Monitoring (50 locations)	-	113
	Grand Total		359,096	848

Note: * Recurrent cost includes operation and management costs.
Source: JICA Study Team

Table 19.1.1 Summary of Proposed Water Allocation Plans for Water Demands in 2030

(Unit: MCM/year)

Catchment Area	LVNCA			LVSCA			RVCA		
Water Demand Category	Water Demand	Water Source		Water Demand	Water Source		Water Demand	Water Source	
		Surface	Groundwater		Surface	Groundwater		Surface	Groundwater
Domestic	424	363	61	464	374	90	264	213	51
Industrial	19	10	9	41	21	20	23	12	11
Irrigation	1,359	1,332	27	1,158	1,107	51	1,393	1,377	16
Livestock	61	61	0	106	106	0	123	123	0
Wildlife	0	0	0	3	3	0	1	1	0
Fisheries	16	16	0	15	15	0	8	8	0
Total	1,879	1,782	97	1,787	1,626	161	1,812	1,734	78
Available Water Resources	5,077	4,969	108	5,937	5,749	188	3,147	3,045	102
Ratio of Water Demands	37.0%	35.9%	89.8%	30.1%	28.3%	85.6%	57.6%	56.9%	76.5%

Catchment Area	ACA			TCA			ENNCA		
Water Demand Category	Water Demand	Water Source		Water Demand	Water Source		Water Demand	Water Source	
		Surface	Groundwater		Surface	Groundwater		Surface	Groundwater
Domestic	941	819	122	343	303	40	125	42	83
Industrial	153	77	76	42	21	21	2	1	1
Irrigation	917	882	35	2,697	2,546	151	539	432	107
Livestock	59	59	0	69	69	0	79	79	0
Wildlife	3	3	0	1	1	0	0	0	0
Fisheries	12	12	0	16	16	0	7	7	0
Total	2,085	1,852	233	3,168	2,956	212	752	561	191
Available Water Resources (*)	1,634	1,334	300	7,828	7,261	567	3,011	2,536	475
Ratio of Water Demands	127.6%	138.8%	77.7%	40.5%	40.7%	37.4%	25.0%	22.1%	40.2%

Total				Present Water Sources**		
Water Demand Category	Water Demand	Water Source		Water Demand	Water Source	
		Surface	Groundwater		Surface	Groundwater
Domestic	2,561	2,114	447	1,186	724	462
Industrial	280	142	138	125	62	63
Irrigation	8,063	7,676	387	1,602	1,602	n.a.
Livestock	497	497	0	255	255	n.a.
Wildlife	8	8	0	8	8	0
Fisheries	74	74	0	42	42	0
Total	11,483	10,511	972	3,218	2,693	525
Available Water Resources (*)	26,634	24,894	1,740	30,452	24,894	5,558
Ratio of Water Demands	43.1%	42.2%	55.9%	10.6%	10.8%	9.4%

Note: * Deficit of Athi Catchment Area is to be met by 472 MCM/year of inter-basin transfer and 93 MCM/year of desalination.

** The data on groundwater use for irrigation and livestock are not available.

Source: JICA Study Team

Table 19.1.2 Summary of Proposed Water Supply Development Plans

Catchment Area		LVNCA			LVSCA			RVCA		
Type of Project		Target Area	Required Capacity (m^3/day)	Service Population (million persons)	Target Area	Required Capacity (m^3/day)	Service Population (million persons)	Target Area	Required Capacity (m^3/day)	Service Population (million persons)
Urban Water Supply	Rehabilitation	20 UCs	135,000		21 UCs	120,000		10 UCs	129,000	
	Expansion	20 UCs	556,000		21 UCs	571,000		10 UCs	254,000	
	New Construction	12 UCs	91,000	6.57	4 UCs	94,000	6.26	3 UCs	15,000	3.34
	Total	32 UCs	782,000 (135,000)		25 UCs	785,000 (120,000)		13 UCs	398,000 (129,000)	
Rural Water Supply	LSRWSS	11 Counties	184,000 (10,000)		14 Counties	277,000 (26,000)		18 Counties	178,000 (7,000)	
	SSRWSS	11 Counties	220,000 (144,000)	5.79	14 Counties	208,000 (150,000)	6.46	18 Counties	120,000 (78,000)	4.11
	Total	11 Counties	404,000 (154,000)		14 Counties	485,000 (176,000)		18 Counties	298,000 (85,000)	

Catchment Area		ACA			TCA			ENNCA		
Type of Project		Target Area	Required Capacity (m^3/day)	Service Population (million persons)	Target Area	Required Capacity (m^3/day)	Service Population (million persons)	Target Area	Required Capacity (m^3/day)	Service Population (million persons)
Urban Water Supply	Rehabilitation	30 UCs	699,000		15 UCs	106,000		6 UCs	32,000	
	Expansion	29 UCs	1,542,000		14 UCs	349,000		6 UCs	61,000	
	New Construction	2 UCs	19,000	17.01	8 UCs	88,000	4.90	6 UCs	31,000	1.04
	Total	32 UCs	2,260,000 (699,000)		23 UCs	543,000 (106,000)		12 UCs	124,000 (32,000)	
Rural Water Supply	LSRWSS	10 Counties	209,000 (100,000)		16 Counties	211,000 (149,000)		14 Counties	119,000 (7,000)	
	SSRWSS	10 Counties	110,000 (108,000)	4.04	16 Counties	145,000 (72,000)	4.96	14 Counties	101,000 (77,000)	3.36
	Total	10 Counties	319,000 (208,000)		16 Counties	356,000 (221,000)		14 Counties	220,000 (84,000)	

Total				
Type of Project		Target Area	Required Capacity (m^3/day)	Service Population (million persons)
Urban Water Supply	Rehabilitation	102 Ucs	1,221,000	
	Expansion	100 UCs	3,333,000	
	New Construction	35 UCs	338,000	39.12
	Total	137 UCs	4,892,000 (1,221,000)	
Rural Water Supply	LSRWSS	47 Counties	1,178,000 (299,000)	
	SSRWSS	47 Counties	904,000 (629,000)	28.72
	Total	47 Counties	2,082,000 (928,000)	

Source: JICA Study Team

Note:
1) LSRWSS: large scale rural water supply system, SSRWSS: small scale rural water supply system
2) For Urban Water Supply and LSRWSS, the figures in parentheses indicate the total capacities of existing water supply systems (including systems under construction)
3) For SSRWSS, the figures in parentheses indicate estimate of water consumption, by applying unit rate of 50 L/p/day.

Table 19.1.3 Summary of Proposed Sanitation Development Plans

Catchment Area		LVNCA			LVSCA			RVCA		
Type of Project		Target Area	Required Capacity (m^3/day)	Service Population (million persons)	Target Area	Required Capacity (m^3/day)	Service Population (million persons)	Target Area	Required Capacity (m^3/day)	Service Population (million persons)
Sewerage	Rehabilitation	7 UCs	21,000	6.03	3 UCs	22,000	6.02	3 UCs	18,000	3.16
	Expansion	7 UCs	230,000		3 UCs	171,000		3 UCs	150,000	
	New Construction	12 UCs	209,000		16 UCs	291,000		6 UCs	72,000	
	Total	19 UCs	460,000 (21,000)		19 UCs	484,000 (22,000)		9 UCs	240,000 (18,000)	
On-site Treatment Facilities		11 Counties	--	6.33	14 Counties	--	6.70	18 Counties	--	4.29

Catchment Area		ACA			TCA			ENNCA		
Type of Project		Target Area	Required Capacity (m^3/day)	Service Population (million persons)	Target Area	Required Capacity (m^3/day)	Service Population (million persons)	Target Area	Required Capacity (m^3/day)	Service Population (million persons)
Sewerage	Rehabilitation	6 UCs	244,000	16.26	6 UCs	32,000	5.24	2 UCs	5,000	0.82
	Expansion	6 UCs	715,000		6 UCs	118,000		2 UCs	27,000	
	New Construction	19 UCs	430,000		12 UCs	248,000		3 UCs	30,000	
	Total	25 UCs	1,389,000 (244,000)		18 UCs	398,000 (32,000)		5 UCs	62,000 (5,000)	
On-site Treatment Facilities		10 Counties	--	4.28	16 Counties	--	5.13	14 Counties	--	3.58

Total				
Type of Project		Target Area	Required Capacity (m^3/day)	Service Population (million persons)
Sewerage	Rehabilitation	27 UCs	342,000	37.53
	Expansion	27 UCs	1,411,000	
	New Construction	68 UCs	1,280,000	
	Total	95 UCs	3,033,000 (342,000)	
On-site Treatment Facilities		47 Counties	--	30.31

Note: The figures in parentheses indicate the total capacities of existing sewerage systems (including systems under construction).
Source: JICA Study Team

Table 19.1.4 Summary of Proposed Irrigation Development Plans

Type of Project	LVNCA			LVSCA			RVCA		
	Large Scale Irrigation Projects (nos)	Target Counties (nos)	Irrigation Area (ha)	Large Scale Irrigation Projects (nos)	Target Counties (nos)	Irrigation Area (ha)	Large Scale Irrigation Projects (nos)	Target Counties (nos)	Irrigation Area (ha)
Large Scale Irrigation	6		78,370	8		75,572	9		78,850
Small Scale Irrigation		11	47,122		12	22,501		14	9,271
Private Irrigation		11	43,421		12	15,133		14	4,045
Total	6	11	168,913	8	12	113,206	9	14	92,166

Type of Project	ACA			TCA			ENNCA		
	Large Scale Irrigation Projects (nos)	Target Counties (nos)	Irrigation Area (ha)	Large Scale Irrigation Project (nos)	County (nos)	Irrigation Area (ha)	Large Scale Irrigation Projects (nos)	Target Counties (nos)	Irrigation Area (ha)
Large Scale Irrigation	4		37,280	4		135,961	3		26,202
Small Scale Irrigation		10	6,484		15	15,784		10	8,116
Private Irrigation		10	2,344		15	10,054		10	7,165
Total	4	10	46,108	4	15	161,799	3	10	41,483

Type of Project	Total			Existing Irrigation Area		
	Large Scale Irrigation Projects (nos)	Target Counties (nos)*	Irrigation Area (ha)	Large Scale Irrigation Projects (nos)	Relevant Counties (nos)	Irrigation Area (ha)
Large Scale Irrigation	34		432,235	9		14,137
Small Scale Irrigation		47	109,278		7	51,923
Private Irrigation		47	82,162		7	75,840
Total	34	47	623,675	9	7	141,900

Note: * One county belongs to plural catchment areas, but total number of counties in Kenya is 47.

Source: JICA Study Team

Table 19.1.5 Summary of Proposed Hydropower Development Plans

LVNCA						LVNCA						LVNCA					
No.	Name of Plan	Type of Plan	River	Installed Capacity	Purpose	No.	Name of Plan	Type of Plan	River	Installed Capacity	Purpose	No.	Name of Plan	Type of Plan	River	Installed Capacity	Purpose
1	Nzoia (34B) Multipurpose Dam Development Plan	M	Nzoia River	16 MW	Water Supply, Irrigation, Flood Control, Hydropower	1	Magwagwa Multipurpose Dam Development Plan	M	Sondu River	115 MW	Water Supply, Irrigation, Hydropower	1	Embobut Multipurpose Dam Development Plan	M	Turkwel River	45 MW	Water Supply, Irrigation, Hydropower
2	Nzoia (42A) Multipurpose Dam Development Plan	M	Nzoia River	25 MW	Flood Control, Hydropower							2	Arror Multipurpose Dam Development Plan	M	Arror River	80 MW	Water Supply, Irrigation, Hydropower
3	Nandi Forest Multipurpose Dam Development Plan	M	Yala River	50 MW	Water Supply, Irrigation, Hydropower							3	Kimwarer Multipurpose Dam Development Plan	M	Kerio River	20 MW	Water Supply, Irrigation, Hydropower
												4	Oletukat Multipurpose Dam Development Plan	M	Ewaso Ng'iro South River	36 MW	Water Supply, Hydropower
												5	Leshota Multipurpose Dam Development Plan	M	Ewaso Ng'iro South River	54 MW	Water Supply, Hydropower
												6	Oldorko Multipurpose Dam Development Plan	M	Ewaso Ng'iro South River	90 MW	Water Supply, Irrigation, Hydropower
			Sub-total	91 MW					Sub-total	115 MW					Sub-total	325 MW	

ACA						TCA						ENNCA					
No.	Name of Plan	Type of Plan	River	Installed Capacity	Purpose	No.	Name of Plan	Type of Plan	River	Installed Capacity	Purpose	No.	Name of Plan	Type of Plan	River	Installed Capacity	Purpose
11	Munyu Multipurpose Dam Development Plan	M	Athi River	40 MW	Irrigation, Hydropower	13	High Grand Falls Multipurpose Dam Development Plan	M, L	Tana River	Stage 1: 500 MW	Water Supply, Irrigation, Hydropower						
12	Thwake Multipurpose Dam Development Plan	M	Athi River	20 MW	Water Supply, Irrigation, Hydropower					Stage 2: +200 MW							
						14	Karura Hydropower Development Project	O	Tana River	90 MW	Hydropower						
			Sub-total	60 MW					Sub-total	790 MW							

Total	
No. of Plans	Total Installed Capacity
14 plans	1,381 MW

Note: Type of Plan

M: Hydropower Component of Multipurpose Dam Development L: Proposed Project in Least Cost Power Development Plan (LCPDP) O: Others (Proposed by Private Company etc.)

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

Table 19.1.6 Summary of Proposed Water Resources Development Plans

Catchment Area	LVNCA			LVSCA			RVCA		
Facilities	Quantity	Total Volume/Yield	Remarks	Quantity	Total Volume/Yield	Remarks	Quantity	Total Volume/Yield	Remarks
Dam	7 nos	1,080 MCM		10 nos	1,000 MCM		10 nos	659 MCM	
Small Dam and Water Pan	3,620 nos	181 MCM		3,880 nos	194 MCM		3,640 nos	182 MCM	
Inter-basin Water Transfer	1 no	189 MCM/year	From Nandi Forest Dam to LVSCA	2 nos	123 MCM/year	From Itare & Londiani Dams to RVCA, and from Amala Dam to RVCA (From Nandi Forest Dam)	-	-	(From Itare, Londiani and Amala Dams)
Intra-basin Water Transfer	1 no	5 MCM/year	From Moiben Dam to Eldoret	-	-		-	-	
Borehole	560 nos	56 MCM/year		1,250 nos	125 MCM/year		160 nos	16 MCM/year	
Desalination	-	-		-	-		-	-	

Catchment Area	ACA			TCA			ENNCA		
Facilities	Quantity	Total Volume/Yield	Remarks	Quantity	Total Volume/Yield	Remarks	Quantity	Total Volume/Yield	Remarks
Dam	16 nos	1,689 MCM		11 nos	5,729 MCM		5 nos	522 MCM	
Small Dam and Water Pan	1,880 nos	94 MCM		3,020 nos	151 MCM		1,820 nos	91 MCM	
Inter-basin Water Transfer	-	-	(From TCA)	1 no	168 MCM/year	From TCA to Nairobi	-	-	
Intra-basin Water Transfer	2 nos	68 MCM/year	From Mzima Springs & Athi River	3 nos	94 MCM/year	From Masinga Dam to Kitui, from Kiambere Dam to Mwingi, and from High Grand Falls Dam to Lamu	-	-	
Borehole	350 nos	35 MCM		1,440 nos	144 MCM/year		1,560 nos	156 MCM/year	
Desalination	1 no	93 MCM/year	Mombasa	-	-		-	-	

Total			Existing Facilities		
Facilities	Quantity	Total Volume/Yield	Facilities	Quantity	Total Volume/Yield
Dam	59 nos	10,679 MCM	Dam	26 nos	3,906 MCM
Small Dam and Water Pan	17,860 nos	893 MCM	Small Dam and Water Pan	4,037 nos	74 MCM
Inter-basin Water Transfer	4 nos	480 MCM/year	Inter-basin Water Transfer	5 nos	185 MCM/year
Intra-basin Water Transfer	6 nos	167 MCM/year	Intra-basin Water Transfer	10 nos	74 MCM/year
Borehole	5,320 nos	532 MCM/year	Borehole	13,758 nos	525 MCM/year
Desalination	1 no	93 MCM/year	Desalination	-	-

Source: JICA Study Team

Table 19.1.7 Summary of Proposed Water Resources Management Plans

Catchment Area	LVNCA	LVSCA	RVCA
1) Monitoring Networks - Surface Water Monitoring - Rainfall Monitoring Stations - Groundwater Monitoring Stations - Reference Point	 24 locations 42 locations 19 locations 2 locations	 23 locations 50 locations 19 locations 5 locations	 23 locations 47 locations 10 locations 4 locations
2) Evaluation of Water Resources	a) Formulation of water resources evaluation team in LVN Regional office b) Enhance evaluation of water quality in water quality test laboratory in Kakamega.	a) Formulation of water resources evaluation team in LVS Regional office b) Enhance evaluation of water quality in water quality test laboratory in Kisumu.	a) Formulation of water resources evaluation team in RV Regional office b) Establishment of additional water quality test laboratories in Lodwar and Kapenguria for timely analysis of water quality c) Enhance evaluation of water quality in water quality test laboratories in Nakuru, Lodwar and Kapenguria.
3) Improvement of Water Permit Issuance and Control	a) Maintenance of the latest version of issued permits b) Revision of standards such as water allocation guidelines based on future demand and water resources c) Increase of water right officers from the current five to seven.	a) Maintenance of the latest version of issued permits b) Revision of standards such as water allocation guidelines based on future demand and water resources c) Increase of water right officers from the current four to seven.	a) Maintenance of the latest version of issued permits b) Revision of standards such as water allocation guidelines based on future demand and water resources c) Increase of water right officers from the current six to 15.
4) Watershed Conservation (Forestation, Small Water Sources Conservation and Soil Erosion Control)	a) Forestation of 234,000 ha to achieve Kenya Vision 2030 target forest recovery of 10%. b) Soil Erosion Control	a) Forestation of 412,000 ha to achieve Kenya Vision 2030 target forest recovery of 10%. b) Small Water Sources Conservation c) Soil Erosion Control	a) Forestation of 1,006,000 ha to achieve Kenya Vision 2030 target forest recovery of 10%. b) Soil Erosion Control
Catchment Area	ACA	TCA	ENNCA
1) Monitoring Networks - Surface Water Monitoring - Rainfall Monitoring Stations - Groundwater Monitoring Stations - Reference Point	 26 locations 38 locations 24 locations 2 locations	 26 locations 47 locations 18 locations 3 locations	 13 locations 34 locations 5 locations 1 locations
2) Evaluation of Water Resources	a) Formulation of water resources evaluation team in Athi Regional office b) Establishment of additional water quality test laboratory in Mombasa for timely analysis of water quality c) Enhance evaluation of water quality in water quality test laboratories in Machakos and Mombasa.	a) Formulation of water resources evaluation team in Tana Regional office b) Establishment of additional water quality test laboratory in Garissa for timely analysis of water quality c) Enhance evaluation of water quality in water quality test laboratories in Embu and Garissa.	a) Formulation of water resources evaluation team in ENN Regional office b) Establishment of additional water quality test laboratories in Marsabit and Wajir for timely analysis of water quality c) Enhance evaluation of water quality in water quality test laboratories in Nyeri, Marsabit and Wajir.
3) Improvement of Water Permit Issuance and Control	a) Maintenance of the latest version of issued permits b) Revision of standards such as water allocation guidelines based on future demand and water resources c) Increase of water right officers from the current six to 16.	a) Maintenance of the latest version of issued permits b) Revision of standards such as water allocation guidelines based on future demand and water resources c) Increase of water right officers from the current seven to 15.	a) Maintenance of the latest version of issued permits b) Revision of standards such as water allocation guidelines based on future demand and water resources c) Increase of water right officers from the current eight to 12.
4) Watershed Conservation (Forestation, Small Water Sources Conservation and Soil Erosion Control)	a) Forestation of 868,000 ha to achieve Kenya Vision 2030 target forest recovery of 10%. b) Small Water Sources Conservation	a) Forestation of 1,366,000 ha to achieve Kenya Vision 2030 target forest recovery of 10%. b) Soil Erosion Control	a) Forestation of 592,000 ha to achieve Kenya Vision 2030 target forest recovery of 10%. b) Small Water Sources Conservation c) Soil Erosion Control

Catchment Area	Total
1) Monitoring Networks - Surface Water Monitoring - Rainfall Monitoring Stations - Groundwater Monitoring Stations - Reference Point	 135 locations 258 locations 95 locations 17 locations
2) Evaluation of Water Resources	a) Formulation of water resources evaluation team in each regional offices of WRMA. b) Establishment of additional six water quality test laboratories in total in RVCA, ACA, TCA and ENNCA.
3) Improvement of Water Permit Issuance and Control	a) Maintenance of the latest version of issued permits b) Revision of standards such as water allocation guidelines based on future demand and water resources c) Increase of water right officers from the current 36 to 72.
4) Watershed Conservation (Forestation and Soil Erosion Control)	a) Forestation of 4,478,000 ha to achieve Kenya Vision 2030 target forest recovery of 10%. b) Small Water Sources Conservation c) Soil Erosion Control

Source: JICA Study Team

Table 19.1.8 Summary of Proposed Flood and Drought Disaster Management Plans

Catchment Area	LVNCA	LVSCA	RVCA
Flood Management Plan	a) Nzoia R. Basin: Flood control by dams, dikes and river improvement b) Nzoia R. Basin: Operation of early flood forecasting and warning system c) Nzoia and Yala R. Basins: Preparation of flood fighting plans for dikes	a) Kano Plain: Flood control by dams, dikes and river improvement b) Kano Plain: Establishment of early flood forecasting and warning system c) Nyando R.: Preparation of flood fighting plan for dikes d) Mouth areas of Sondu and Kuja Rivers: Community-based disaster management e) Kisumu City: Provision of urban drainage measures	a) Narok: Flood control by river improvement and dam, and preparation of flood hazard map and evacuation plan b) Mogotio: Flood control by river improvement and preparation of hazard map c) Narok: Provision of urban drainage measures d) Nakuru: Provision of urban drainage measures
	Target Area *: 1. Yala Swamp (a/b/c)	Target Area *: 2. Kano Plain (a/b/c), 3. Sondu Rivermouth (d), 4. Kuja Rivermouth (d), 5. Kisumu (e)	Target Area *: 8. Nakuru (d), 9. Narok (a/c), 10. Mogotio (b)
Drought Management Plan	a) Monitoring reference water levels which correspond to reserve or normal discharge (as a part of WRM plan) b) Establishment of 2 Basin Drought Conciliation Councils c) Early Drought Forecasting based on long-term rainfall prediction d) Water Use Restriction Rule for Reservoirs (Existing 5 dams and proposed 7 dams)	a) Monitoring reference water levels which correspond to reserve or normal discharge (as a part of WRM plan) b) Establishment of 5 Basin Drought Conciliation Councils c) Early Drought Forecasting based on long-term rainfall prediction d) Water Use Restriction Rule for Reservoirs (Existing 2 dams and proposed 10 dams)	a) Monitoring reference water levels which correspond to reserve or normal discharge (as a part of WRM plan) b) Establishment of 7 Basin Drought Conciliation Councils c) Early Drought Forecasting based on long-term rainfall prediction d) Water Use Restriction Rule for Reservoirs (Existing 5 dams and proposed 10 dams)
Catchment Area	ACA	TCA	ENNCA
Flood Management Plan	a) Kilifi (Downmost Athi): Community-based disaster management b) Taveta (Lumi Rivermouth): Community-based disaster management c) Kwale (Vanga): Flood control by river training and preparation of hazard map d) Nairobi: Provision of urban drainage measures e) Mombasa: Provision of urban drainage measures	a) Garissa: Flood control by river structure and dam, and preparation of flood hazard map and evacuation plan b) Lower Tana: Community-based disaster management c) Kiambere Dam: Improvement of discharge warning system	a) Mandera: Flood control by river structures, and preparation of flood hazard map and evacuation plan b) Isiolo: Flood control by river structures and preparation of flood hazard map c) Isiolo: Provision of urban drainage measures
	Target Area *: 11. Downmost Athi (a), 12. Lumi Rivermouth (b), 13. Nairobi City (d), 14. Kwale (c), 15. Mombasa (e)	Target Area *: 16. Lower Tana (a/b/c), 17. Ijara (a/b/c)	Target Area *: 20. Mandera (a), 21. Isiolo (b/c)
Drought Management Plan	a) Monitoring reference water levels which correspond to reserve or normal discharge (as a part of WRM plan) b) Establishment of 6 Basin Drought Conciliation Councils c) Early Drought Forecasting based on long-term rainfall prediction d) Water Use Restriction Rule for Reservoirs (Existing 8 dams and proposed 16 dams)	a) Monitoring reference water levels which correspond to reserve or normal discharge (as a part of WRM plan) b) Establishment of 1 Basin Drought Conciliation Council c) Early Drought Forecasting based on long-term rainfall prediction d) Water Use Restriction Rule for Reservoirs (Existing 8 dams and proposed 11 dams)	a) Monitoring reference water levels which correspond to reserve or normal discharge (as a part of WRM plan) b) Establishment of 1 Basin Drought Conciliation Council c) Early Drought Forecasting based on long-term rainfall prediction d) Water Use Restriction Rule for Reservoirs (Existing 1 dam and proposed 5 dams)

Plan	Total
Flood Management Plan	17 areas
Drought Management Plan	d) Water Use Restriction Rule for Reservoirs (Existing 29 dams and proposed 59 dams)

Note: * The underlined numbers that are provided to each target area name correspond to the table "Proposed Areas Subject to Flood Disaster Management Plan" shown in Section 6.9 (2) e).

