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 - Ⅲ MAIN REPORT (2/2)

OCTOBER 2013

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.

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FINAL REPORT

List of Reports

VOLUME - I	EXECUTIVE SUMMARY	
VOLUME - II	MAIN REPORT (1/2)	
	Part A :	Overall Concepts and Frameworks
	Part B :	Lake Victoria North Catchment Area
	Part C :	Lake Victoria South Catchment Area
	Part D :	Rift Valley Catchment Area
VOLUME - III	MAIN REPORT (2/2)	
	Part E :	Athi Catchment Area
	Part F :	Tana Catchment Area
	Part G :	Ewaso Ng'iro North Catchment Area
	Part H :	Action Plan for WRMA Regional Offices toward 2022
VOLUME - IV	SECTORAL REPORT (1/3)	
	A :	Socio-economy
	B :	Meteorology and Hydrology
	C :	Water Supply
	D :	Sanitation
VOLUME - V	SECTORAL REPORT (2/3)	
	E :	Agriculture and Irrigation
	F :	Hydropower
	G :	Water Resources Development
	H :	Water Resources Management
	J :	Flood and Drought Disaster Management
VOLUME - VI	SECTORAL REPORT (3/3)	
	K :	Environmental and Social Considerations
	L :	Institution
	M :	Database and GIS
	N :	Pilot Activities
VOLUME - VII	DATA BOOK	
	Part A :	Meteorological and Hydrological Data
	Part B :	Irrigation Inventory
	Part C :	Subletting Works

EXCHANGE RATE

US$1.00 = KSh 85.24 = ¥79.98

as of November 1, 2012

Part E
Athi Catchment Area

Location Map (ACA)

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

**FINAL REPORT
VOLUME - III MAIN REPORT (2/2)**

PART E: ATHI CATCHMENT AREA

Location Map
Abbreviation

Table of Contents

List of Tables

Page

List of Figures

Page

List of Abbreviations and Acronyms

ACA	:	Athi Catchment Area
ALRMP	:	Arid Land Resources Management Project
ACA	:	Athi Catchment Area
ASAL	:	Arid and Semi-arid Land
B/C	:	Benefit and Cost
BOD	:	Biochemical Oxygen Demand
CBD	:	Central Business District
CBDM	:	Community-based disaster management
COD	:	Chemical Oxygen Demand
D/D	:	Detailed Design
DO	:	Dissolved oxygen
EIRR	:	Economic Internal Rate of Return
ENN	:	Ewaso Ng'iro North
F/S	:	Feasibility Study
IUCN	:	International Union for Conservation of Nature
JICA	:	Japan International Cooperation Agency
KMD	:	Kenya Meteorological Department
LCPDP	:	Least Cost Power Development Plan
LSRWSS	:	Large Scale Rural Water Supply System
LVN	:	Lake Victoria North
LVNCA	:	Lake Victoria North Catchment Area
LVS	:	Lake Victoria South
M/P	:	Master Plan
MDNKOAL	:	Ministry of State for Development of Northern Kenya and Other Arid Lands
MORDA	:	Ministry of Regional Development Authority
MWI	:	Ministry of Water and Irrigation
NRW	:	Non-Revenue Water
NWMP	:	National Water Master Plan
O&M	:	Operation and Maintenance
SS	:	Suspended Solids
SSRWSS	:	Small Scale Rural Water Supply System
TARDA	:	Tana and Athi River Development Authority
WB	:	World Bank
WRM	:	Water Resources Management
WRMA	:	Water Resource Management Authority
WRUA	:	Water Resources Users Association
WSC	:	Water Service Company / Water and Sewerage Company
WSP	:	Water Service Provider
WWTP	:	Waste Water Treatment Plant

Abbreviations of Measures

Length

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

Area

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

Volume

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

Weight

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

Time

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

Money

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

Energy

kcal	=	Kilocalorie
kW	=	kilowatt
MW	=	megawatt
kWh	=	kilowatt-hour
GWh	=	gigawatt-hour

Others

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

NOTE

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

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

3. Information to be updated

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

   (1) Information on the proposed development projects

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

   (2) Information on the water demand

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

4. Exchange rate for cost estimate

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

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

CHAPTER 1 INTRODUCTION

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

This volume, as Main Report Part E, presents the water master plan for the Athi Catchment Area (ACA). The water master plan of ACA consists of the following eight component plans as mentioned in Chapter 7 of the Main Report Part A.