Source: JICA Study Team

Table 19.1.9 Summary of Proposed Environmental Management Plans (1/2)

Catch-ment Area	Target	Proposed Setting Point			Reserve[*1] (m^3/s)	Monitoring Point of WRM [*2]
LVNCA	Nzoia River	Environmental flow rate	1	Lower reaches of the Nzoia River : LVN-F1	34.1	1EE01
			2	Reference point (Webuye Town) : LVN-F2	15.9	1DA02
			3	Moi's Bridge Town : LVN-F3	2.5	1BB01
		Environmental monitoring	4	Lower reaches of the Nzoia River : LVN-M1	34.1	1EE01
			5	Reference point (Webuye Town) : LVN-M2	15.9	1DA02
	Yala River	Environmental flow rate	1	Reference point (Yala Town) : LVN-F4	6.7	1FG01
			2	Downstream of Nandi Forest Dam: LVN-F5	5.1	1FE02
		Environmental monitoring	3	Yala Swamp : LVN-M3	-	1FG03
	Lake Victoria	Environmental monitoring	1	Near river mouth of the Nzoia River : LVN-M4	-	-
			2	Near river mouth of the Yala River : LVN-M5	-	-
LVSCA	Nyando River	Environmental flow rate	1	Reference point (Ahero Town) : LVS-F1	1.7	1GD03
			2	Near Muhoroni Town : LVS-F2	1.9	1GD07
		Environmental monitoring	3	Reference point (Ahero Town): LVS-M1	1.7	1GD03
			4	Near Muhoroni Town : LVS-M2	1.9	1GD07
	Sondu River	Environmental flow rate	1	Reference point (Upstream of the Sondu Dam) : LVS-F3	10.5	1JG05
			2	Confluence point with the Itare River : LVS-F4	3.7	1JF08
		Environmental monitoring	3	Reference point (Upstream of the Sondu Dam) : LVS-M3	10.5	1JG05
			4	Confluence point with the Itare River : LVS-M4	3.7	1JF08
	Gucha - Migori River	Environmental flow rate	1	Confluence point of both rivers : LVS-F5	2.4	1KB05
			2	Reference point (Gucha River) : LVS-F6	0.4	1KB03
			3	Reference point (Migori River) : LVS-F7	1.5	1KC03
		Environmental monitoring	4	Confluence point of both rivers : LVS-M5	2.4	1KB05
			5	Reference point (Gucha River) : LVS-M6	0.4	1KB03
			6	Reference point (Migori River) : LVS-M7	1.5	1KC03
	Mara River	Environmental flow rate	1	Reference point (Upstream of the Masai-Mara National Park) : LVS-F8	4.3	1LA04
		Environmental monitoring	1	Reference point (Upstream of the Masai-Mara National Park) : LVS-M8	4.3	1LA04
	Lake Victoria	Environmental monitoring	1	Near river mouth of the Nyando River : LVS-M9	-	-
			2	Near river mouth of the Sondu River : LVS-M10	-	-
			3	Near river mouth of the Gucha River : LVS-M11	-	-
	Kisumu City and Homa Bay Town	Environmental monitoring	1	Kisumu City (Main discharge point: Lower reaches of the Kibos River): LVS-M12	-	-
			2	Homa Bay Town (Major discharge point) : LVS-M13	-	-
RVCA	Turkwel River	Environmental flow rate	1	Reference point (Lodwar Town) : RV-F1	0.0	2B21
			2	Confluence point with the Suam River (Downstream of the Turkwel Dam) : RV-F2	0.0	-
		Environmental monitoring	3	Reference point (Lodwar Town) : RV-M1	0.0	2B21
			4	Confluence point with the Suam River (Downstream of the Turkwel Dam) : RV-M2	0.0	-
	Kerio River	Environmental flow rate	1	Reference point (Downstream of confluence with the Arror River) : RV-F3	0.0	2C16
		Environmental monitoring	2	Downstream of the South Turkana National Reserve : RV-M3	-	-
			3	Reference point (Downstream of confluence with the Arror River) : RV-M4	0.0	2C16
	Ewaso Ng'iro South River	Environmental flow rate	1	Reference point (Narok Town) : RV-F4	0.0	2K06
		Environmental monitoring	2	Lower reaches of the Ewaso Ng'iro South River: RV-M5	0.0	2K04
	Lake Turkana	Environmental flow rate	1	Representative point : RV-F5	-	2B13
		Environmental monitoring	2	Representative point : RV-M6	-	2B13
	Lake Baringo	Environmental flow rate	1	Representative point : RV-F6	-	2EH1
		Environmental monitoring	2	Representative point : RV-M7	-	2EH1
	Lake Bogoria	Environmental flow rate	1	Representative point : RV-F7	-	2EB10
		Environmental monitoring	2	Representative point : RV-M8	-	2EB10
	Lake Nakuru	Environmental flow rate	1	Representative point : RV-F8	-	2FC04
		Environmental monitoring	2	Representative point : RV-M9	-	2FC04
	Lake Elementaita	Environmental flow rate	1	Representative point : RV-F9	-	2FA08
		Environmental monitoring	2	Representative point : RV-M10	-	2FA08

Table 19.1.9 Summary of Proposed Environmental Management Plans (2/2)

Catch-ment Area	Target	Proposed Setting Point			Reserve*1 (m^3/s)	Monitoring Point of WRM *2
RVCA (Contd.)	Lake Naivasha	Environmental flow rate	1	Representative point : RV-F10	-	2GD06
		Environmental monitoring	2	Representative point : RV-M11	-	2GD06
	Lake Magadi	Environmental flow rate	1	Representative point : RV-F11	-	New
		Environmental monitoring	2	Representative point : RV-M12	-	New
	Nakuru and Naivasha towns	Environmental monitoring	1	Nakuru Town (Main discharge channel) : RV-M13	-	-
			2	Naivasha Town (Main discharge channel) : RV-M14	-	-
ACA	Athi River	Environmental flow rate	1	Reference point (Confluence point with the Tsavo River) : ACA-F1	8.9	3HA12
			2	Upstream of Tsavo national parks : ACA-F2	9.8	3F09
			3	Reference point (Kangundo Town) : ACA-F3	8.6	3DB01
		Environmental monitoring	4	Reference point (Confluence point with the Tsavo River) : ACA-M1	8.9	3HA12
			5	Upstream of Tsavo national parks : ACA-M2	9.8	3F09
			6	Reference point (Kangundo Town) : ACA-M3	8.6	3DB01
	Lumi River	Environmental flow rate	1	Reference point : ACA-F4	0.0	3J15
		Environmental monitoring	2	Reference point : ACA-M4	0.0	3J15
	Nairobi River	Environmental monitoring	1	Downstream of Nairobi City : ACA-M5	1.1	3BA29
	Lake Chala	Environmental flow rate	1	Representative point : ACA-F5	-	3J12
		Environmental monitoring	2	Representative point : ACA-M6	-	3J12
	Lake Jipe	Environmental flow rate	1	Representative point : ACA-F6	-	3J02
		Environmental monitoring	2	Representative point : ACA-M7	-	3J02
	Lake Amboseli	Environmental monitoring	1	Representative point : ACA-M8	-	-
	Nairobi and Mombasa cities	Environmental monitoring	1	Nairobi City (Main discharge point): ACA-M9	-	-
			2	Mombasa City (Main discharge point) : ACA-M10	-	-
TCA	Tana River	Environmental flow rate	1	Reference point (Downstream of Garissa Town) : TCA-F1	53.5	4G01
			2	Upper reaches of the Meru National Park : TCA-F2	52.1	4F13
			3	Reference point(Upstream of Masinga Dam) : TCA-F3	1.5	4BE01
		Environmental monitoring	4	Tana Delta : TCA-M1	42.7	4G02
			5	Upstream of the Tana River Primate National Reserve : TCA-M2	-	-
			6	Reference point (Downstream of Garissa Town) : TCA-M3	53.5	4G01
			7	Upstream of the Meru National Park : TCA-M4	52.1	4F13
			8	Reference point (Upstream of Masinga Dam) : TCA-M5	1.5	4BE01
	Chania River	Environmental flow rate	1	Reference point (Downstream of Thika Town) : TCA-F4	8.5	4CC03
		Environmental monitoring	2	Reference point (Downstream of Thika Town): TCA-M6	8.5	4CC03
ENNCA	Ewaso Ng'iro North River	Environmental flow rate	1	Reference point (Archers' Post Town) : ENN-F1	0.0	5ED01
			2	Downstream of confluence point with the Ewaso Narok River: ENN-F2	1.3	5DC02
		Environmental monitoring	3	Reference point (Archers' Post Town) : ENN-M1	0.0	5ED01
			4	Downstream of confluence point with the Ewaso Narok River: ENN-M2	1.3	5DC02
Total		Environmental flow rate	36 points		-	
		Environmental monitoring	50 points		-	

Note: *1 Reserve includes the water for ecological needs and basic human needs as mentioned in WRMA Guidelines for Water Allocation.

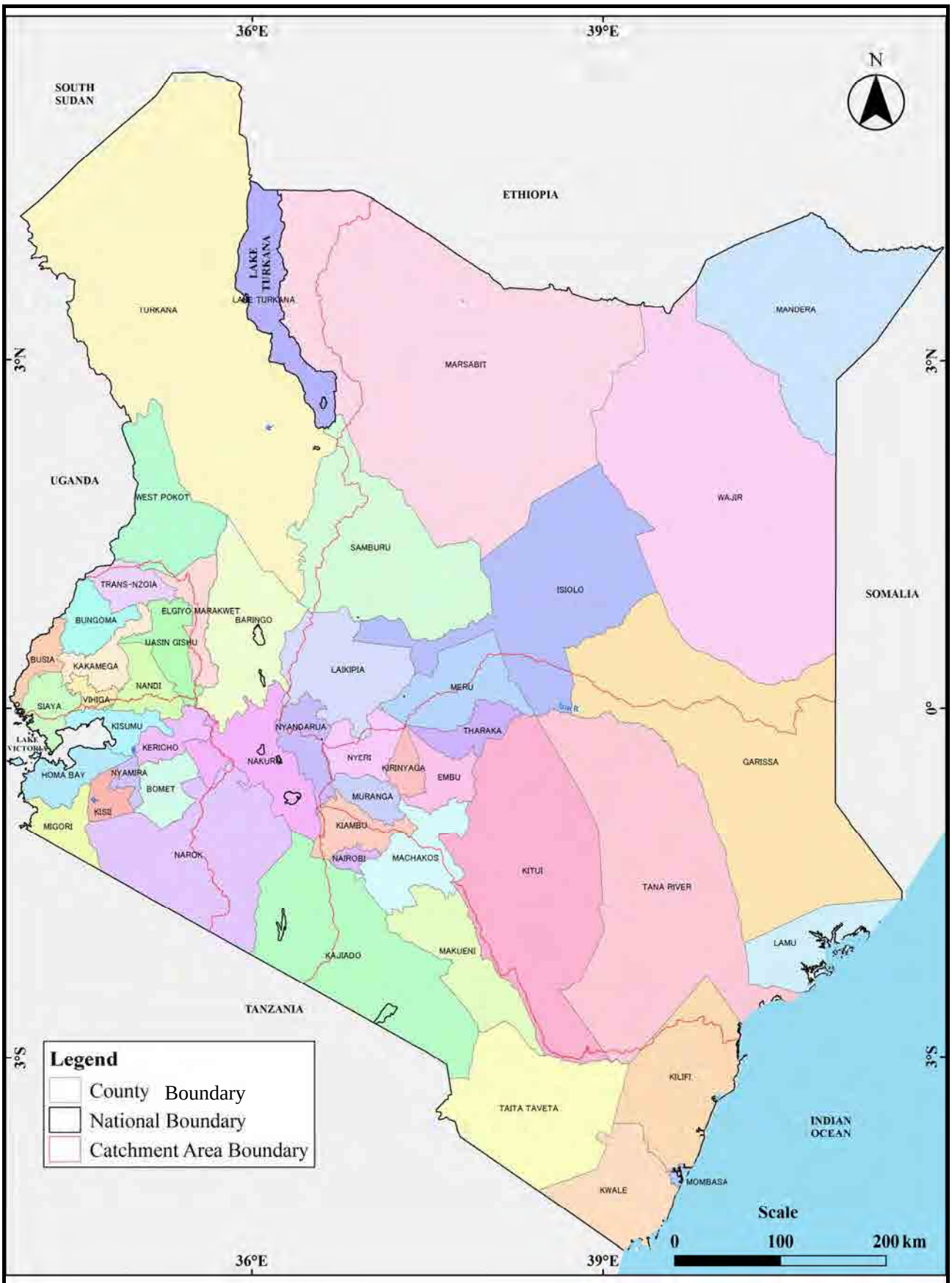
*2 WRM = Water Resource Management

Source: JICA Study Team referring to existing water resources monitoring points.

Figures

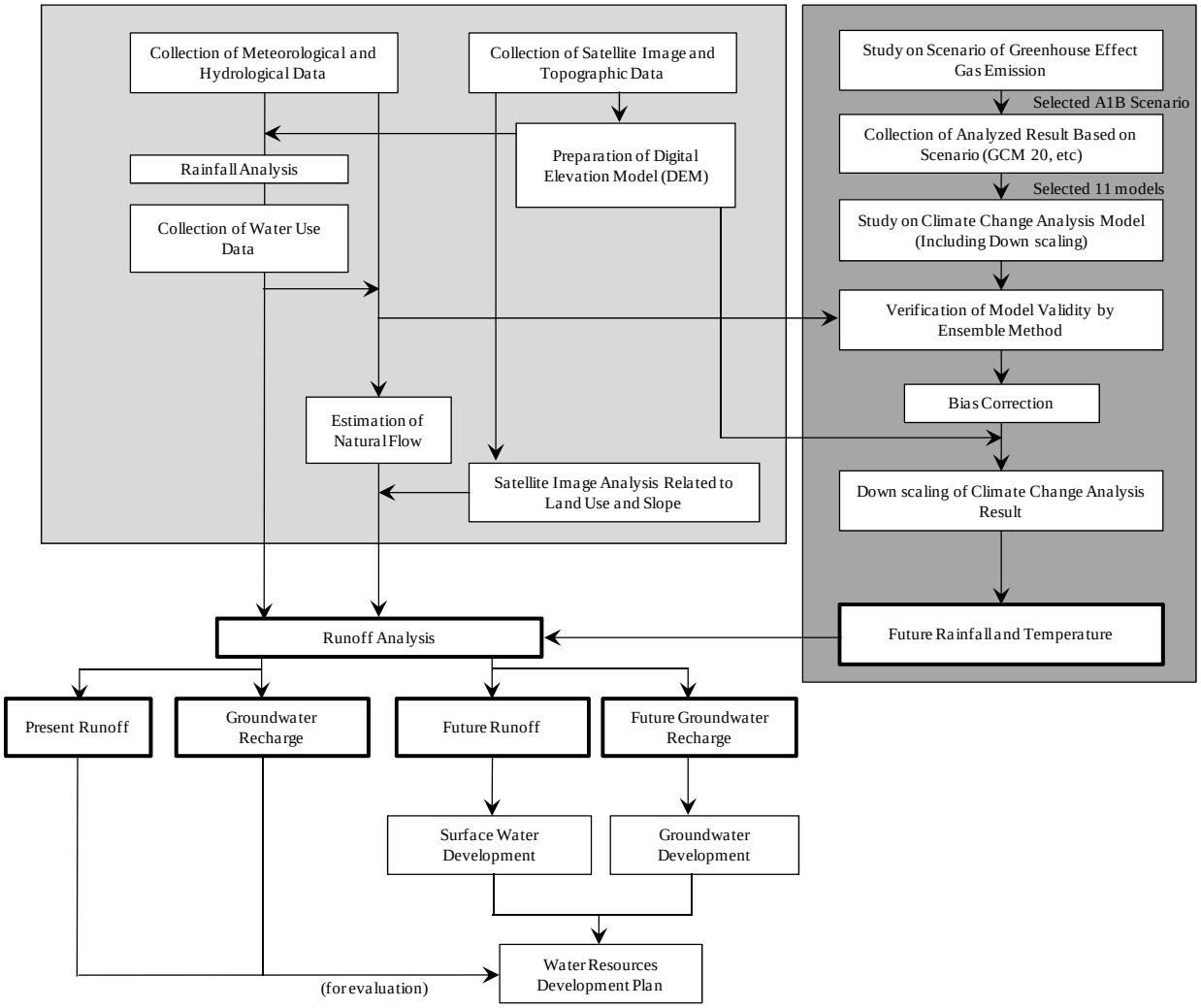
Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 1.3.1 Catchment Areas of WRMA**
JAPAN INTERNATIONAL COOPERATION AGENCY	



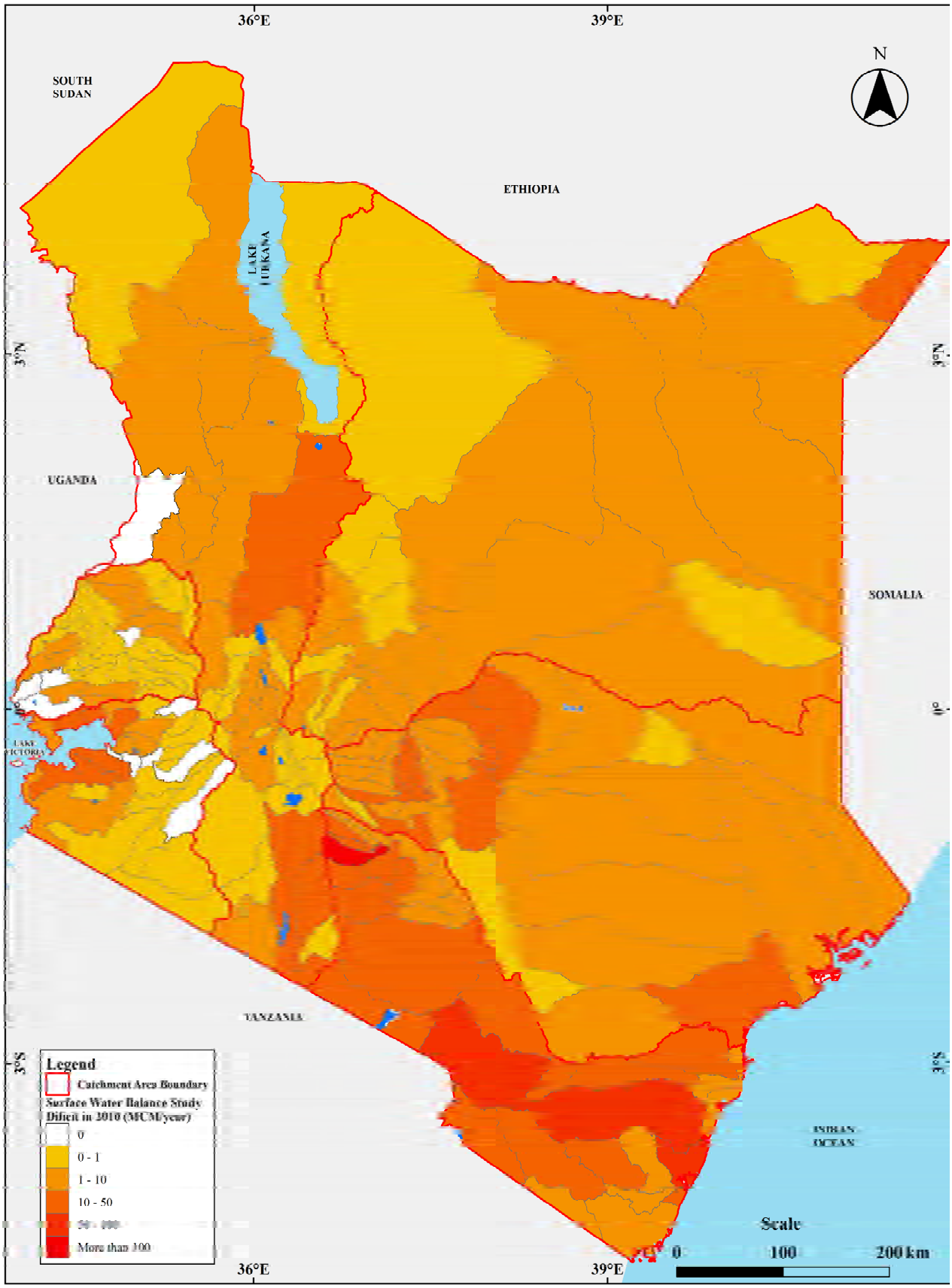
Source: JICA Study Team based on GIS data from Kenya National Bureau of Statistics

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 2.2.1 Administrative Boundary by County**
JAPAN INTERNATIONAL COOPERATION AGENCY	



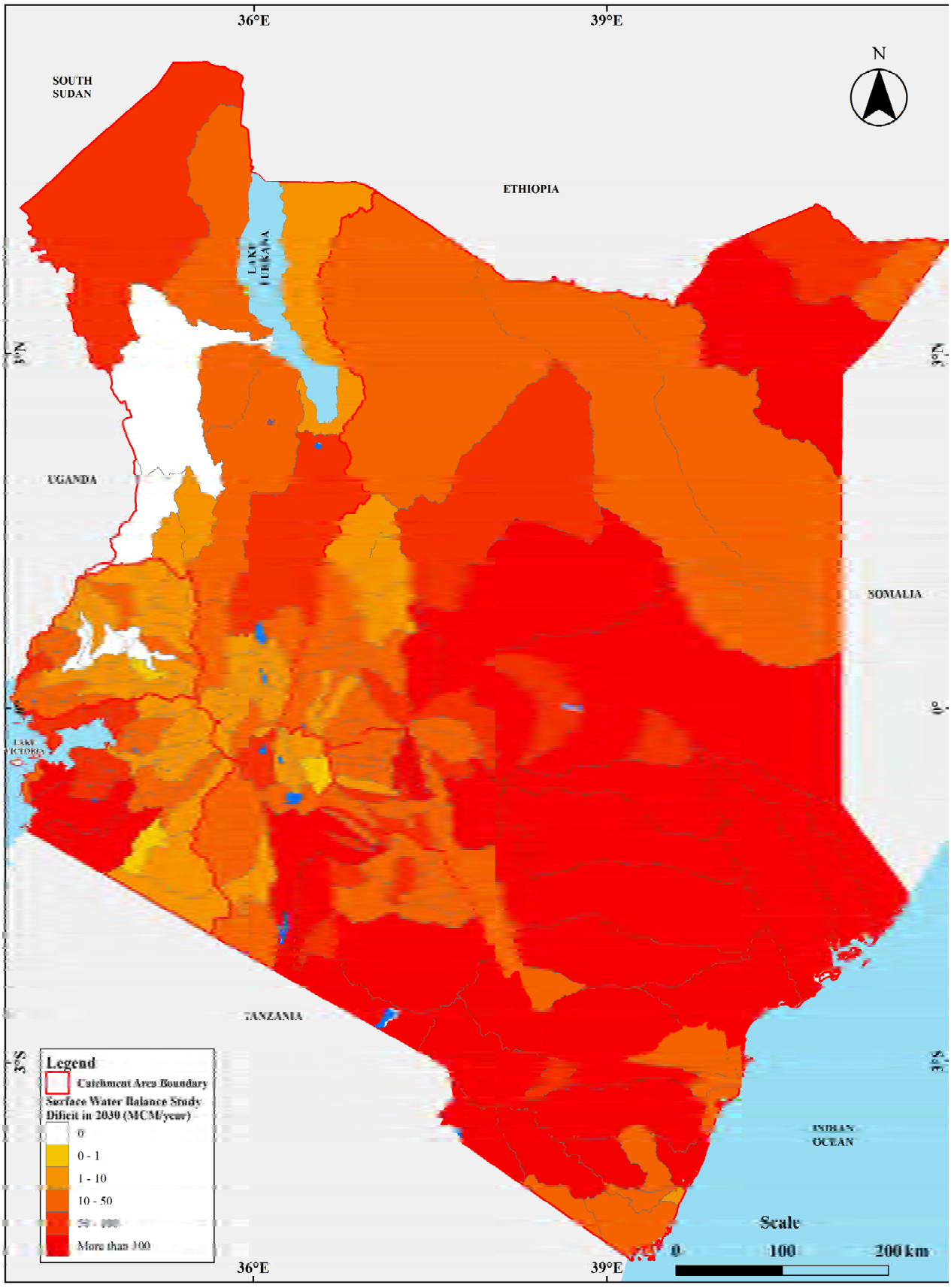
Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 4.1.1 Flowchart for Projection on Effects of Future Climate Change and Formulation of Water Resources Development Plan**
JAPAN INTERNATIONAL COOPERATION AGENCY	



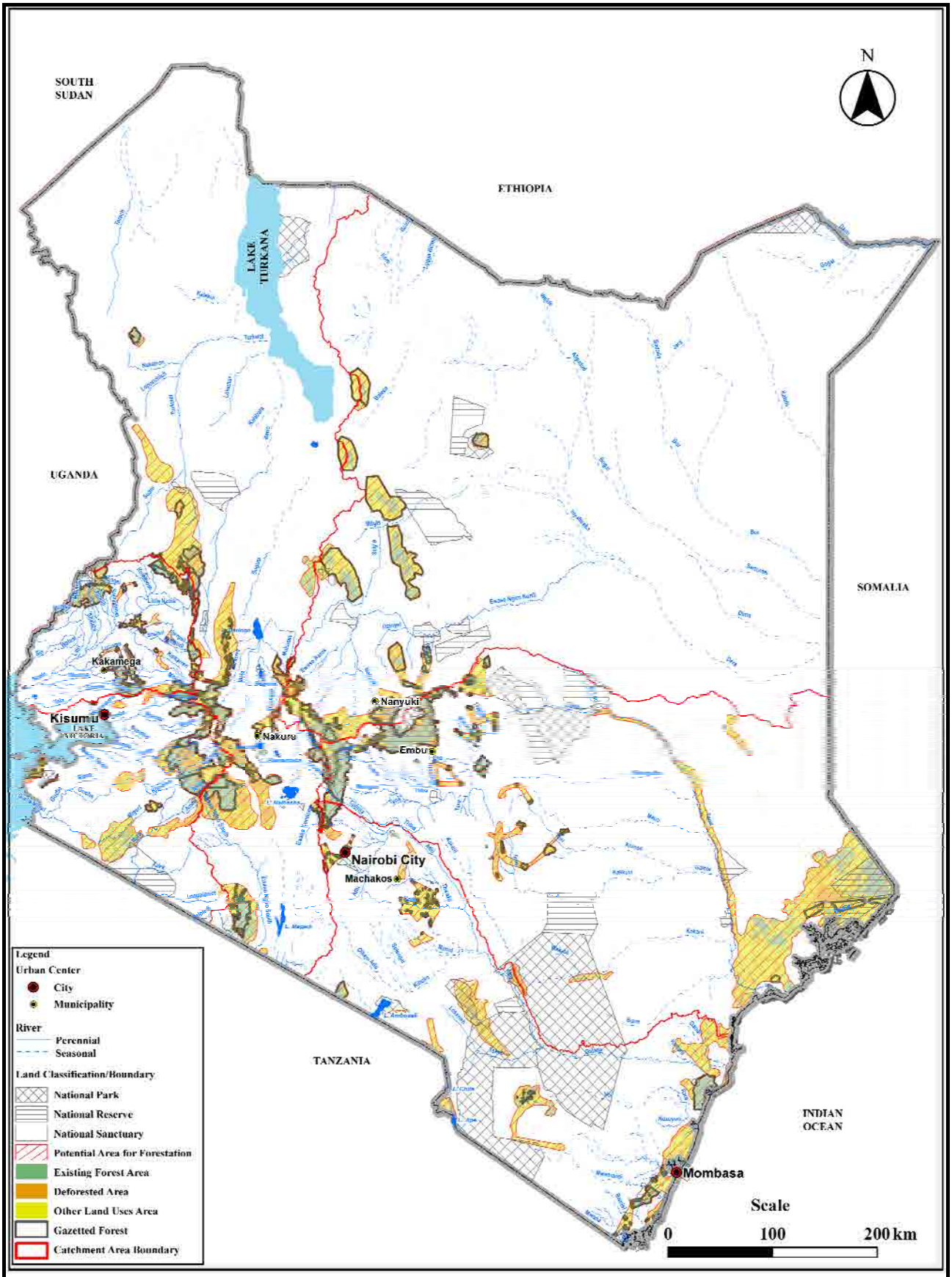
Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 5.3.1** **Annual Deficit for 10-Year Probable Drought under Present (2010) Water Demand Condition**
JAPAN INTERNATIONAL COOPERATION AGENCY	



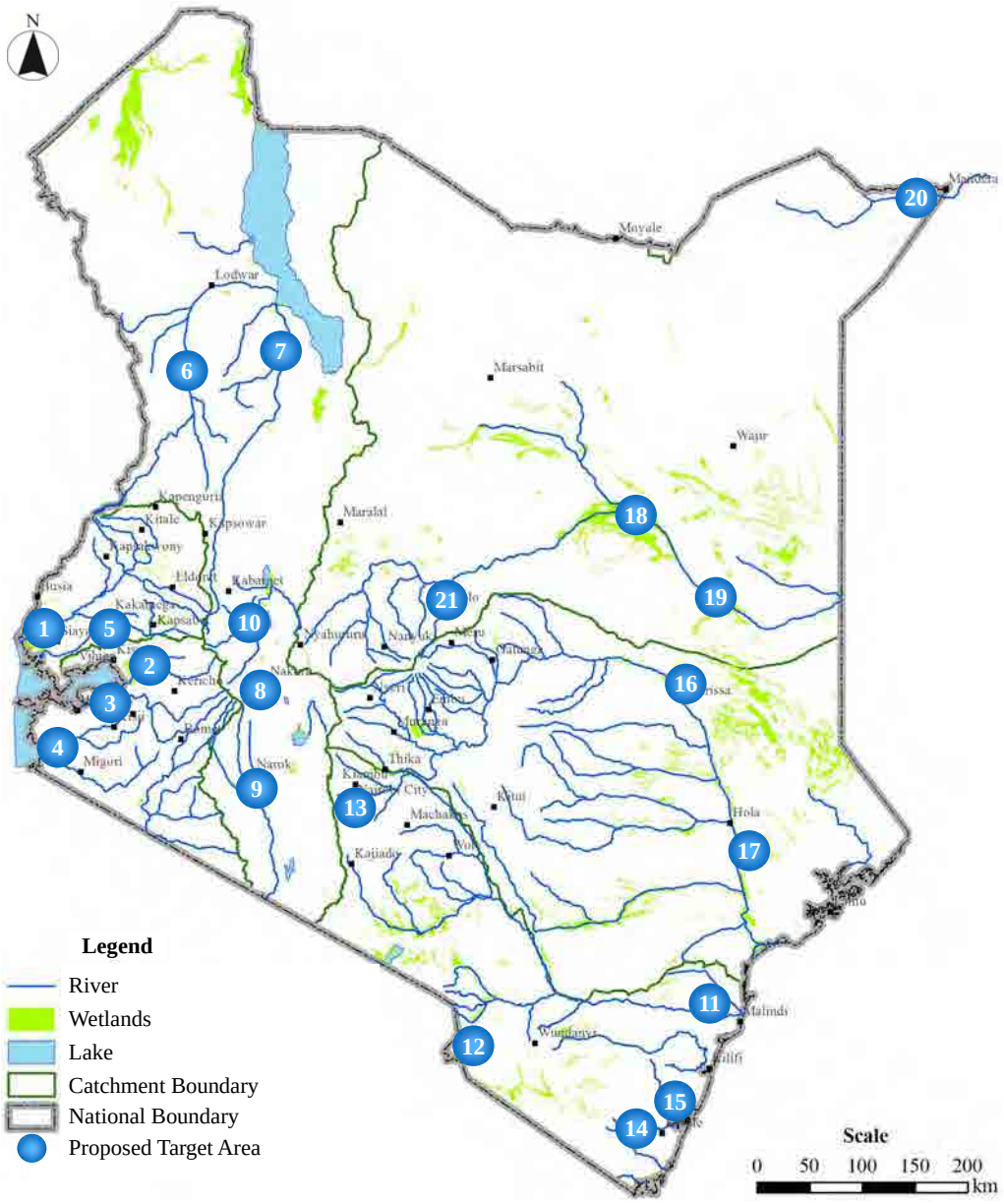
Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 5.3.2** **Annual Deficit for 10-Year Probable Drought under Future (2030) Water Demand Condition**
JAPAN INTERNATIONAL COOPERATION AGENCY	



Source: JICA Study Team

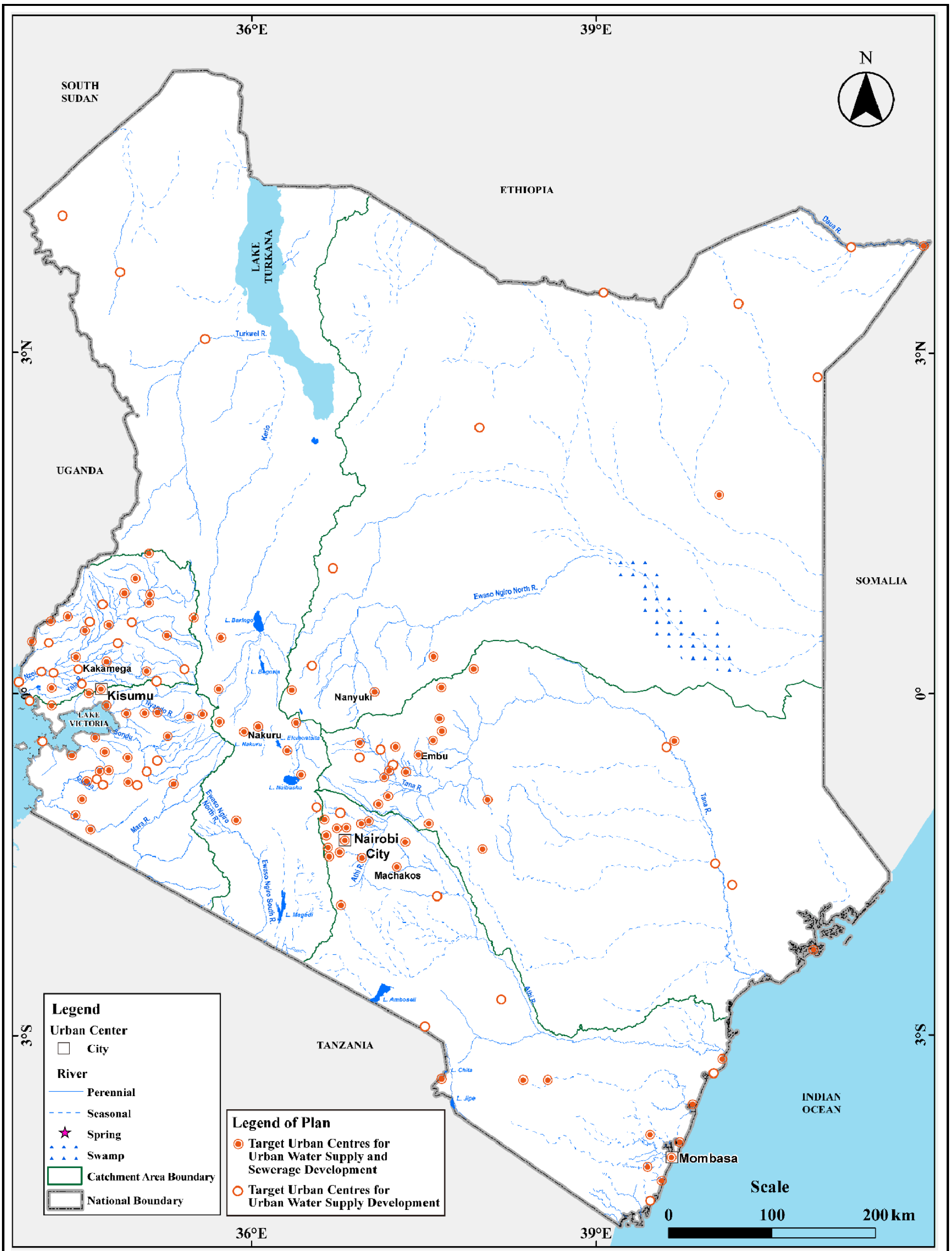
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 6.8.1 Current Situation of Forest Areas and Potential Areas for Forestation**
JAPAN INTERNATIONAL COOPERATION AGENCY	



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

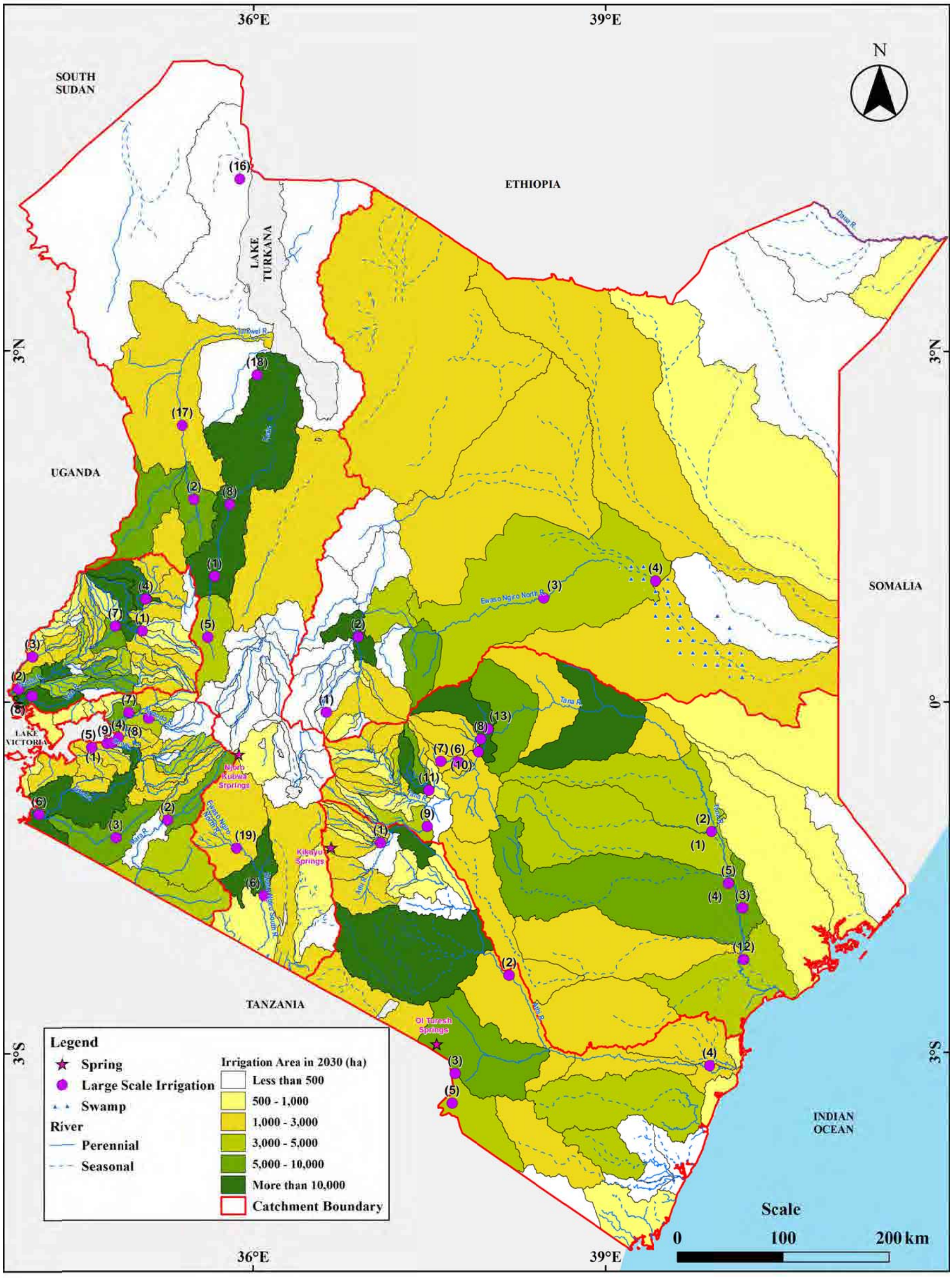
Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 6.9.1 Proposed Target Areas for Flood Disaster Management Plan**
JAPAN INTERNATIONAL COOPERATION AGENCY	



Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030 JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure 7.3.1** **Target Urban Centres for Proposed Water Supply and Sanitation Development Plans**