<u>Development plans</u>

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

<u>Management plans</u>

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

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

CHAPTER 2 CATCHMENT CHARACTERISTICS

ACA is located in the southern part of the country and borders on the Tana Catchment Area (TCA) in the north, Indian Ocean in the east, Tanzania in the south, and Rift Valley Catchment Area (RVCA) 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. Based on the Census 2009, population of the area in 2010 was estimated at 9.79 million, or 25.4% of the total population of Kenya. Population density is 167 person/km^2.

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

The Athi River flows from the southeast of Nairobi, north-eastward in the upstream reaches, and then turn its flow direction to the southeast in the north of Ol Doinyo Sapuk National Park, and flows along the catchment area boundary with the Tana Catchment Area and pours into the Indian Ocean in the northern of Malindi. The drainage area of the Athi River is 37,750 km^2, or 64.4% of ACA. The Lumi River, Lake Jipe, and Lake Chala flow into the territory of Tanzania and the Umba River reversely 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 comes to 19,493 km^2.

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

ACA is classified as a semi-arid land except in the upstream area of the Athi River which is classified as a humid land (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 comes to 810 mm. The renewable water resources, which is defined by precipitation minus evapotranspiration is estimated at 4.5 BCM/year in 2010 for ACA and the per capita renewable water resources is calculated at 464 m^3/year/capita.

Major cities and towns found in ACA are Nairobi (the capital city), Mombasa (the second largest), Kiambu, Machakos, Kajiado, Malindi, and Kilifi. The catchment area includes the whole area of Nairobi, Makuweni, Taita Taveta, Kwale, and Mombasa counties, a part of Kiambu, Machakos, Kajiado, and Kilifi counties.

In Nairobi, there are various kinds of industries such as agricultural equipment, brewing and beverages, cement, chemicals and pharmaceuticals, coffee processing, construction material, electricity appliances, food processing, etc. In the suburbs of Nairobi, there are shoes and meat processing in Limuru, while cement, brewing and beverages, meat processing, and textile along the Athi River, and food processing and light industry in Machakos. In the downstream areas, textile industry in Voi and food processing in Malindi and Kilifi are famous. Mombasa also has various kinds of industries such as brewing and beverages, cement, construction material, food processing, meat processing, oil refinery, etc.

CHAPTER 3 WATER RESOURCES, WATER DEMANDS, AND WATER ALLOCATION

3.1 General

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

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

The present (2010) water uses were estimated, and future water demands for the year 2030 were projected for the subsectors of domestic, industrial, irrigation, livestock, wildlife, and inland fisheries uses. Since records available for the actual water usage at present were insufficient, the present water demands were estimated and will be utilised as water uses. The future water demand projections were based on the socioeconomic frameworks set in Kenya Vision 2030. The estimates and projections are detailed in Chapter 6 of the Main Report Part A and Sectoral Reports (C) and (E).

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

The following sections are brief explanation of the available water resources, present water uses and future water demands, and proposed water allocation plan for ACA, which are the basis for water resources development and management plans.

3.2 Available Water Resources

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

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
Percentage of 2010 values	111%	98%	109%

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

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

The above table shows that the 2030 surface water runoff will increase to 111% of 2010 runoff, while the 2030 sustainable yield of groundwater will decrease to 98% of 2010 yield, both due to climate change impacts, resulting in an increase of 2030 available water resources to 109% of 2010 resources.

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

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

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

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

Water Demands by Subsector (ACA)

(Unit: MCM/year)

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 A, Section 6.10 and Setoral Report (G), Sub-section 3.3.1 (3))

The total projected water demands of 4,586 MCM/year in 2030 amount to approximately 4.0 times of the present water demands of 1,145 MCM/year mainly due to the increase in population from 9.79 million to 20.54 million and irrigation areas from 44,898 ha to 278,526 ha mentioned in Chapter 6 of the Main Report Part A. Monthly water demands in 2030 by sub-basin are shown in Table 3.3.1.