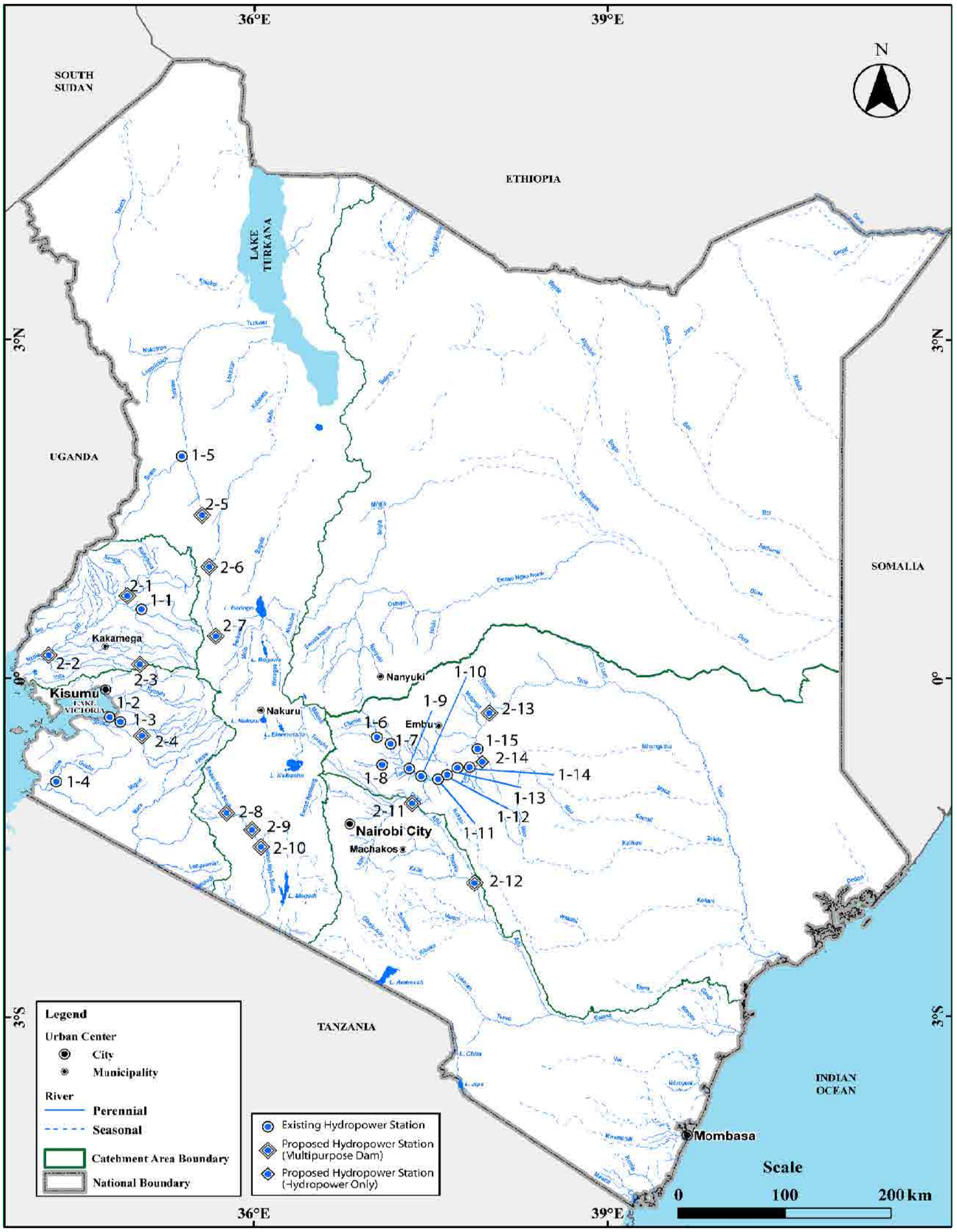
LVNCA		LVSCA		RVCA		ACA		TCA		ENNCA	
No	Name of Project	No	Name of Project	No	Name of Project	No	Name of Project	No	Name of Project	No	Name of Project
1.	Kibolo Irrigation	1.	Ahero and West Kano Irrigation	1.	Arror Irrigation	1.	Kanzalu Irrigation Exteision	1.	High Grand Falls Irrigation	1.	Kieni Irrigation
2.	Lower Nzoia Irrigation	2.	Amala Irrigation	2.	Embobut Irrigation	2.	Kibwezi Irrigation Extention	2.	Hola Irrigation Expansion	2.	Kihoto Irrigation
3.	Lower Sio Irrigation	3.	Ilooiterre Irrigation	3.	Kimwarer Irrigation	3.	Mt. Kilimanjaro Irrigation	3.	Hola Irrigation Greater Extention	3.	Kom (Wajir) Irrigation
4.	Moi's Bridge Irrigation	4.	Kano Plain Irrigation	4.	Lower Ewaso Ng'iro Irrigation	4.	Taita Taveta Irrigation	4.	Kora Irrigation		
5.	Upper Nzoia Irrgation	5.	Lower Kuja Irrigation (Stage-1)	5.	Norera Irrigation						
6.	Yala Swamp Drainage & Irrigation	6.	Lower Kuja Irrigation (Stage-2)	6.	Oldekesi Irrigation						
		7.	Nandi Forest Irrigation	7.	Perkera Irrigation Extention						
		8.	Nyando Irrigation	8.	Todonyang-Omo Irrigation						

Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

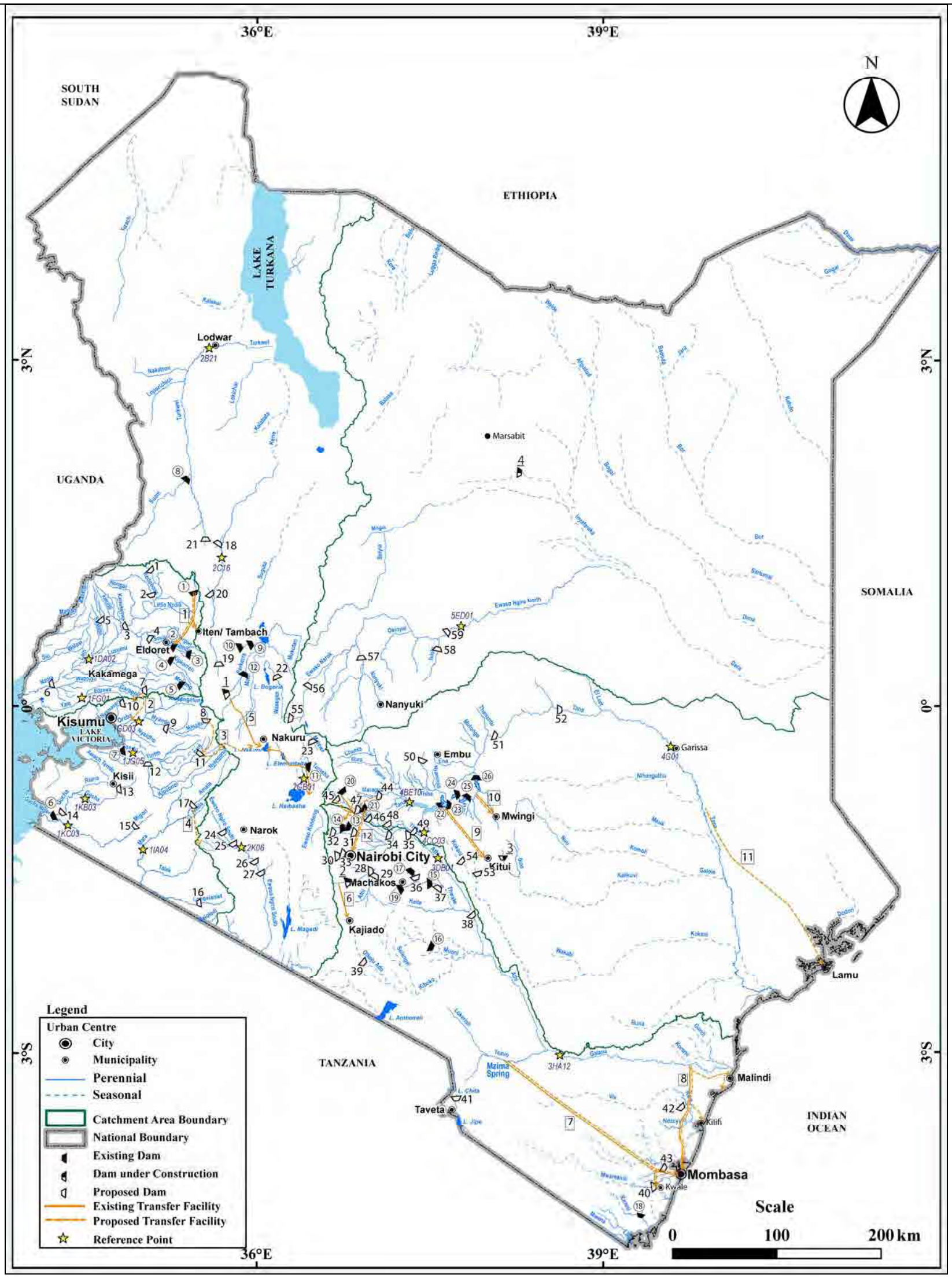
Figure 7.5.1
Proposed Irrigation Development Plan



No.	Existing Hydropower Stations	Installed Capacity	No.	Proposed Hydropower Stations	Installed Capacity
1-1	Sosiani	0.4 MW	2-1	Nzoia (34B)	16 MW
1-2	Sangoro	21 MW	2-2	Nzoia (42A)	25 MW
1-3	Sondu/Miriu	60 MW	2-3	Nandi Forest	50 MW
1-4	Gogo Falls	2 MW	2-4	Magwagwa	115 MW
1-5	Turkwel	106 MW	2-5	Embobut	45 MW
1-6	Sagana	1.5 MW	2-6	Arror	80 MW
1-7	Mesco	0.35 MW	2-7	Kimwarer	20 MW
1-8	Wanji	7.4 MW	2-8	Oletukat	36 MW
1-9	Tana	14.8 MW	2-9	Leshota	54 MW
1-10	Ndula	2 MW	2-10	Oldorko	90 MW
1-11	Masinga	40 MW	2-11	Munyu	40 MW
1-12	Kamburu	94.2 MW	2-12	Thwake	20 MW
1-13	Gitaru	225 MW	2-13	High Grand Falls	(Stage 1) 500 MW
1-14	Kindaruma	40 MW			(Stage 2) +200 MW
1-15	Kiambere	164 MW	2-14	Karura	90 MW
	Total	778.65 MW		Total	1,381 MW

Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 7.6.1 Proposed Hydropower Development Plan**
JAPAN INTERNATIONAL COOPERATION AGENCY	



Existing Dams													
①	Moiben (Chebara)	②	Twin Rivers	③	Ellegirini	④	Kipkarren	⑤	Lessos	⑥	Gogo Falls	⑦	Sondu/Miriu
⑧	Turkwel	⑨	Chemeron	⑩	Kirandich	⑪	Turasha	⑫	Aram	⑬	Ruiru	⑭	Bathi
⑮	Mulima	⑯	Manooni	⑰	Muoni	⑱	Kikoneni	⑲	Maruba	⑳	Sasumua	㉑	Thika (Ndakaini)
㉒	Masinga	㉓	Kamburu	㉔	Gitaru	㉕	Kindaruma	㉖	Kiambere				
Dams under Construction													
1	Chemususu	2	Kiserian	3	Umaa	4	Badasa						
Proposed Dams													
1	Siyoi	2	Moi's Bridge	3	Nzoia 34B	4	Kibolo	5	Teremi	6	Nzoia 42A	7	Nandi Forest
8	Londiani	9	Nyando (Koru)	10	Kibos	11	Itare	12	Magwagwa	13	Bunyunyu	14	Katieno
15	Ilooiterre	16	Sand River (Naikara)	17	Amala	18	Murung-Sebit	19	Kimwarer	20	Arror	21	Embobut
22	Waseges	23	Malewa	24	Upper Narok	25	Oletukat	26	Leshota	27	Oldorko	28	Upper Athi
29	Stony Athi	30	Kikuyu	31	Ruaka (Kiambaa)	32	Kamiti 1	33	Ruiru-A (Ruiru 2)	34	Ndarugu (Ndarugu 1)	35	Munyu
36	Mbuuni	37	Kiteta	38	Thwake	39	Olkishunki	40	Pemba	41	Lake Chala	42	Rare
43	Mwachi	44	Maragua 4	45	Ndiara	46	Chania-B	47	Karimenu 2	48	Thika 3A	49	Yatta
50	Thiba	51	High Grand Falls	52	Kora	53	Mutuni	54	Kitimui	55	Nyahururu	56	Rumuruti
57	Kihoto	58	Isiolo	59	Archers' Post								
Water Transfer Schemes													
1	Moiben Dam to Eldoret/ Iten/ Tambach (Expansion)	2	Nandi Forest Dam to LVSCA (New)	3	Itare and Londiani Dams to Nakuru (New)	4	Amala Transfer from Amala Dam to RVCA (New)						
5	Chemususu Dam to Nakuru (Under Construction)	6	Kiserian Dam to Kajiado (Under Construction)	7	Mzima Springs to Mombasa (Expansion)	8	Sabaki Scheme from Athi River to Mombasa (Expansion)						
9	Masinga Dam to Kitui (Expansion)	10	Kiambere Dam to Mwingi (Expansion)	11	High Grand Falls Dam to Lamu (New)	12	TCA to Nairobi in ACA (Expansion)						

Source: JICA Study Team

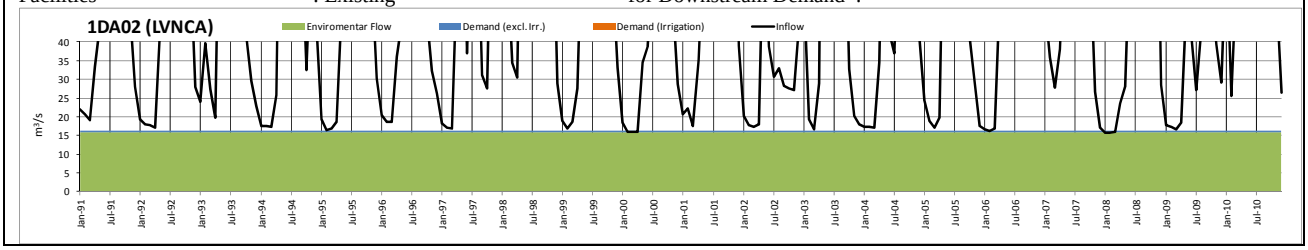
THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

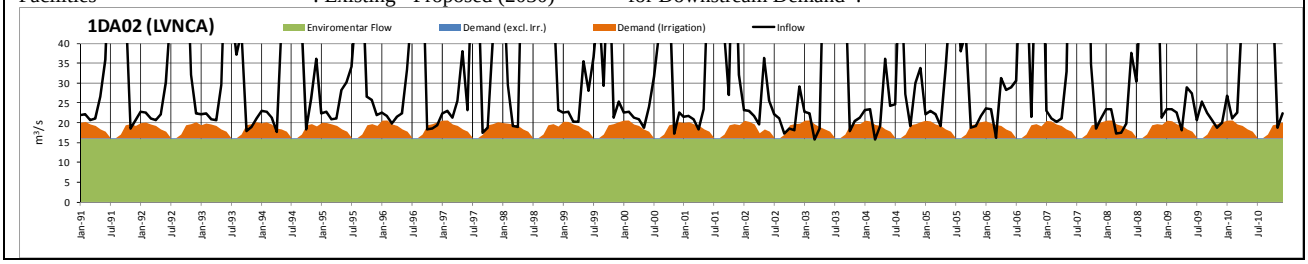
Figure 7.7.1
Proposed Dams and Water Transfers Plan

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

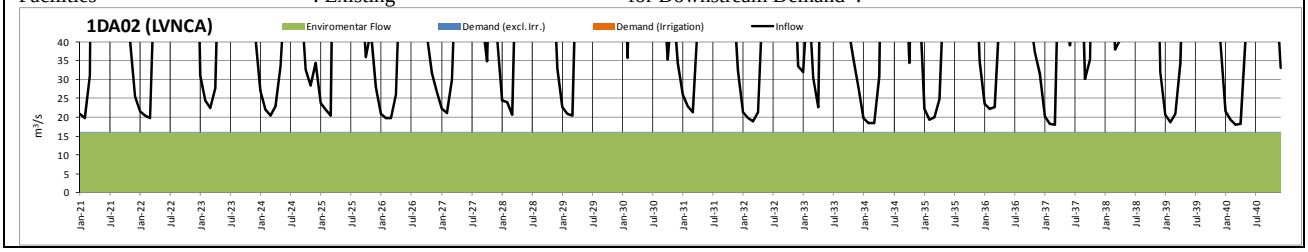
River Flow	: Present (1991-2010)	Reserve:	15.9	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained		
Facilities	: Existing	for Downstream Demand*:	0.2	(m^3/s)



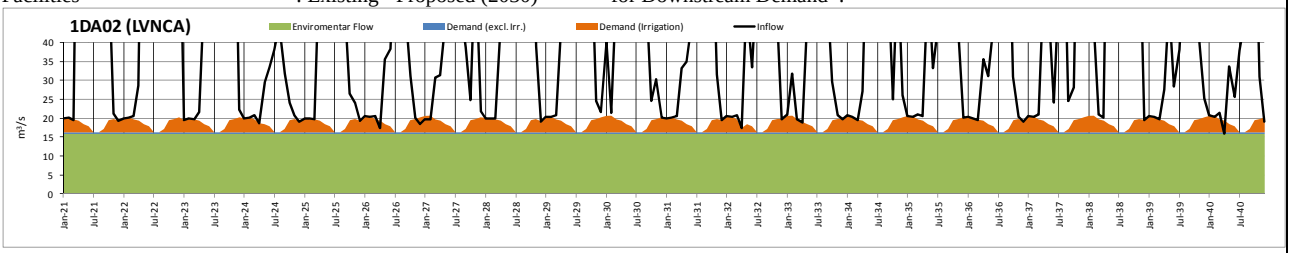
River Flow	: Present (1991-2010)	Reserve:	15.9	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained		
Facilities	: Existing +Proposed (2030)	for Downstream Demand*:	3.6	(m^3/s)



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



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



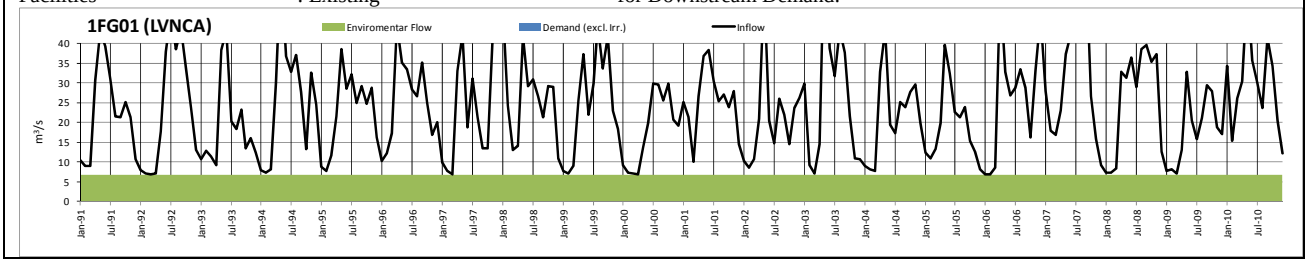
Note: * Irrigation water demand is the average irrigation water demand during March, April, May and June.

Source: JICA Study Team

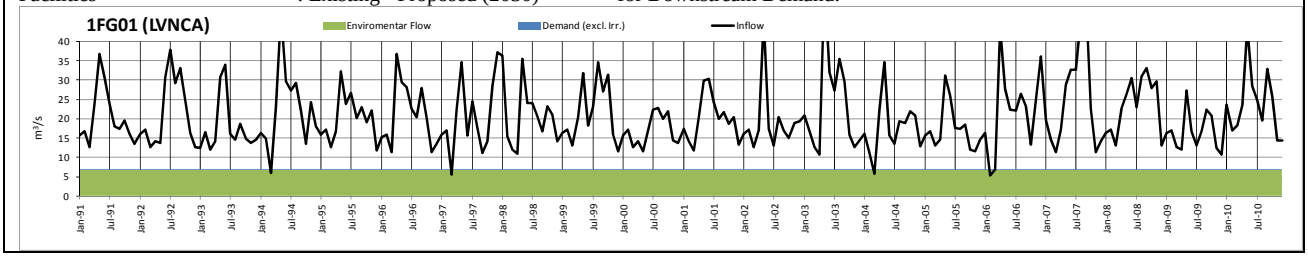
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 7.7.2 River Flow at Reference Point 1DA02 under Present and Future Water Demands and Facilities Conditions (LVNCA) (1/2)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

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

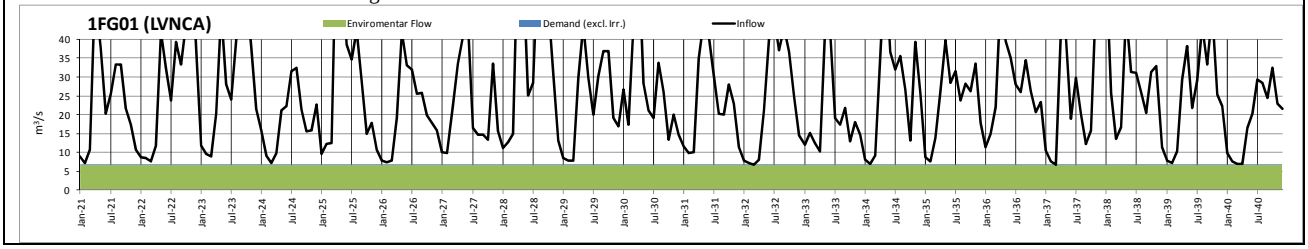
River Flow	: Present (1991-2010)	Reserve:	6.7	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained for Downstream Demand:	0.1	(m^3/s)
Facilities	: Existing			



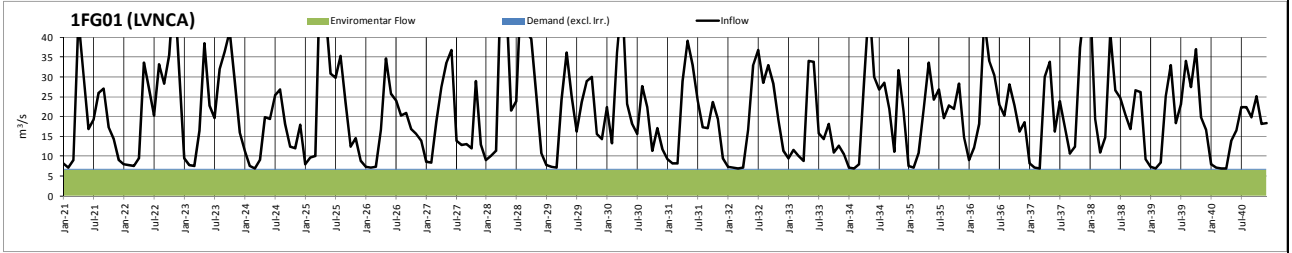
River Flow	: Present (1991-2010)	Reserve:	6.7	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained for Downstream Demand:	0.2	(m^3/s)
Facilities	: Existing +Proposed (2030)			



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

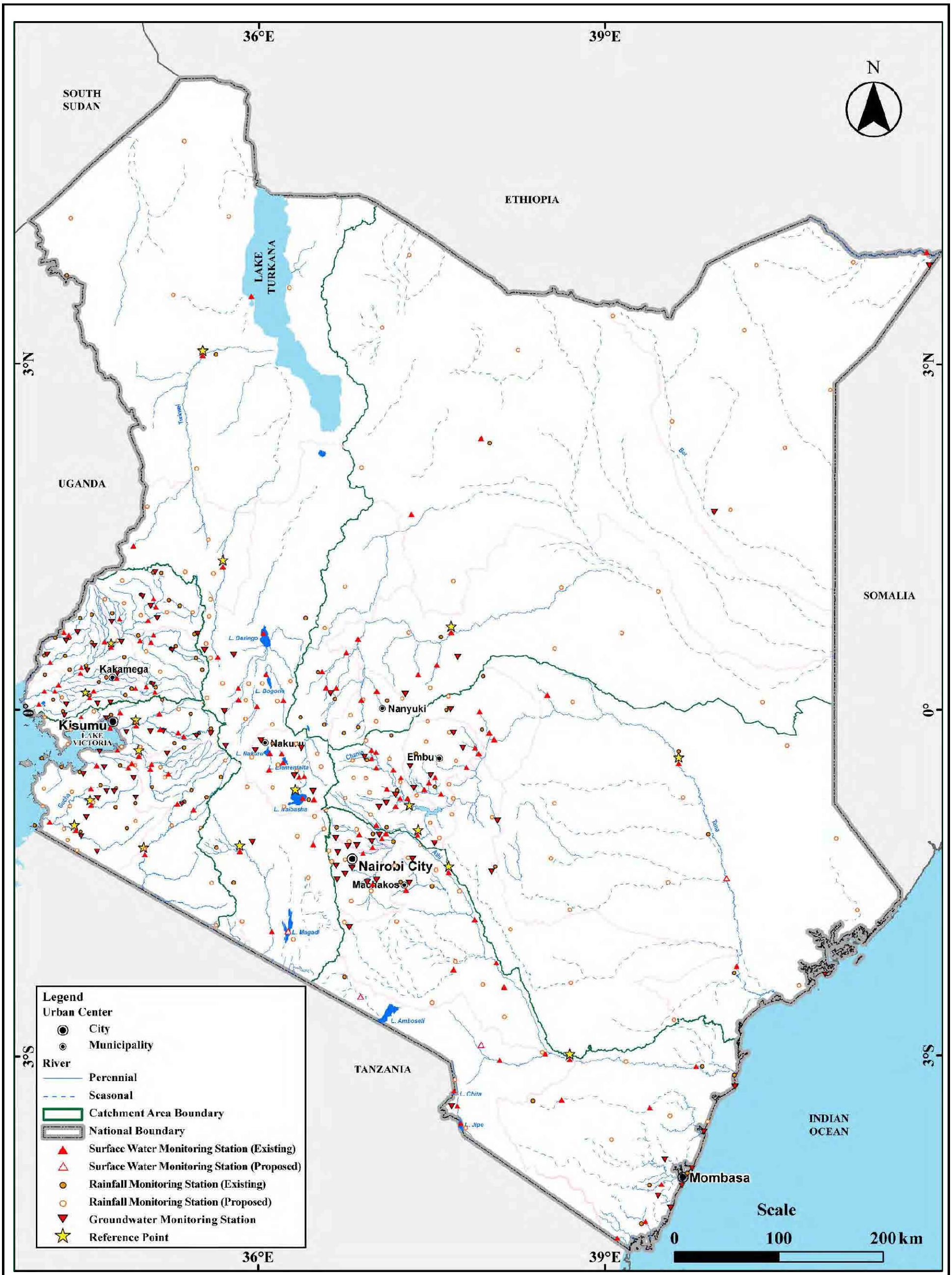


River Flow	: Future (2021-2040)	Reserve:	6.7	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained for Downstream Demand:	0.2	(m^3/s)
Facilities	: Existing +Proposed (2030)			



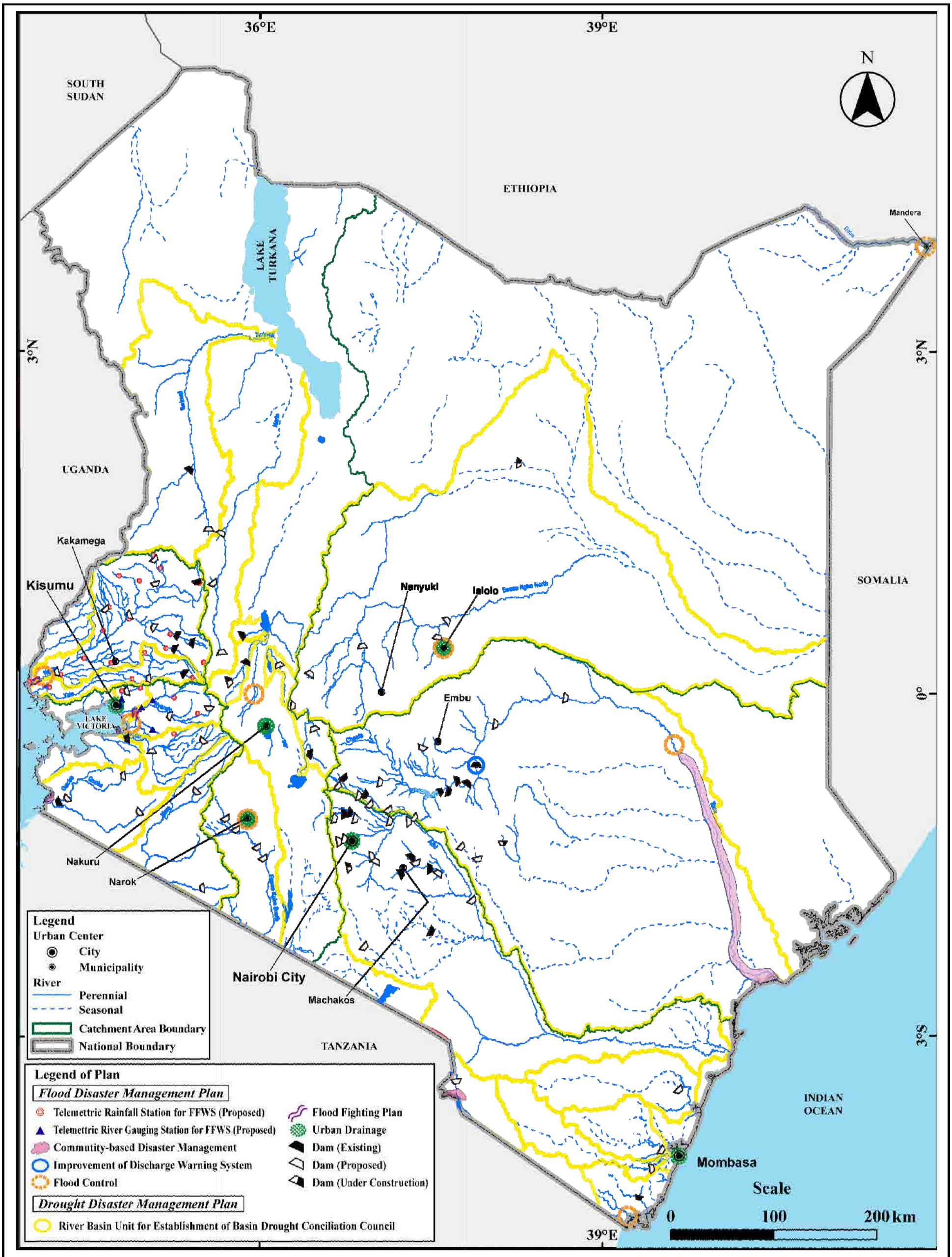
Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 7.7.2 River Flow at Reference Point 1FG01 under Present and Future Water Demands and Facilities Conditions (LVNCA) (2/2)**
JAPAN INTERNATIONAL COOPERATION AGENCY	



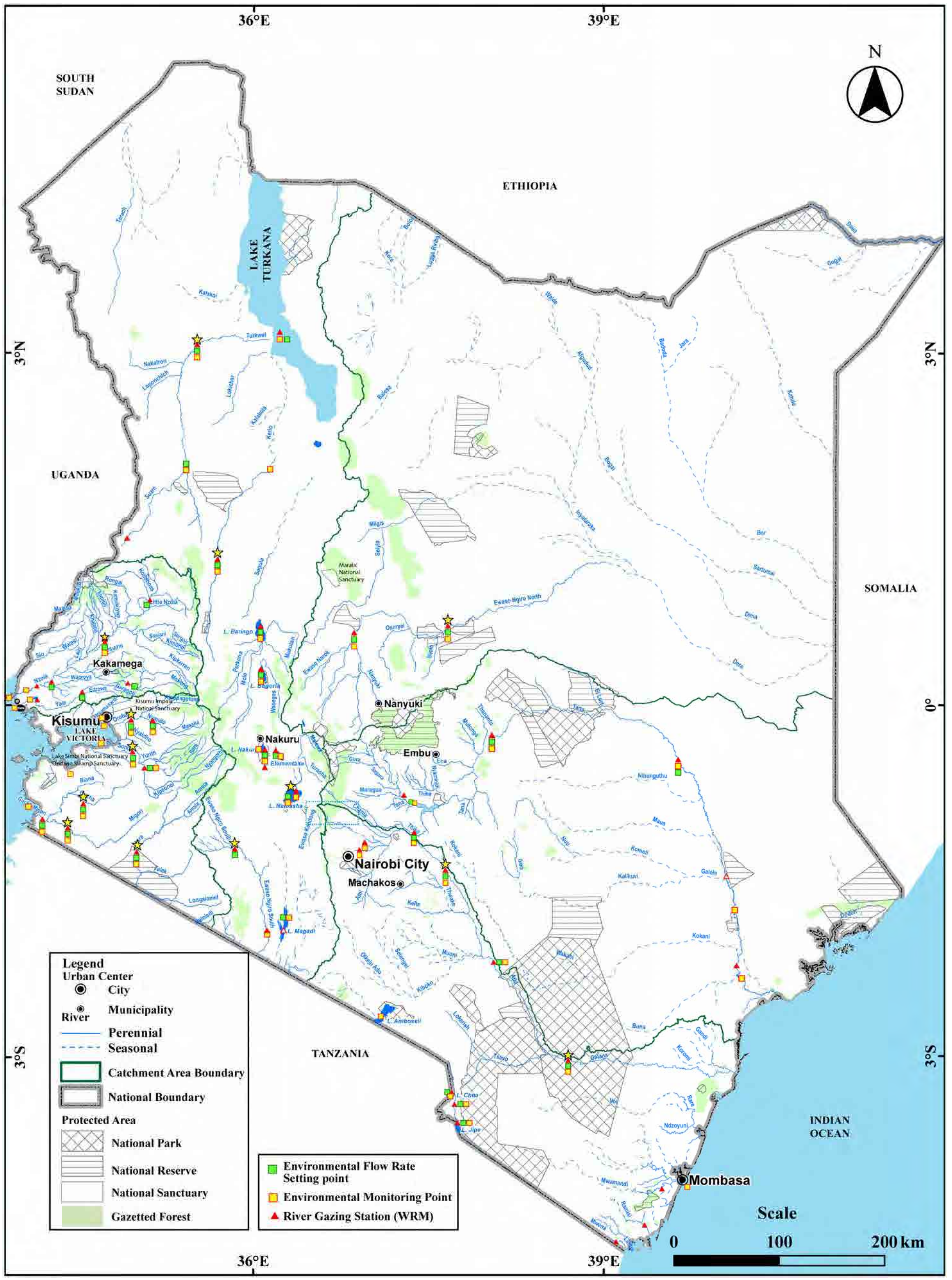
Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 7.8.1** **Proposed Monitoring Network for Water Resources Management**
JAPAN INTERNATIONAL COOPERATION AGENCY	



Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 7.9.1** **Proposed Flood and Drought Disaster Management Plan**
JAPAN INTERNATIONAL COOPERATION AGENCY	

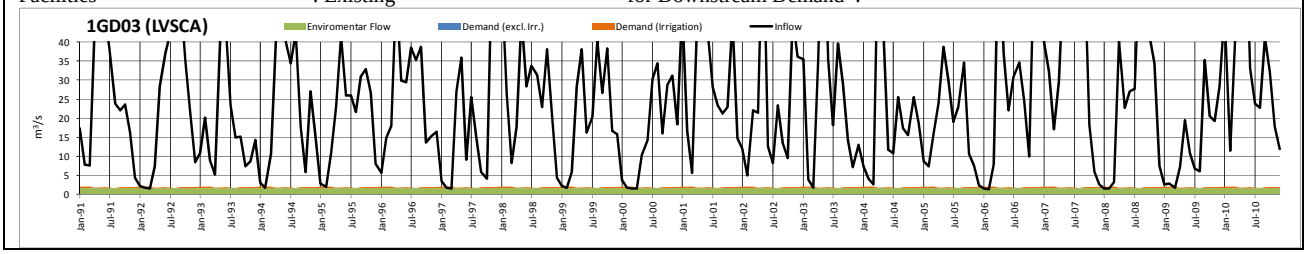


Source: JICA Study Team

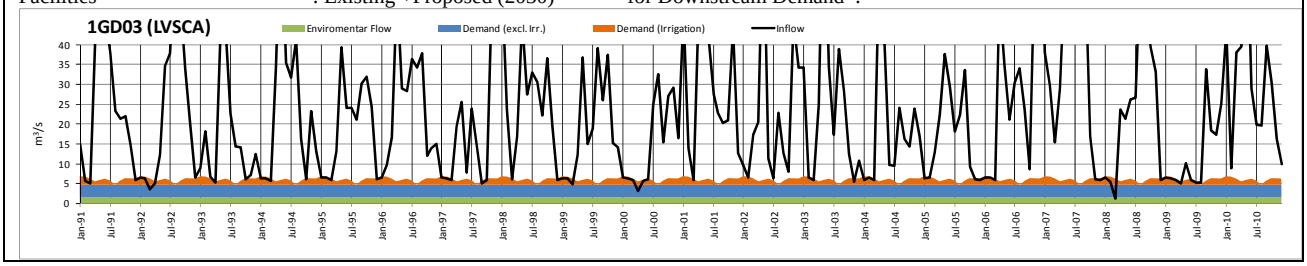
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 7.10.1 Proposed Environmental Management Plan**
JAPAN INTERNATIONAL COOPERATION AGENCY	

River Name: Nyando River (LVSCA)
Reference Point: 1GD03

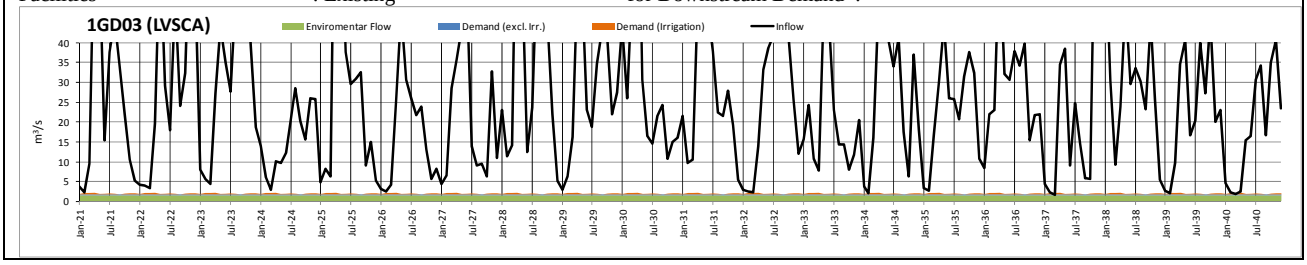
River	: Present (1991-2010)	Reserve:	1.6	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained	0.4	(m^3/s)
Facilities	: Existing	for Downstream Demand*:		



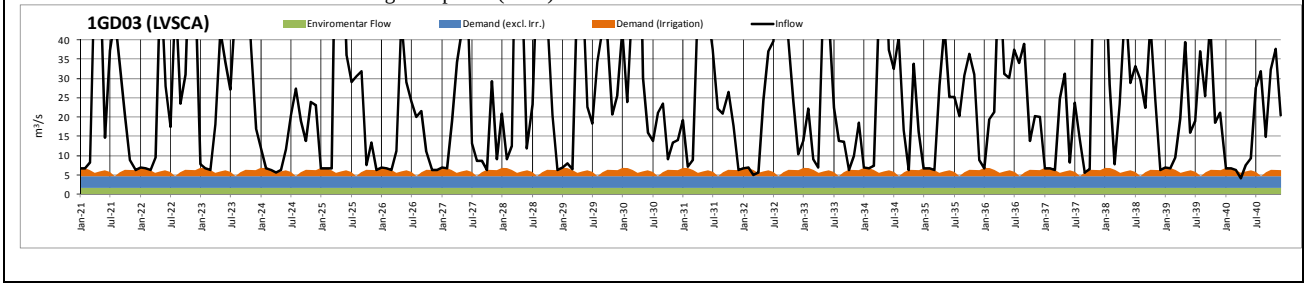
River	: Present (1991-2010)	Reserve:	1.6	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained	4.5	(m^3/s)
Facilities	: Existing +Proposed (2030)	for Downstream Demand*:		



River	: 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	: 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*:		



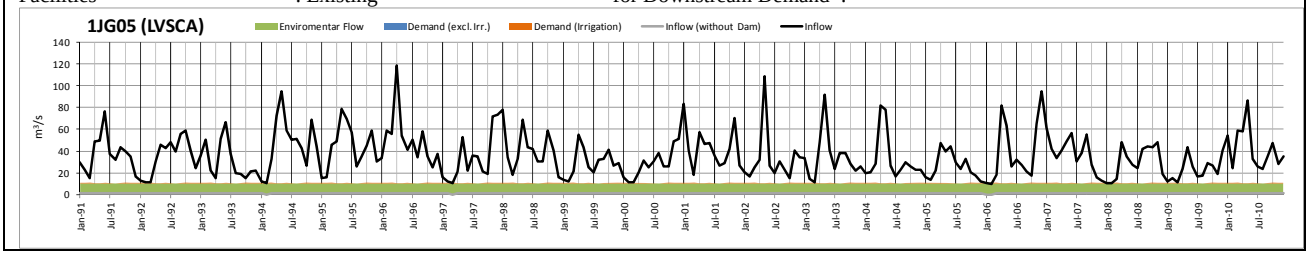
Note: * Irrigation water demand is the average irrigation water demand during March, April, May and June.

Source: JICA Study Team

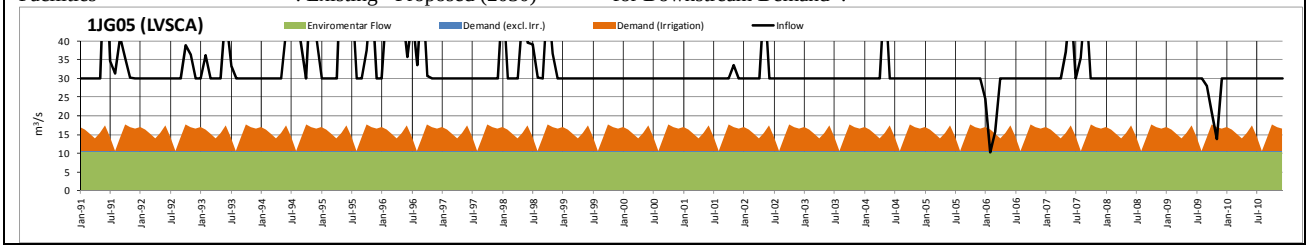
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 8.7.1 River Flow at Reference Point 1GD03 under Present and Future Water Demands and Facilities Conditions (LVSCA) (1/5)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

River Name: Sondu River (LVSCA)
Reference Point: 1JG05

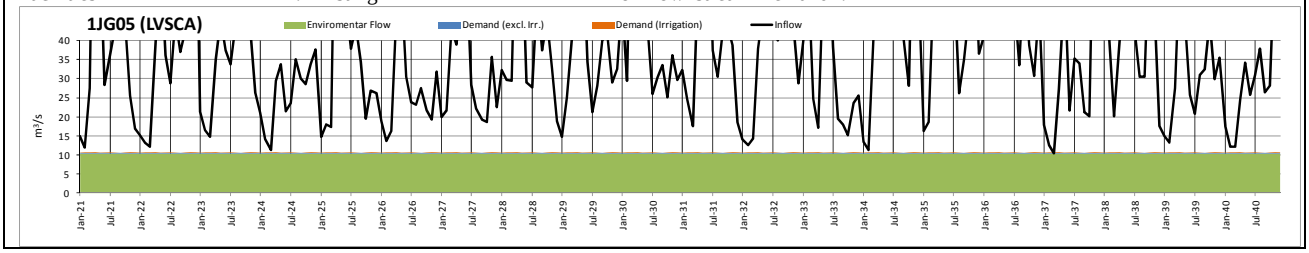
River	: Present (1991-2010)	Reserve:	10.4	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained	0.2	(m^3/s)
Facilities	: Existing	for Downstream Demand*:		



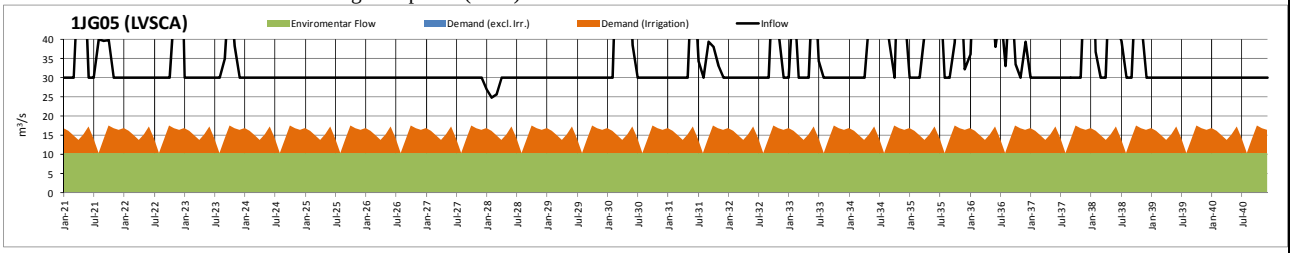
River	: Present (1991-2010)	Reserve:	10.4	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained	5.4	(m^3/s)
Facilities	: Existing +Proposed (2030)	for Downstream Demand*:		



River	: 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	: 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*:		



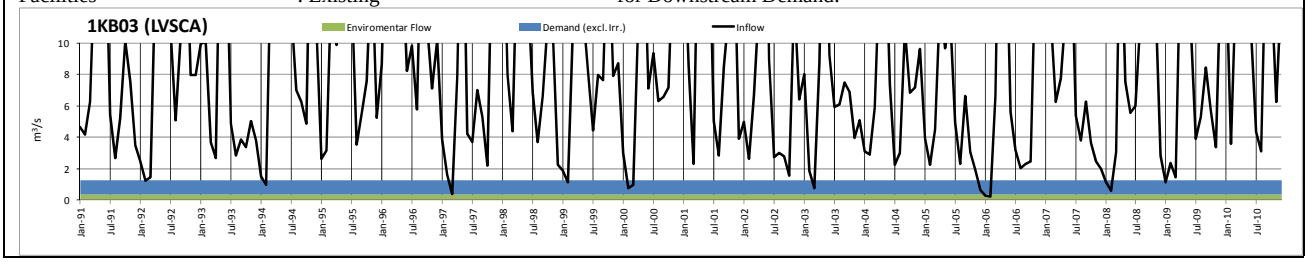
Note: * Irrigation water demand is the average irrigation water demand during March, April, May and June.
Hydropower discharge is constant from the proposed Magwagwa Dam.