3.4 Proposed Water Allocation Plan

(1) Water Balance Study

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

Available Water Resources and Water Demands (ACA)

(Unit: MCM/year)

2010			2030		
Water Resources	Water Demands	Percentage	Water Resources	Water Demands	Percentage
1,503	1,145	76%	1,634	4,586	281%

Source: JICA Study Team

The present water demands of 1,145 MCM/year represents 76% of the available 2010 water resources of 1,503 MCM/year. The ratio of 76% of water demand to water resources, which is called a water stress ratio, shows a very tight balance between water resources and demands compared with the ratio of 40% regarded to indicate severe water stress. The existing water transfer facilities from the TCA to Nairobi with the capacity of 181 MCM/year have an important role in reducing the tight situation.

The water demands for 2030 are expected to increase for about 281% against the 2030 available water resources. This implies that the available water resources and demands should maintain a balance by maximum utilisation of water resources.

In order to examine in more details the situation of future water balance from the spatial and temporal viewpoints, a surface water balance study for 2030 was carried out. Since the surface water demands occupy more than 80% of the total demands nationwide, it was judged that the surface water balance would give general situation of water deficits. This study divided the catchment area into 33 sub-basins and applying a study model with the existing dams and water transfers only, as discussed in Section 6.11 of the Main Report Part A. Conditions of the water balance study are described in Subsection 4.6.3 of this report and detailed in Chapter 4 of the Sectoral Report (G).

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

Water Demands and Water Deficits (ACA)

(Unit: MCM/year)

2010			2030		
Water Demands	Water Deficits	Percentage	Water Demands	Water Deficits	Percentage
1,145	745	65%	4,586	4,153	91%

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

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

(2) Modified Future Water Demands

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

The modified water demands are summarised below.

Modified Water Demand Projections for 2030 (ACA)

(Unit: MCM/year)

Year	Domestic	Industrial	Irrigation	Livestock	Wildlife	Fisheries	Total
2030	941	153	917	59	3	12	2,085

Source: JICA Study Team (Ref. Setoral Report (G), Sub-section 4.4.1)

The modified irrigation water demand of 917 MCM/year in the above table is a sum of the demand of 877 MCM/year calculated by the water balance study using the water resources of ACA (including the existing demand of 114 MCM/year supplied from Tanzania) and the demand of 40 MCM/year to be supplied by water resources of Tanzania for the new irrigation development in ACA. The projected irrigation water demand of 3,418 MCM/year following Kenya Vision 2030 as stated in Section 3.3 was reduced to 877 MCM/year due to limited water resources in ACA. The proposed irrigation area in 2030 for ACA is 91,006 ha including the new irrigation area of 5,280 ha, for which water resources of Tanzania will be used.

(3) Proposed Water Allocation Plan

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

Water Resources Allocation Plan in 2030 (ACA)

(Unit: MCM/year)

Subsector	Water Demand	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

The calculation model of water balance included information on dams and water transfer from TCA which were studied by AWSB and WB study team.

Results of the water balance calculation disclosed that an amount of water transfer from TCA was less than their amount. The difference may be caused by difference in study levels of hydrological analysis and criteria used.

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

CHAPTER 4 DEVELOPMENT AND MANAGEMENT PLANS

4.1 General

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

Eight component plans include: water supply, sanitation, irrigation, hydropower and water resources development plans (five development plans); and water resources, flood and drought disaster and environmental management plans (three management plans).

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

4.2 Water Supply Development Plan

4.2.1 Current Situation of Water Supply

As shown in Section 3.2 of Main Report Part A, the current population of ACA as of 2010 is estimated to be 9.79 million, which is composed of 6.51 million of urban population and 3.28 million of rural population. 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 presented 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 sources. Around 24% of the population get drinking water from the said unimproved drinking water sources. Also, around 22% of the population get water from springs, wells, or boreholes. Unprotected wells and springs are categorised as an unimproved drinking water sources, but the utilisation ratio of unprotected sources is unknown.

It is projected that the urban population will increase by 11.22 million while the rural population will decrease by 0.47 million in 2030 as shown in Section 3.2 of Main Report Part A. Hence, the total population will become 20.54 million in 2030 as shown below.

Projected Population (ACA)

(Unit: million persons)

Year	Urban population	Rural Population	Total
2010	6.51	3.28	9.79
2030	17.73	2.81	20.54

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

Currently, the piped water supply covers 63% of the urban population of ACA, and this ratio is the highest among the six catchment areas. However, it is required to implement a large-scale urban water supply system development to cope with the rapid growth of the urban population and achieve the target coverage ratio of 100%.