Source: JICA Study Team

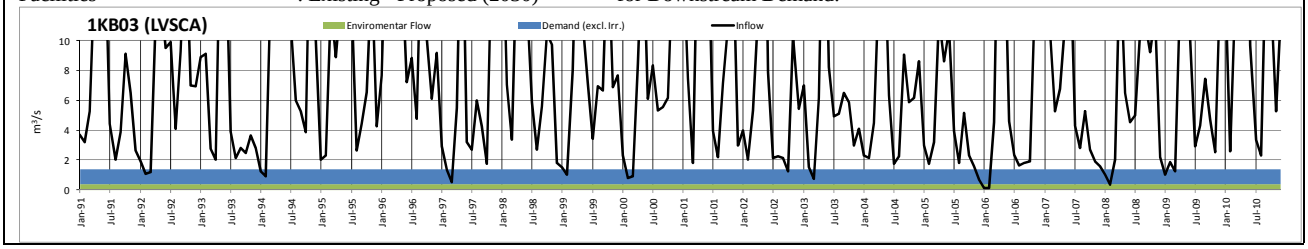
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 8.7.1 River Flow at Reference Point 1JG05 under Present and Future Water Demands and Facilities Conditions (LVSCA) (2/5)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

River Name: Gucha River (LVSCA)
Reference Point: 1KB03

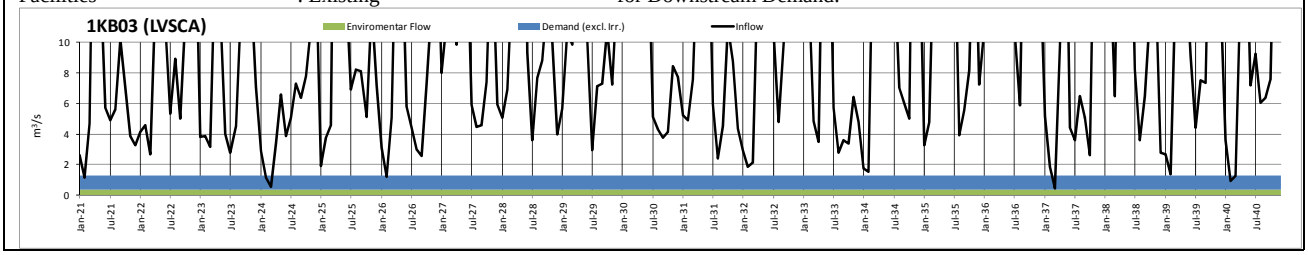
River	: Present (1991-2010)	Reserve:	0.4	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained for Downstream Demand:	0.9	(m^3/s)
Facilities	: Existing			



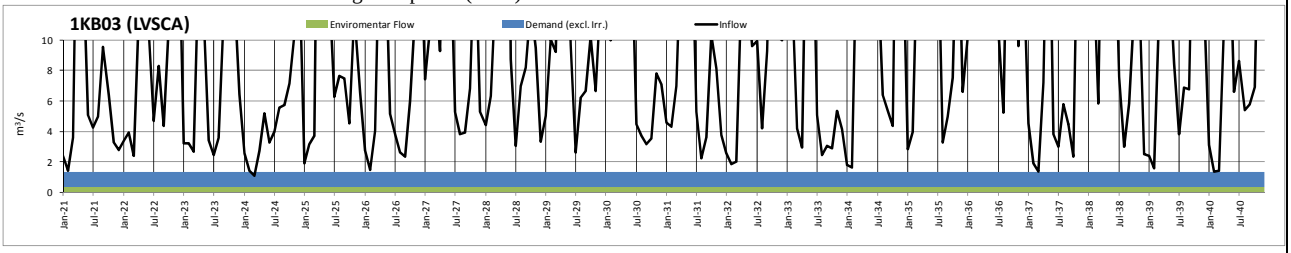
River	: Present (1991-2010)	Reserve:	0.4	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained for Downstream Demand:	1.0	(m^3/s)
Facilities	: Existing +Proposed (2030)			



River	: Future (2021-2040)	Reserve:	0.4	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained for Downstream Demand:	0.9	(m^3/s)
Facilities	: Existing			



River	: Future (2021-2040)	Reserve:	0.4	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained for Downstream Demand:	1.0	(m^3/s)
Facilities	: Existing +Proposed (2030)			

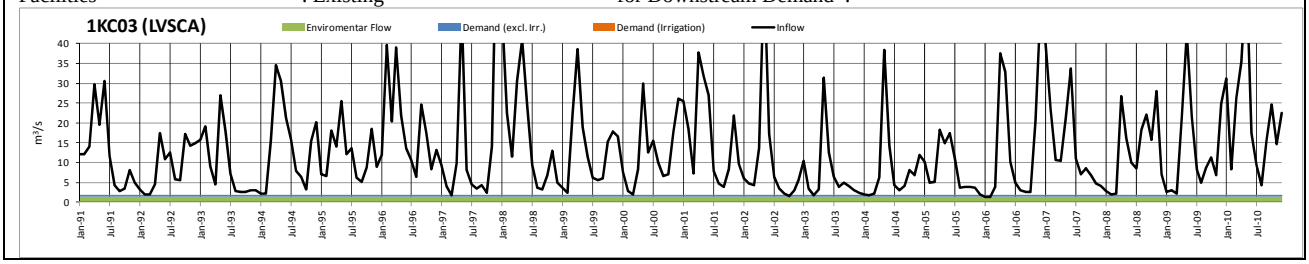


Source: JICA Study Team

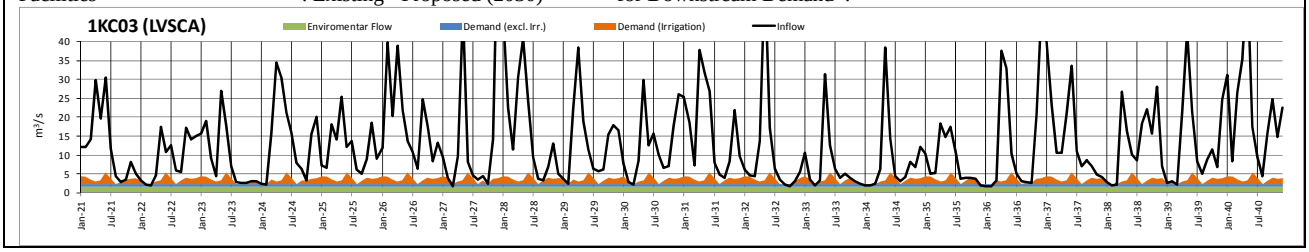
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 8.7.1 River Flow at Reference Point 1KB03 under Present and Future Water Demands and Facilities Conditions (LVSCA) (3/5)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

River Name: Migori River (LVSCA)
Reference Point: 1KC03

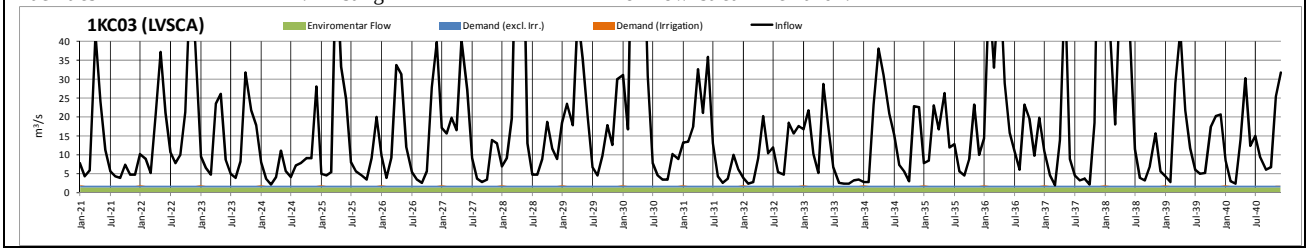
River	: Present (1991-2010)	Reserve:	1.5	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained for Downstream Demand*:	0.4	(m^3/s)
Facilities	: Existing			



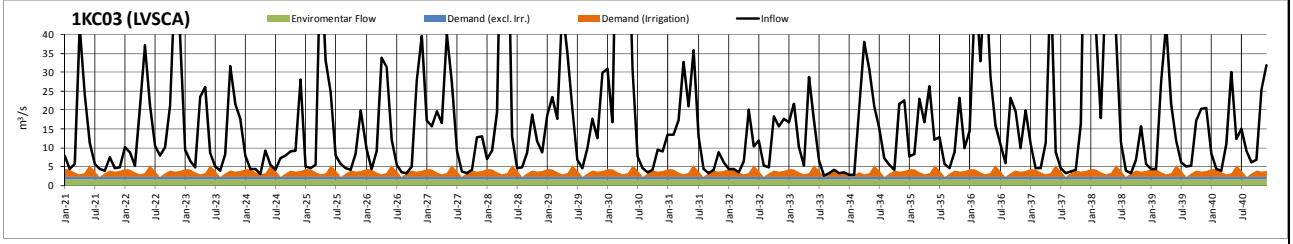
River	: Present (1991-2010)	Reserve:	1.5	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained for Downstream Demand*:	2.3	(m^3/s)
Facilities	: Existing +Proposed (2030)			



River	: Future (2021-2040)	Reserve:	1.5	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained for Downstream Demand*:	0.4	(m^3/s)
Facilities	: Existing			



River	: Future (2021-2040)	Reserve:	1.5	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained for Downstream Demand*:	2.3	(m^3/s)
Facilities	: Existing +Proposed (2030)			



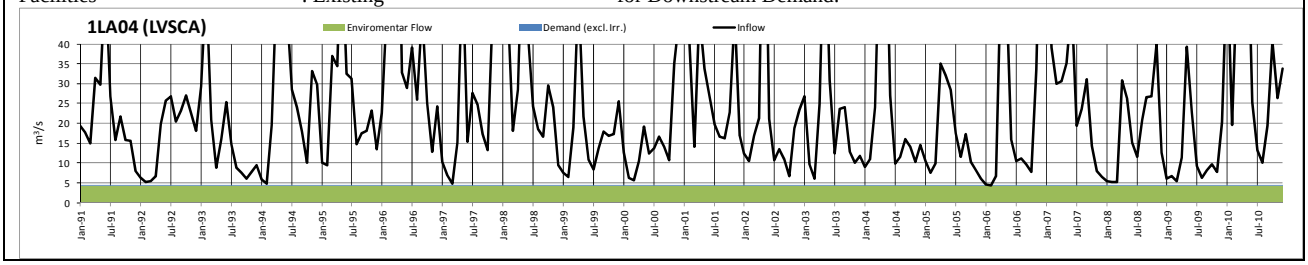
Note: * Irrigation water demand is the average irrigation water demand during March, April, May and June.

Source: JICA Study Team

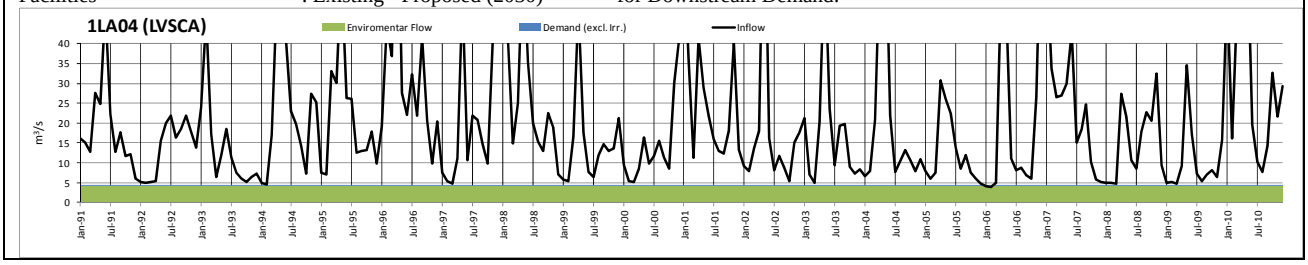
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 8.7.1 River Flow at Reference Point 1KC03 under Present and Future Water Demands and Facilities Conditions (LVSCA) (4/5)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

River Name: Mara River (LVSCA)
Reference Point: 1LA04

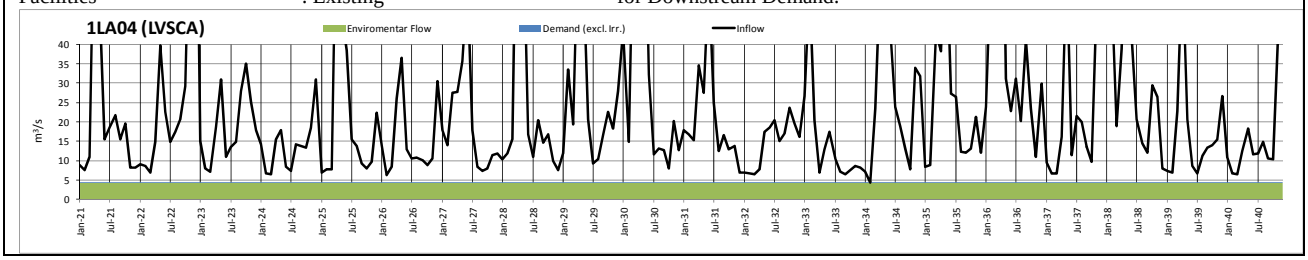
River	: Present (1991-2010)	Reserve:	4.3	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained	0.1	(m^3/s)
Facilities	: Existing	for Downstream Demand:		



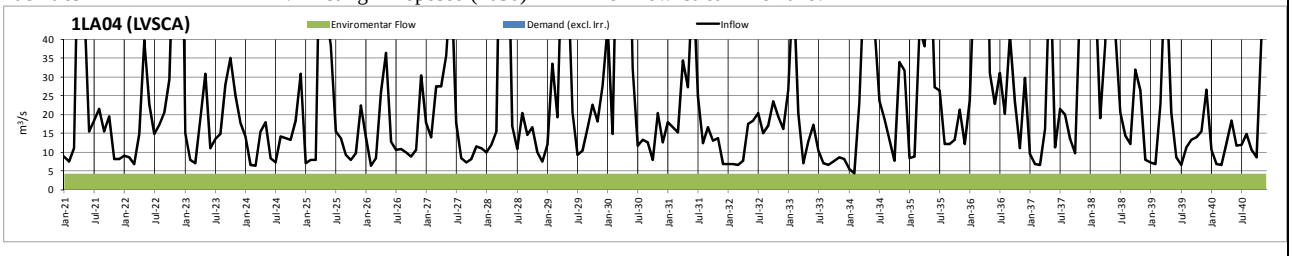
River	: Present (1991-2010)	Reserve:	4.3	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained	0.1	(m^3/s)
Facilities	: Existing +Proposed (2030)	for Downstream Demand:		



River	: Future (2021-2040)	Reserve:	4.3	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained	0.1	(m^3/s)
Facilities	: Existing	for Downstream Demand:		



River	: Future (2021-2040)	Reserve:	4.3	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained	0.1	(m^3/s)
Facilities	: Existing +Proposed (2030)	for Downstream Demand:		

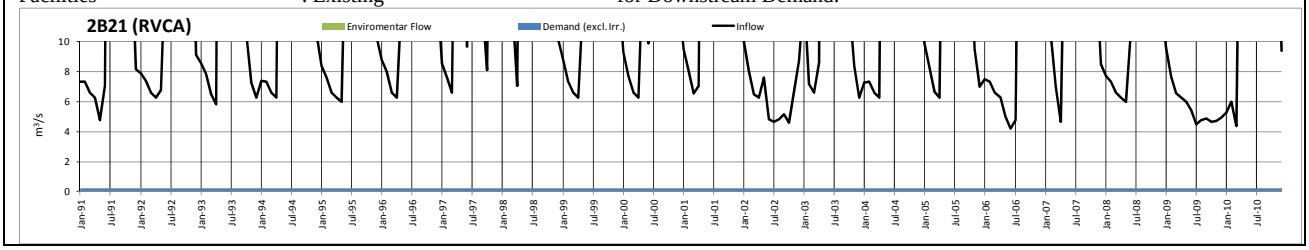


Source: JICA Study Team

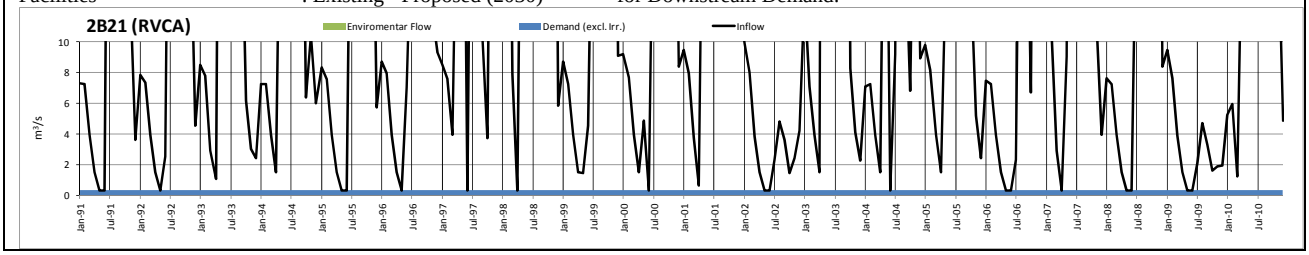
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 8.7.1 River Flow at Reference Point 1LA04 under Present and Future Water Demands and Facilities Conditions (LVSCA) (5/5)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

River Name: Turkwel River (RVCA)
Reference Point: 2B21

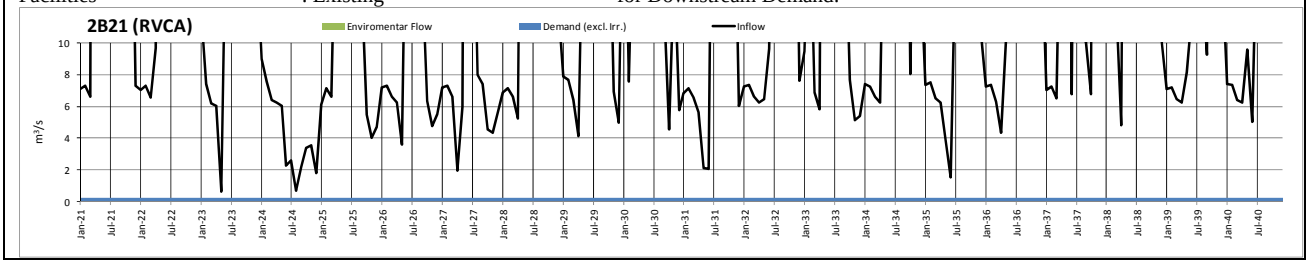
River	: Present (1991-2010)	Reserve:	0.0	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained for Downstream Demand:	0.3	(m^3/s)
Facilities	: Existing			



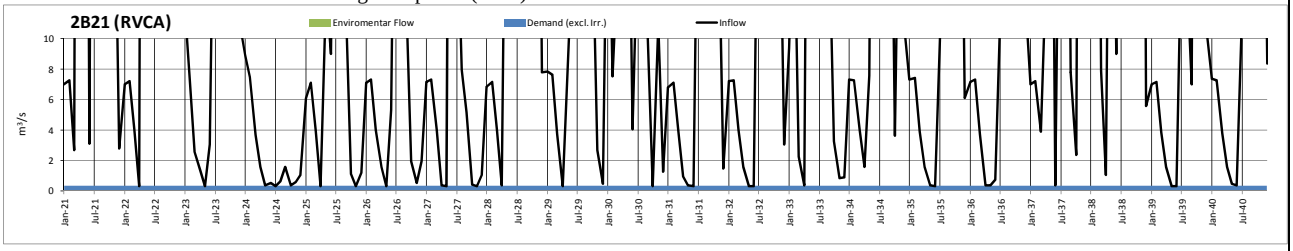
River	: Present (1991-2010)	Reserve:	0.0	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained for Downstream Demand:	0.3	(m^3/s)
Facilities	: Existing +Proposed (2030)			



River	: Future (2021-2040)	Reserve:	0.0	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained for Downstream Demand:	0.3	(m^3/s)
Facilities	: Existing			



River	: Future (2021-2040)	Reserve:	0.0	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained for Downstream Demand:	0.3	(m^3/s)
Facilities	: Existing +Proposed (2030)			

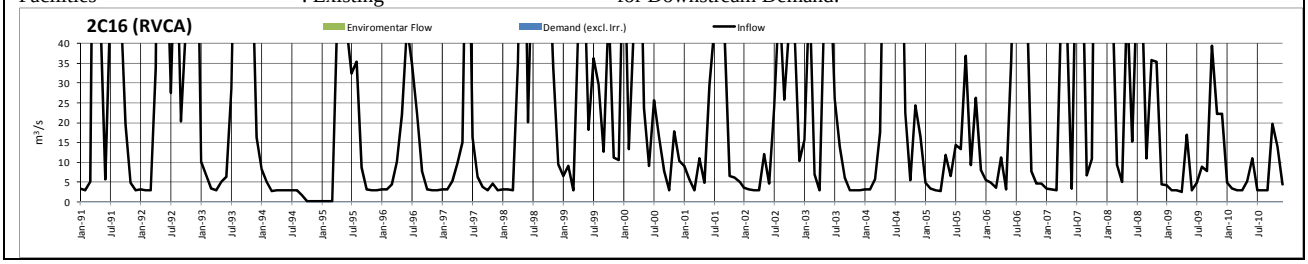


Source: JICA Study Team

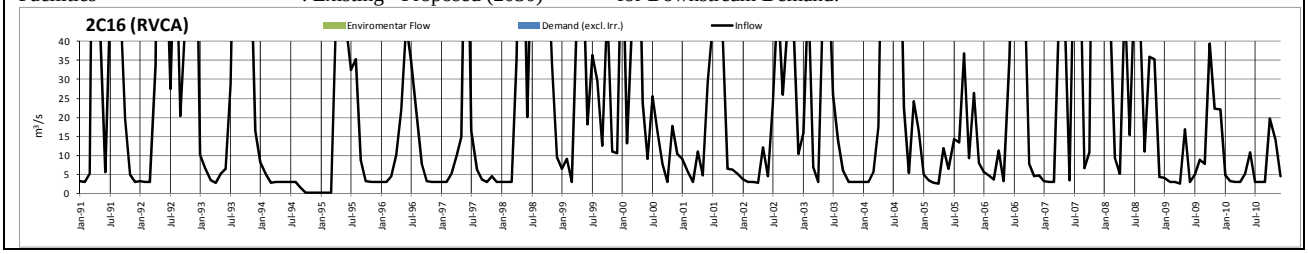
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 9.7.1 River Flow at Reference Point 2B21 under Present and Future Water Demands and Facilities Conditions (RVCA) (1/4)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