Around 54% of population in the catchment area are supplied with water through pipes by registered WSPs. As for the Nairobi and satellite towns, there are registered 11 urban WSPs and seven rural WSPs that manage the water supply systems. These systems cover around 2.96 million service population with water supply capacity of 572,213 m^3/day. The Non-revenue Water (NRW) ratio in the area is relatively lower compared to other areas. Out of the 11 urban WSPs, only two WSPs have records of more than 50% of NRW ratio. Current situations of the WSPs in Nairobi and satellite towns are shown in Table 4.2.1.

As for Mombasa and coastal surrounding areas, the water supply system managed by registered WSPs covers 1.46 million service population. Table below shows the six urban WSPs with total water supply capacity of 87,520 m^3/day. The NRW ratio in the area is also relatively lower compared to other areas. No WSPs have records of more than 50% of NRW ratio. Current situations of the WSPs in Mombasa and coastal surrounding areas are shown in Table 4.2.2. As for other areas in ACA, the situation is shown in Table 4.2.3.

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 being carried out under the World Bank fund. No major difference has not been found in overall concept for planning between these studies and NWMP 2030. Based on the results of the studies, it is required to provide F/S reports of water supply development projects, which will cover the future water demand of each UC.

4.2.2 Development Strategy

ACA is divided into three, namely, Nairobi surrounding areas, Mombasa surrounding areas, and other areas. Urban water supply systems (UWSSs) planning and the characteristics of the three areas are shown below.

Characteristics of Areas (ACA)

Catchment	Features
Nairobi and Satellite Towns	The area has the highest population density in Kenya. Out of 30 urban centres in ACA, 15 urban centres are located in this area with 4.46 million urban population or 76% of the current urban population. Thika in the TCA is also covered by water supply system of Nairobi. The area is highly dependent on water sources in ACA.
Mombasa and Coastal Surrounding Areas	There are eight urban centres with1.28 million urban population, which is 20% of the current urban population in ACA. Only limited surface water source are available, and water supply development plan with spring, well field, and desalination plant should be considered.
Other Areas	This is the outskirt of the abovementioned areas. There are seven urban centres that planned to use surface water on a priority basis. As for the rural water supply, it is planned to use groundwater on a priority basis.

Source: JICA Study Team.

Based on the overall concept mentioned in Section 7.3 of the Main Report Part A, UWSSs are planned for 32 urban centres (UCs) in ACA. In case that the same water resources are used for several UCs such that there will be 16 UCs in Nairobi and satellite towns and nine UCs in Mombasa and coastal surrounding areas, only one water supply system is planned to cover several UCs. However, UWSS in other seven UCs are planned for each UC independently.

The water supply capacity required for UWSS in ACA is 2,260,000 m^3/day in 2030 against the current water supply capacity (including capacity under construction) of 699,000 m^3/day, therefore, an additional capacity of 1,561,000 m^3/day is required to be developed by 2030. This will be done through the following three types of projects;

a) Rehabilitation of existing UWSS

In order to achieve 20% of NRW ratio, water meters will be installed for all households and old pipes of exiting UWSS of 30 UCs, which have 699,000 m^3/day of water supply capacity, need to be replaced. In addition, the rehabilitation includes replacement and repair of mechanical and electrical equipment in water treatment plants and pumping stations.

b) Expansion of UWSS

Expansion of UWSS is planned for 29 UCs, out of the above 30 UCs, to meet the water demand in 2030. The total expansion has a capacity of 1,542,000 m^3/day.

c) Construction of new UWSS

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

c) Incorporation of existing plan

According to data from WSBs, there are 31 plans of water supply development projects to cover 21 UCs and surrounding areas, 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 incorporated in NWMP 2030.

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

a) Development of LSRWSS

LSRWSS is proposed mainly for areas with high population density or areas with difficulties using groundwater for personal or community use. LSRWSS will be developed for 2.05 million residents in ten counties of ACA.

b) Development of SSRWSS

SSRWSS is proposed for 2.00 million residents in ten counties of ACA, and it includes the construction and improvement of boreholes, wells, and springs for personal and community use, which will be implemented by individuals or communities.

4.2.3 Proposed Water Supply Development Plan

The proposed UWSS is presented in Table 4.2.4, while the proposed LSRWSS and SSRWSS are shown in Tables 4.2.5 and 4.2.6, respectively. The proposed water supply development plan for ACA is outlined below.