River Name: Kerio River (RVCA)
Reference Point: 2C16

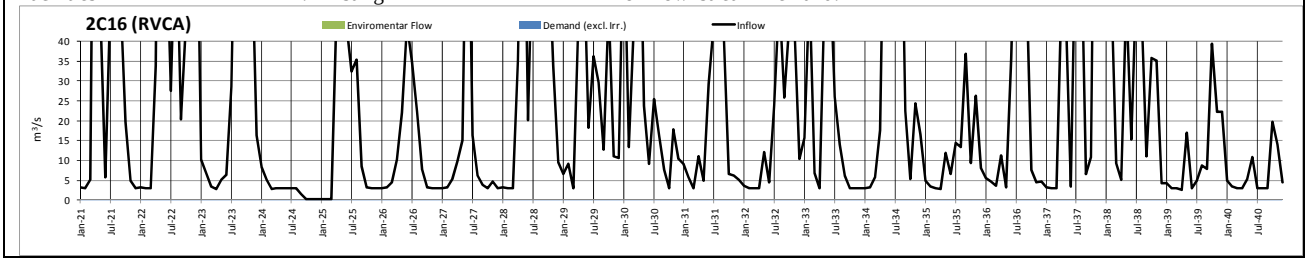
River	: Present (1991-2010)	Reserve:	0.0	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained for Downstream Demand:	0.1	(m^3/s)
Facilities	: Existing			



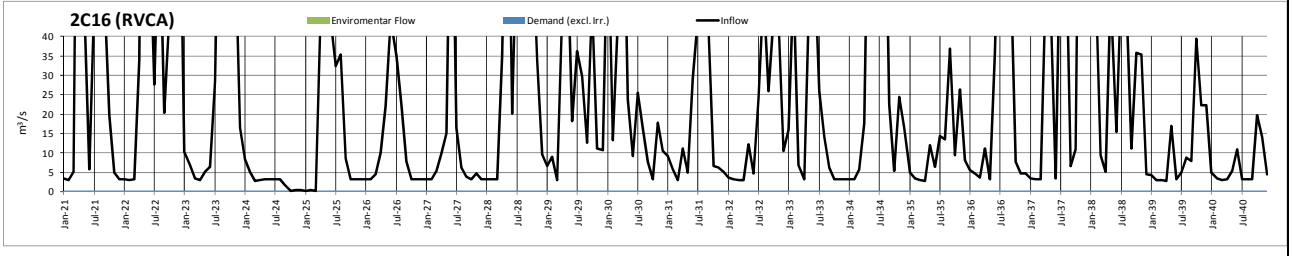
River	: Present (1991-2010)	Reserve:	0.0	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained for Downstream Demand:	0.1	(m^3/s)
Facilities	: Existing +Proposed (2030)			



River	: Future (2021-2040)	Reserve:	0.0	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained for Downstream Demand:	0.1	(m^3/s)
Facilities	: Existing			



River	: Future (2021-2040)	Reserve:	0.0	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained for Downstream Demand:	0.1	(m^3/s)
Facilities	: Existing +Proposed (2030)			

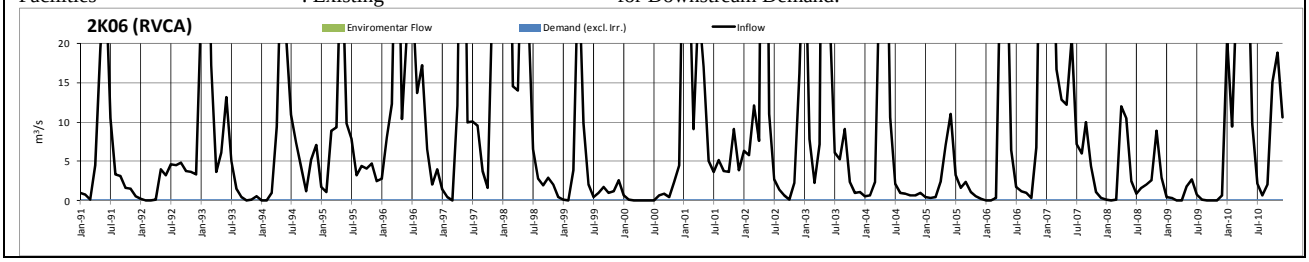


Source: JICA Study Team

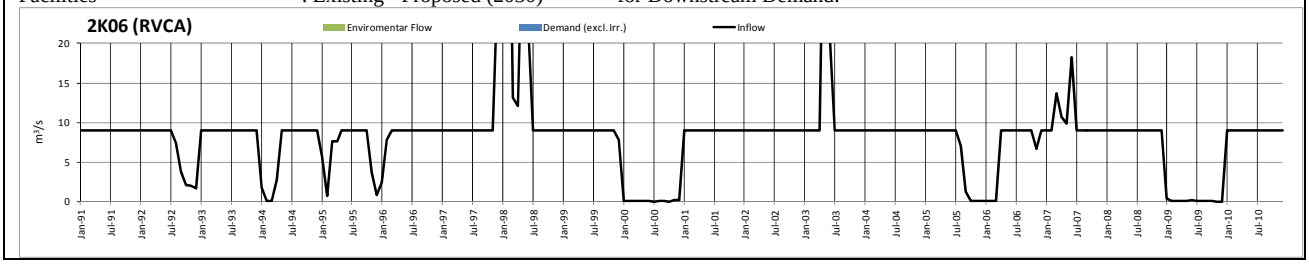
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 9.7.1** **River Flow at Reference Point 2C16 under Present and Future Water Demands and Facilities Conditions (RVCA) (2/4)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

River Name: Ewaso Ng'iro South River (RVCA)
Reference Point: 2K06

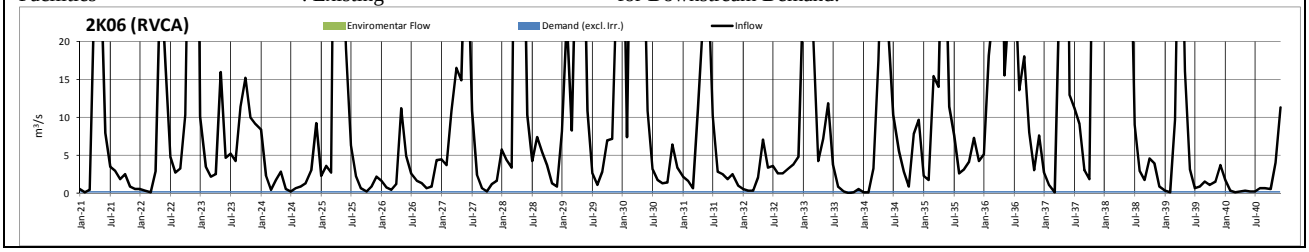
River	: Present (1991-2010)	Reserve:	0.0	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained for Downstream Demand:	0.1	(m^3/s)
Facilities	: Existing			



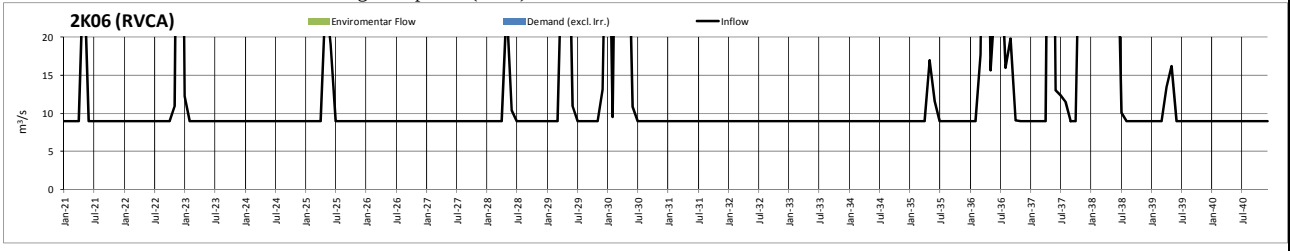
River	: Present (1991-2010)	Reserve:	0.0	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained for Downstream Demand:	0.1	(m^3/s)
Facilities	: Existing +Proposed (2030)			



River	: Future (2021-2040)	Reserve:	0.0	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained for Downstream Demand:	0.1	(m^3/s)
Facilities	: Existing			



River	: Future (2021-2040)	Reserve:	0.0	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained for Downstream Demand:	0.1	(m^3/s)
Facilities	: Existing +Proposed (2030)			



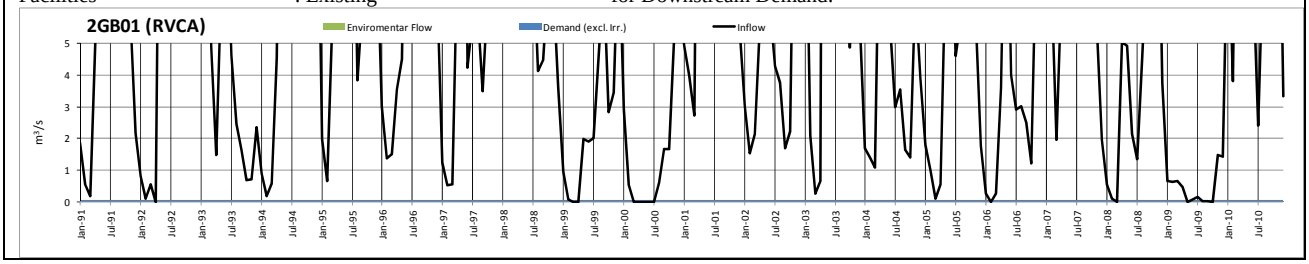
Note: Hydropower discharge is constant from the proposed Oletukat Dam.

Source: JICA Study Team

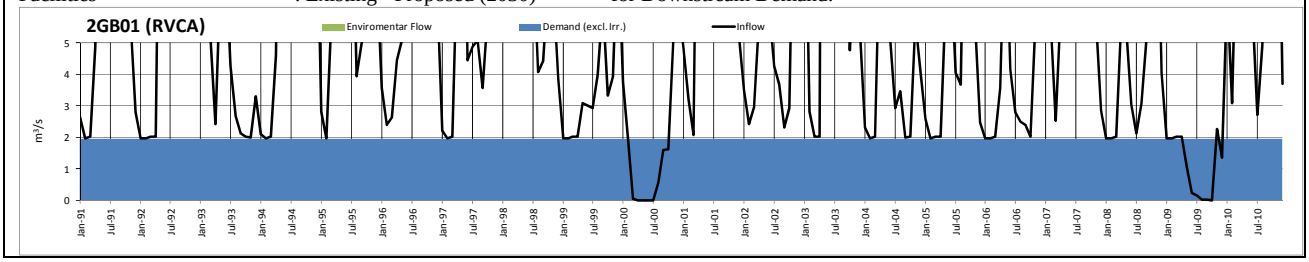
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 9.7.1 River Flow at Reference Point 2K06 under Present and Future Water Demands and Facilities Conditions (RVCA) (3/4)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

River Name: Malewa River (RVCA)
Reference Point: 2GB01

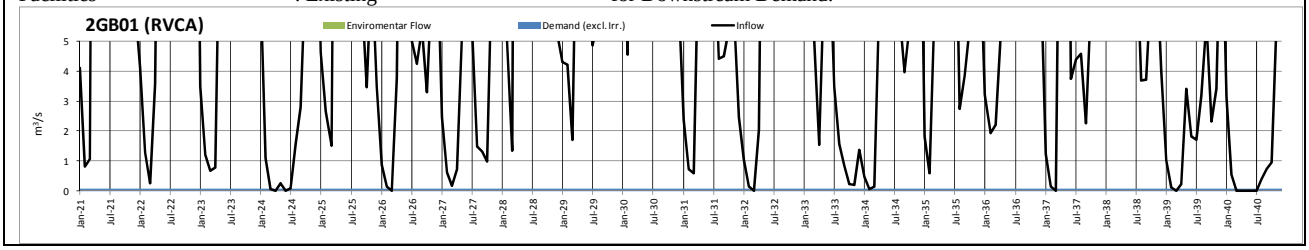
River	: Present (1991-2010)	Reserve:	0.0	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained	0.1	(m^3/s)
Facilities	: Existing	for Downstream Demand:		



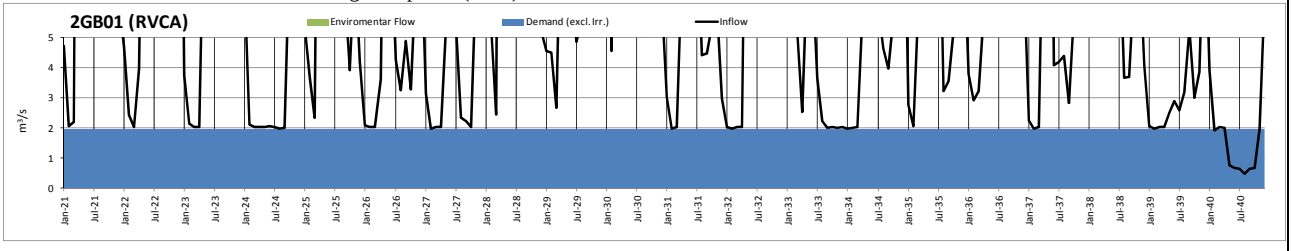
River	: Present (1991-2010)	Reserve:	0.0	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained	2.0	(m^3/s)
Facilities	: Existing +Proposed (2030)	for Downstream Demand:		



River	: 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	: Future (2021-2040)	Reserve:	0.0	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained	2.0	(m^3/s)
Facilities	: Existing +Proposed (2030)	for Downstream Demand:		

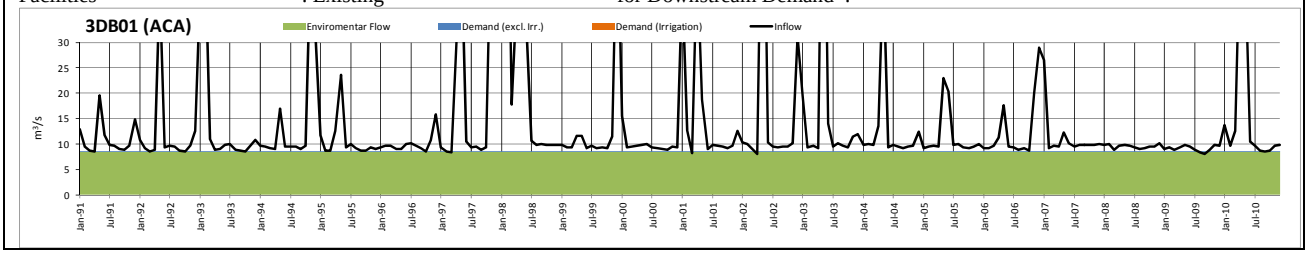


Source: JICA Study Team

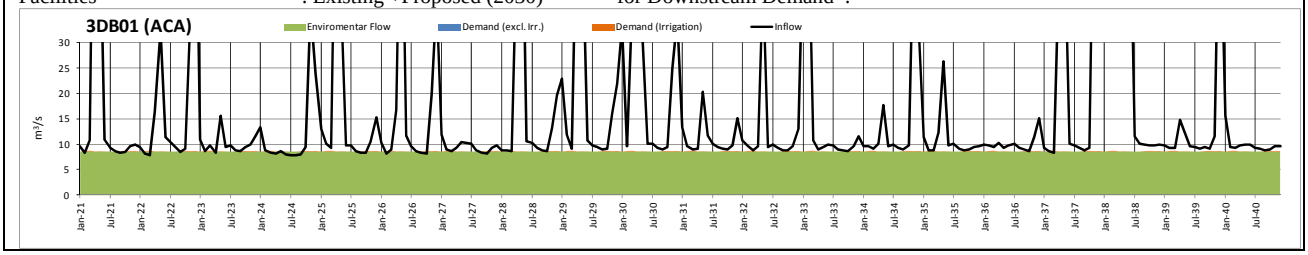
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 9.7.1** **River Flow at Reference Point 2GB01 under Present and Future Water Demands and Facilities Conditions (RVCA) (4/4)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

River Name: Athi River (middle) (ACA)
Reference Point: 3DB01

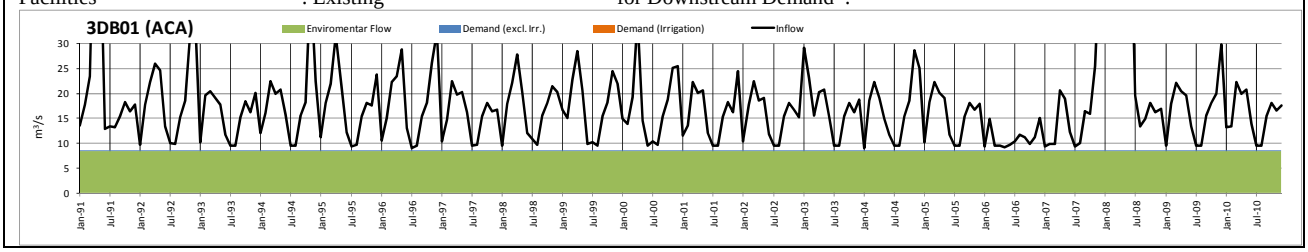
River	: Present (1991-2010)	Reserve:	8.6	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained	0.1	(m^3/s)
Facilities	: Existing	for Downstream Demand*:		



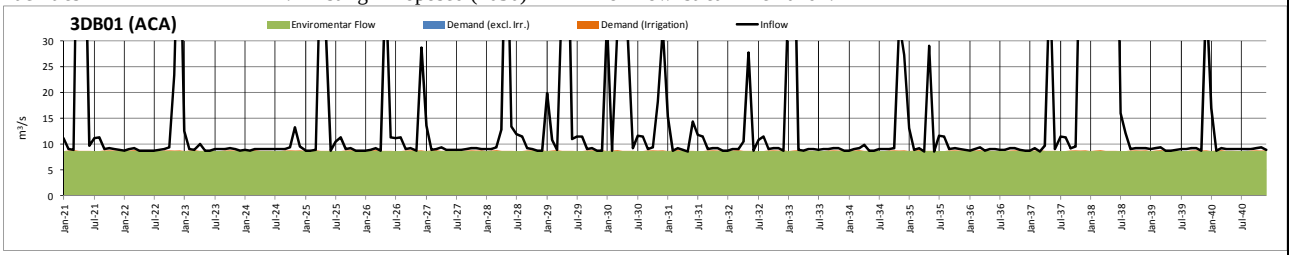
River	: Present (1991-2010)	Reserve:	8.6	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained	0.1	(m^3/s)
Facilities	: Existing +Proposed (2030)	for Downstream Demand*:		



River	: Future (2021-2040)	Reserve:	8.6	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained	0.1	(m^3/s)
Facilities	: Existing	for Downstream Demand*:		



River	: Future (2021-2040)	Reserve:	8.6	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained	0.1	(m^3/s)
Facilities	: Existing +Proposed (2030)	for Downstream Demand*:		



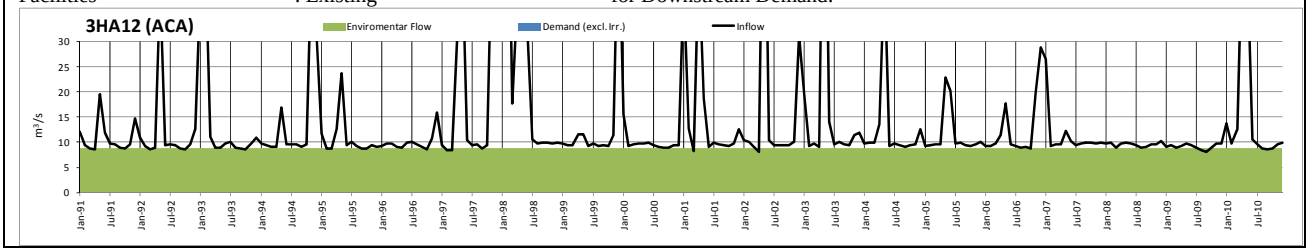
Note: * Irrigation water demand is the average irrigation water demand during May, June, and July.

Source: JICA Study Team

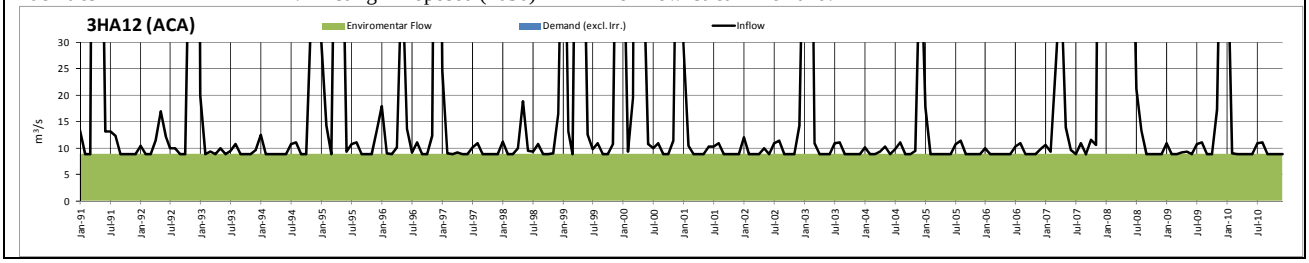
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 10.7.1 River Flow at Reference Point 3DB01 under Present and Future Water Demands and Facilities Conditions (ACA) (1/2)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

River Name: Athi River (lower) (ACA)
Reference Point: 3HA12

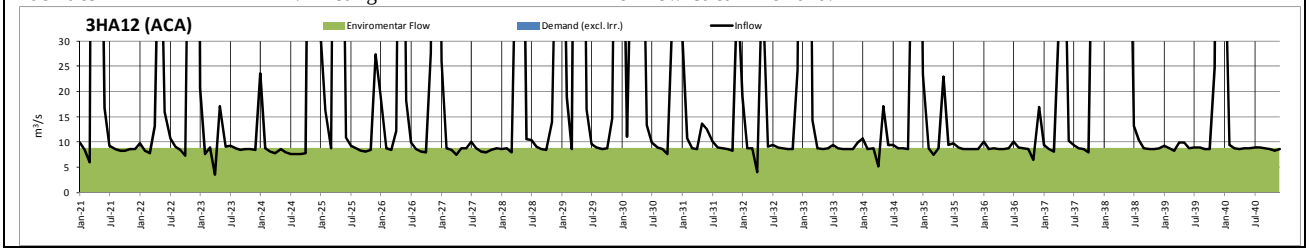
River	: Present (1991-2010)	Reserve:	8.9	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained	0.1	(m^3/s)
Facilities	: Existing	for Downstream Demand:		



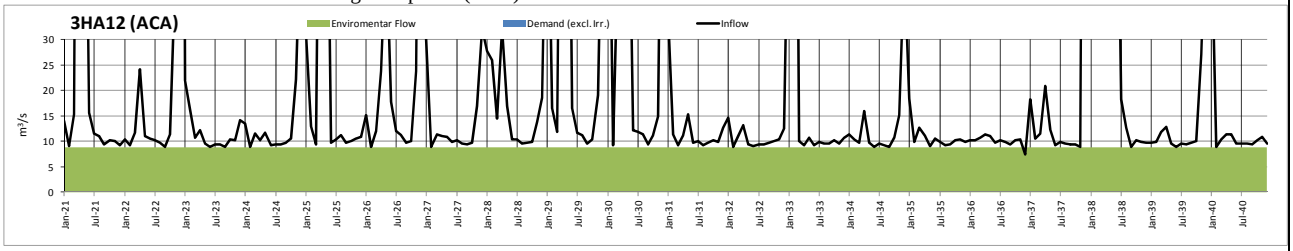
River	: Present (1991-2010)	Reserve:	8.9	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained	0.1	(m^3/s)
Facilities	: Existing +Proposed (2030)	for Downstream Demand:		



River	: Future (2021-2040)	Reserve:	8.9	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained	0.1	(m^3/s)
Facilities	: Existing	for Downstream Demand:		



River	: Future (2021-2040)	Reserve:	8.9	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained	0.1	(m^3/s)
Facilities	: Existing +Proposed (2030)	for Downstream Demand:		

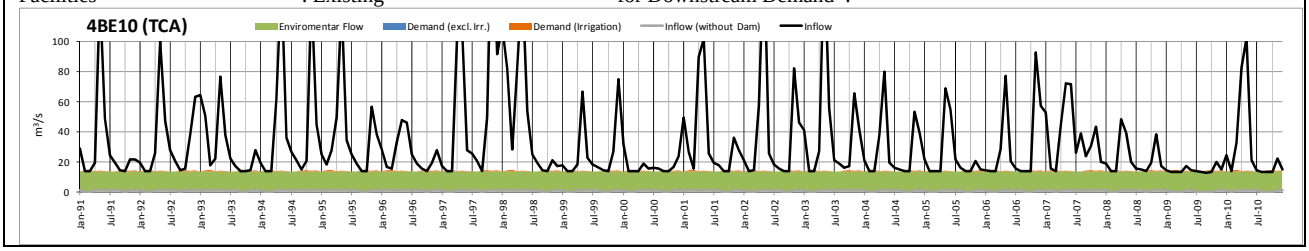


Source: JICA Study Team

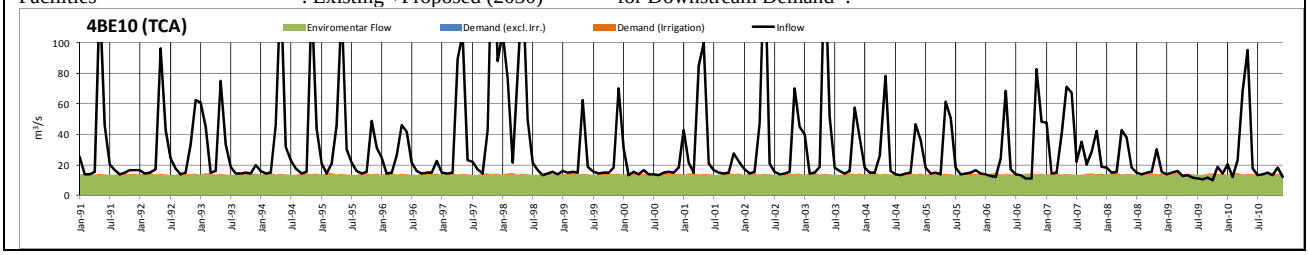
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 10.7.1 River Flow at Reference Point 3HA12 under Present and Future Water Demands and Facilities Conditions (ACA) (2/2)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

River Name: Tana River (upper) (TCA)
Reference Point: 4BE10

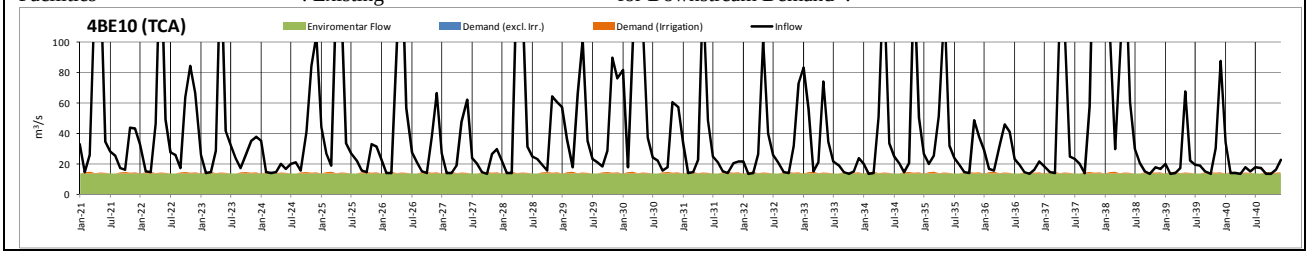
River	: Present (1991-2010)	Reserve:	13.5	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained	0.7	(m^3/s)
Facilities	: Existing	for Downstream Demand*:		



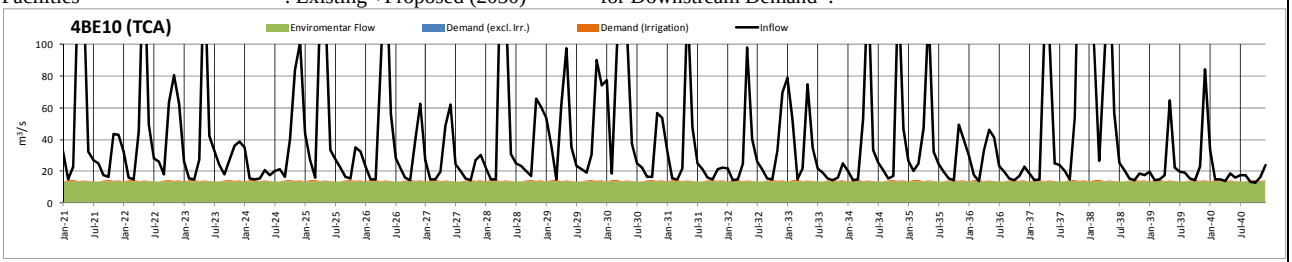
River	: Present (1991-2010)	Reserve:	13.5	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained	0.9	(m^3/s)
Facilities	: Existing +Proposed (2030)	for Downstream Demand*:		



River	: Future (2021-2040)	Reserve:	13.5	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained	0.7	(m^3/s)
Facilities	: Existing	for Downstream Demand*:		



River	: Future (2021-2040)	Reserve:	13.5	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained	0.9	(m^3/s)
Facilities	: Existing +Proposed (2030)	for Downstream Demand*:		



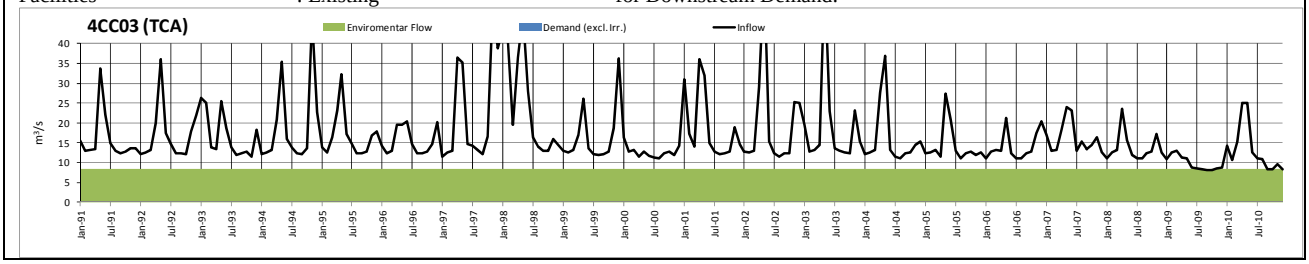
Note: * Irrigation water demand is the average irrigation water demand during March, April, and May.

Source: JICA Study Team

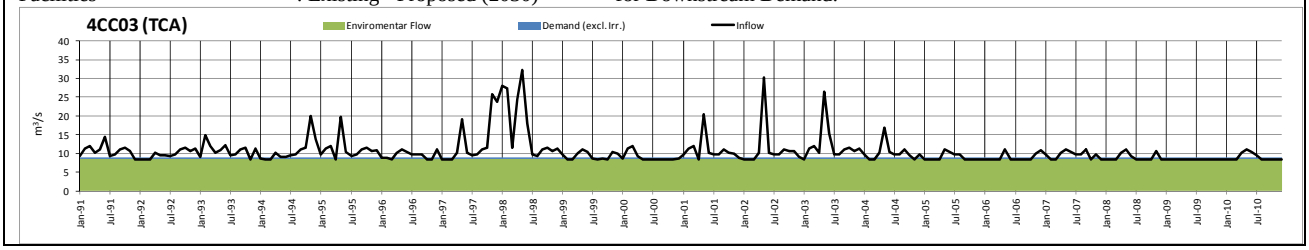
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 11.7.1** **River Flow at Reference Point 4BE10 under Present and Future Water Demands and Facilities Conditions (TCA) (1/3)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

River Name: Thika River (TCA)
Reference Point: 4CC03

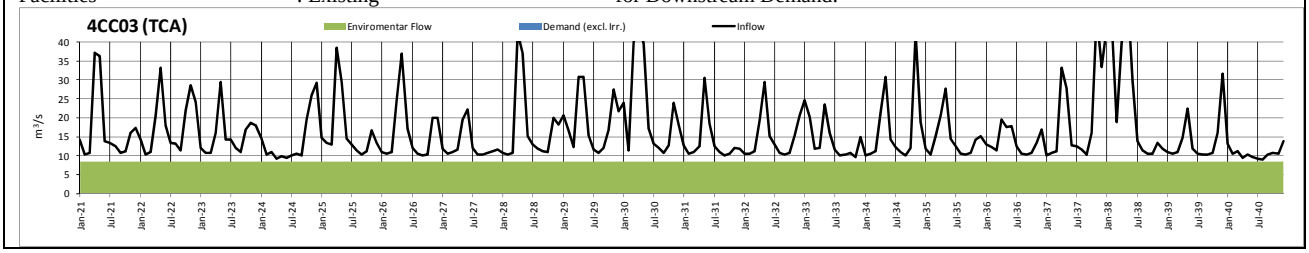
River	: Present (1991-2010)	Reserve:	8.4	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained for Downstream Demand:	1.4	(m^3/s)
Facilities	: Existing			



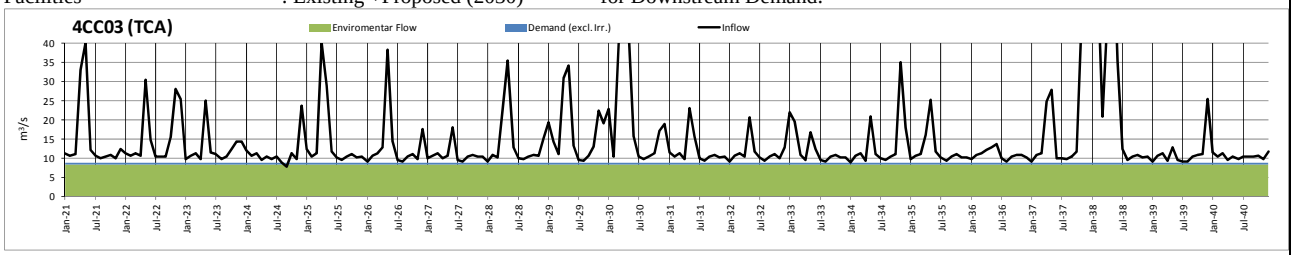
River	: Present (1991-2010)	Reserve:	8.4	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained for Downstream Demand:	1.7	(m^3/s)
Facilities	: Existing +Proposed (2030)			



River	: Future (2021-2040)	Reserve:	8.4	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained for Downstream Demand:	1.4	(m^3/s)
Facilities	: Existing			



River	: Future (2021-2040)	Reserve:	8.4	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained for Downstream Demand:	1.7	(m^3/s)
Facilities	: Existing +Proposed (2030)			

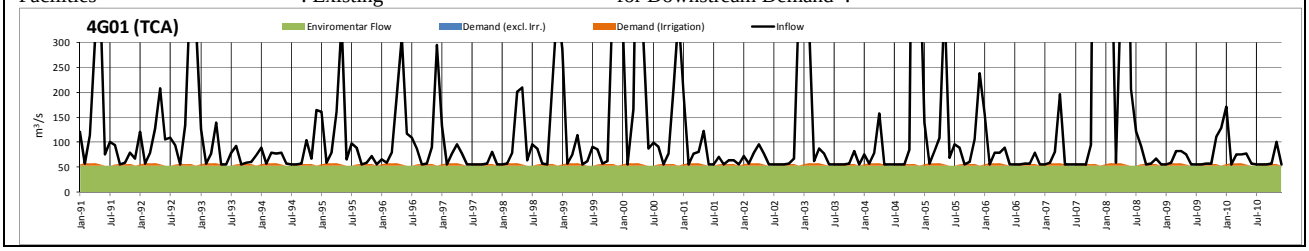


Source: JICA Study Team

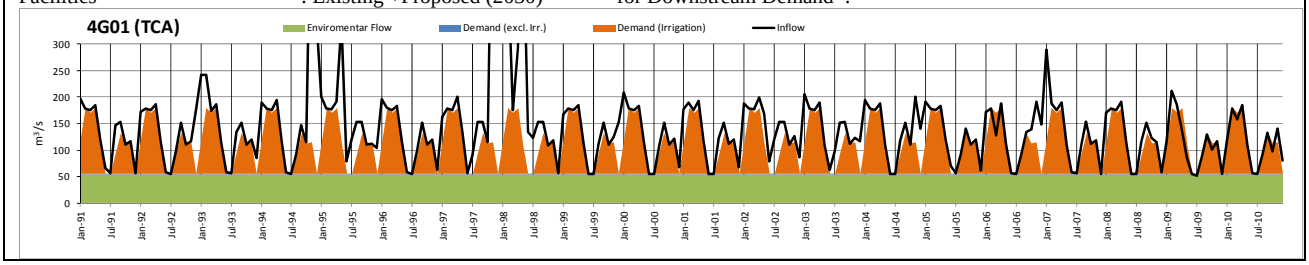
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 11.7.1 River Flow at Reference Point 4CC03 under Present and Future Water Demands and Facilities Conditions (TCA) (2/3)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

River Name: Tana River (lower) (TCA)
Reference Point: 4G01

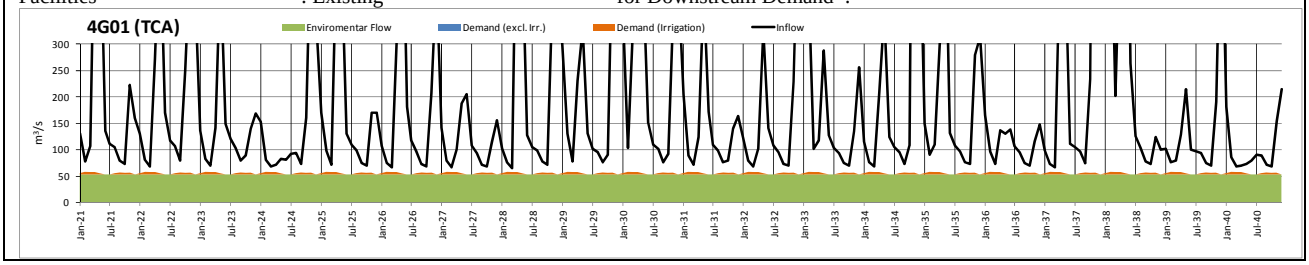
River	: Present (1991-2010)	Reserve:	53.5	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained		
Facilities	: Existing	for Downstream Demand*:	3.5	(m^3/s)



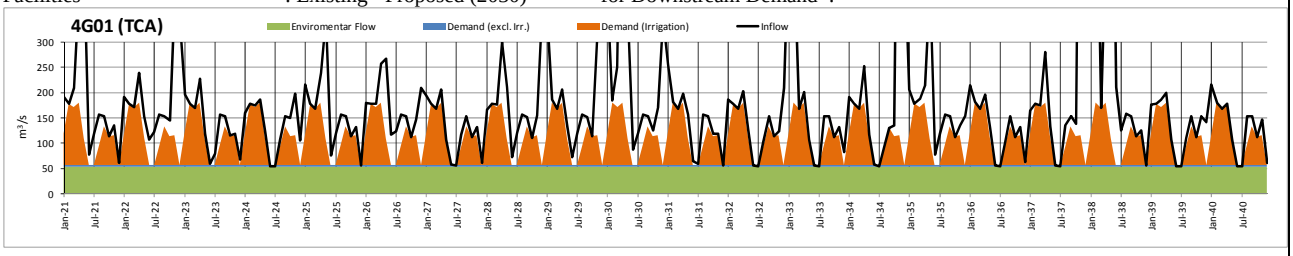
River	: Present (1991-2010)	Reserve:	53.5	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained		
Facilities	: Existing +Proposed (2030)	for Downstream Demand*:	99.7	(m^3/s)



River	: Future (2021-2040)	Reserve:	53.5	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained		
Facilities	: Existing	for Downstream Demand*:	3.5	(m^3/s)



River	: Future (2021-2040)	Reserve:	53.5	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained		
Facilities	: Existing +Proposed (2030)	for Downstream Demand*:	99.7	(m^3/s)



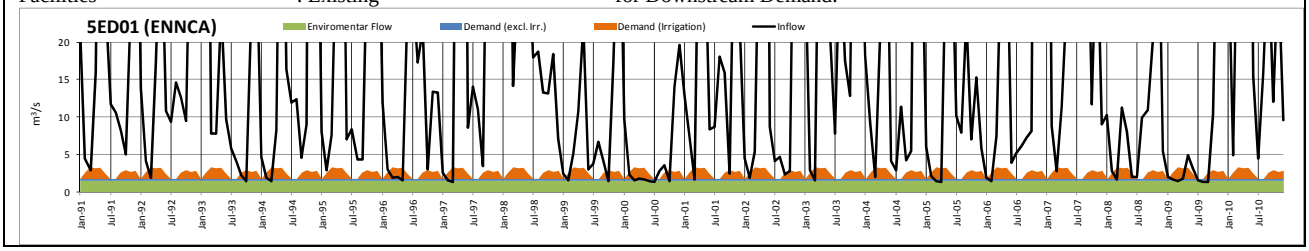
Note: * Irrigation water demand is the average irrigation water demand during March, April, and May.

Source: JICA Study Team

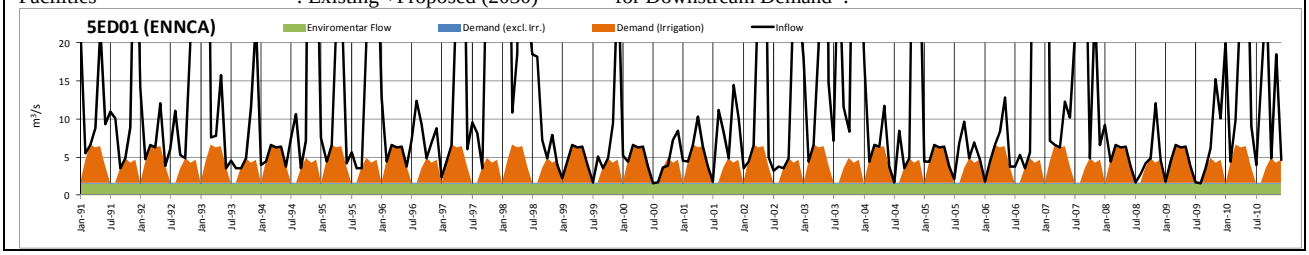
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 11.7.1 River Flow at Reference Point 4G01 under Present and Future Water Demands and Facilities Conditions (TCA) (3/3)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

River Name: Ewaso Ng'iro North River (ENNCA)
Reference Point: 5ED01

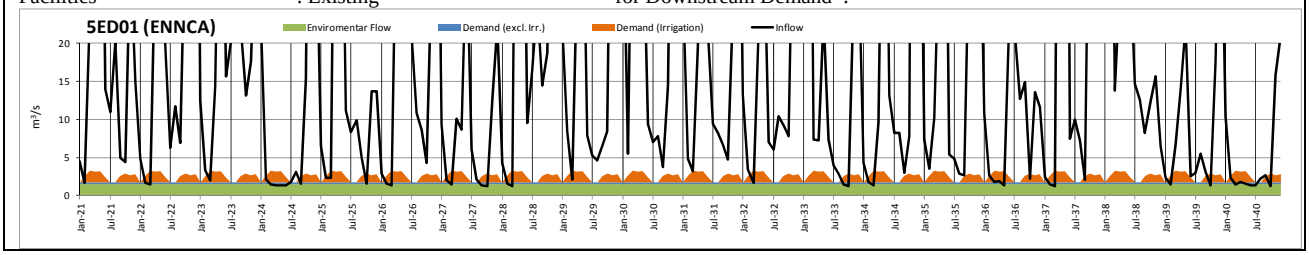
River	: Present (1991-2010)	Reserve:	1.6	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained for Downstream Demand:	1.4	(m^3/s)
Facilities	: Existing			



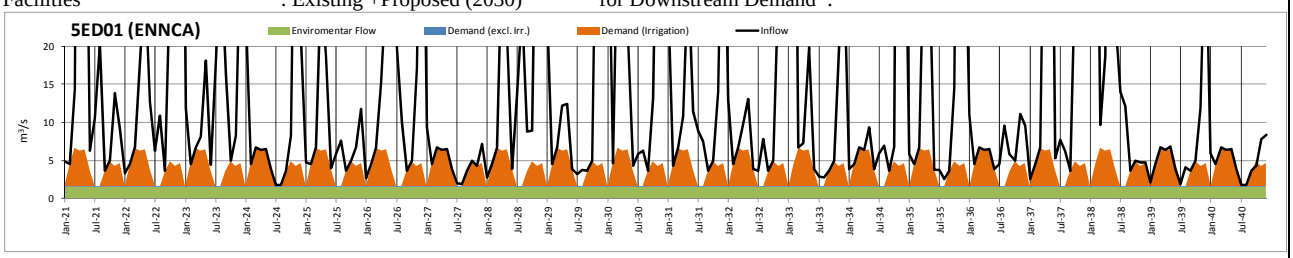
River	: Present (1991-2010)	Reserve:	1.6	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained for Downstream Demand*:	4.9	(m^3/s)
Facilities	: Existing +Proposed (2030)			



River	: Future (2021-2040)	Reserve:	1.6	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained for Downstream Demand*:	1.4	(m^3/s)
Facilities	: Existing			



River	: Future (2021-2040)	Reserve:	1.6	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained for Downstream Demand*:	4.9	(m^3/s)
Facilities	: Existing +Proposed (2030)			



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

Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 12.7.1 River Flow at Reference Point 5ED01 under Present and Future Water Demands and Facilities Conditions (ENNCA)**
JAPAN INTERNATIONAL COOPERATION AGENCY	