Proposed Water Supply Development Plan (ACA)

Type of Project		Target Area	Target Capacity (m^3/day)	Target 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 UCs	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 (ACA) includes Thika with 0.51 million population. Thika is located in TCA, but Thika has been connected with water supply system in ACA.
Source: JICA Study Team based on Tables 4.2.4 to 4.2.6.

With the above water supply development, the water supply situation of ACA in 2030 will be 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 referred to Sectoral Report (C), Section 2.3. Figures for 2030 were based on Tables 4.2.2 to 4.2.4.)

In order to ensure water sources required for the water supply systems in Nairobi and surrounding area, it is proposed to construct eight new dams in ACA and five new dams in TCA, and expand the inter-basin water transfer system from TCA, 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 areas in ACA, it is proposed to construct four new dams in ACA. (Ref. Sectoral Report (G), Section 4.7)

4.3 Sanitation Development Plan

4.3.1 Current Situation of Sanitation Development

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

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

4.3.2 Development Strategy

Based on the overall planning concept and framework described in Section 7.4 of the Main Report Part A, sewerage system development is planned for 25 UCs in ACA. The sewerage system development will be conducted under the following three types of projects:

a) Rehabilitation of existing sewerage system

The rehabilitation includes repair and replacement of mechanical and electrical equipment of wastewater treatment plants (WWTPs) and pumping stations, as well as replacement of damaged sewer pipes in six UCs. This rehabilitation will be carried out for existing sewerage systems with the 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 will be expanded. This type of project includes expansion and/or new construction of sewerage pipes, pumping stations, and WWTPs. The expansion will provide an additional capacity of 715,000 m^3/day.

c) Construction of New Sewerage System

There are no sewerage systems in 19 UCs. New sewerage systems will be constructed in the concerned UCs that will provide an additional capacity of 430,000 m^3/day to meet the demand in 2030.

c) Incorporation of existing plan

According to data from WSBs, there are 15 plans of sewerage development projects, which have 396,000 m^3/day of total treatment capacity. (Refer to Sectoral Report (D), Section 2.4) These plans are to be incorporated in NWMP 2030.

Outside the sewerage service area, the improved on-site treatment facilities will be available for the remaining 4.28 million residents in 2030. Currently, 6.72 million residents (71% of the entire population) are using the existing on-site treatment facilities, but unimproved ones will be improved with new housing facilities. Development of on-site sanitation facilities is planned for ten counties in ACA.

4.3.3 Proposed Sanitation Development Plan

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

Proposed Sanitation Development Plan (ACA)

Type of Project		Target Area	Target Capacity (m^3/day)	Target 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 based on Tables 4.3.1 and 4.3.2.

About 92% of the 17.73 million urban population in ACA is expected to be covered by the sewerage system. The ratio of ACA is higher than the national target of 80%, because there are many large scale UCs, that prioritised sewerage development. With the above sanitation development, the sanitation situation of ACA in 2030 will be as follows.

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 above are referred to Sectoral Report (D), Section 2.3, and figures for 2030 above are based on Tables 4.3.1 and 4.3.2.)

4.4 Irrigation Development

4.4.1 Current Situation of Irrigation Development

The 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 supply is very limited due to large number of water users for domestic use in urban areas and irrigated agriculture. On the other hand, some areas in the southwest of ACA, near Tanzania, can receive stable river water and groundwater originating from the skirt of Mt. Kilimanjaro. The total crop area in ACA in 2011 was 876,544 ha. 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 crop area is 5.1%. Almost all the existing irrigation systems have deteriorated mainly due to poor maintenance.

4.4.2 Development Strategy

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

a) In order to utilise limited water resources efficiently, the water-saving irrigation methods should be introduced to improve water productivity in all irrigation areas;

b) In order to strengthen the agricultural sector in ACA, irrigation development should be focused on agricultural productivity by increasing the cropping intensity of the existing irrigation areas through the rehabilitation and upgrading of existing irrigation systems; and

c) Owing to the sufficient land resources available, but quite limited water resources for irrigation in ACA, priority should be given to the extension of existing irrigation schemes to maximise the irrigation area. This will be done through the construction of storage dams in semi-arid lands. Development of small-scale dam irrigation and groundwater irrigation should also be considered as far as water resources are available.

4.4.3 Proposed Irrigation Development Plan

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

Proposed Irrigation Areas in 2030 (ACA)

(Unit: ha)

Category	Existing Irrigation Area in 2010	New Irrigation Area in 2030						Total Irrigation Area in 2030
		Surface Water Irrigation			Ground-water Irrigation (Borehole)	Water Harvesting Irrigation (Small Dam/ Water Pan)	Total New Irrigation Area	
		Weir	Dam	Total				
Large-scale	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. Sectoral Report (E), Section 3.4)

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 7.5 of the Main Report Part A, 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 4.6 due to limitation of available water resources.

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

a) Taila Tabeta Irrigation Project (3,780 ha, Weir)
b) Mt. Kilimanjaro Spring Irrigation Project (1,500 ha, Spring)
c) Kibwezi Irrigation Extension Project (17,000 ha, Thwake multipurpose dam); and
d) Kanzal Dam Irrigation Project (15,000 ha, Munyu multipurpose dam).

The irrigation water demands necessary for the abovementioned irrigation development projects were estimated at 882 MCM/year for surface irrigation area and 35 MCM/year for groundwater irrigation area as shown in Table 6.5.7 in the Main Report Part A.

4.5 Hydropower Development Plan (ACA)

4.5.1 Current Situation of Hydropower

(1) Existing Hydropower Station

There is no hydropower station in the catchment area. Locations of existing hydropower stations are as shown in Figure 4.5.1.

(2) Multipurpose Dam Development Project by Tana and Athi Rivers Development Authority (TARDA)

There are two multipurpose dam projects proposed by TARDA, namely, Munyu and Thwake dams. Munyu dam is designed for hydropower and irrigation. According to the information from TARDA, hydropower component of Munyu Dam has an installed capacity of 40 MW. Thwake Dam is designed for water supply, irrigation, and hydropower development. According to the information from TARDA, hydropower component of Thwake Dam has an installed capacity of 20 MW.

4.5.2 Development Strategy

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

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

Of the above strategies, development strategy for ACA will be as follows:

c) LCPDP projects: There is no project proposed for LCPDP.
d) Multipurpose dam development schemes: There are two multipurpose dam schemes proposed, namely, Thwake and Munyu dams.

4.5.3 Proposed Hydropower Development Plan

Based on the development strategy as mentioned in Subsection 4.5.2, the following hydropower development plans will be incorporated in the NWMP 2030.

(1) Thwake Multipurpose Dam

As one of the proposed multipurpose dam projects by MORDA, Thwake Dam is considered as a candidate project of NWMP 2030. Thwake Dam is planned to be constructed in the middle reach of Athi River. According to the information provided by TARDA in November 2012, Thwake Dam is planned to have an installed capacity of 20 MW.

(2) Munyu Multipurpose Dam

As one of the proposed multipurpose dam projects by MORDA, Munyu Dam is considered as a candidate project of NWMP 2030. Munyu Dam is planned to be constructed in the upstream reach of Athi River. According to the information provided by TARDA in November 2012, Munyu Dam is planned to have an installed capacity of 40 MW.

Proposed Hydropower Development Schemes (ACA)

No.	Name of Scheme	Installed Capacity (MW)	Purpose	Source of Information
1	Thwake Multipurpose Dam	20	Water Supply, Irrigation, Hydropower	TARDA
2	Munyu Multipurpose Dam	40	Irrigation, Hydropower	TARDA
	Total	60		

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

Locations of Hydropower Development Projects are shown in Figure 4.5.2.

4.6 Water Resources Development Plan

4.6.1 Current Situation of Water Resources Development

ACA has a total catchment area of 58,639 km^2, and an annual average rainfall of 810 mm which is between rather rich rainfall of around 1,300-1,400 mm in the LVNCA and LVSCA and less rainfall of around 500 mm in the RVCA and ENNCA. The annual rainfall differs spatially within the catchment area, ranging from around 500 mm in the southern part near the border of Tanzania to 1,200 mm in the western mountainous area. The main rivers in ACA are Athi, Gashi, Mwachi, and Cha Shimba rivers. The available water resources estimated in ACA for 2010 (present) are 1,198 MCM/year for surface water and 305 MCM/year for groundwater.

The present water demands in ACA were estimated to be 1,145 MCM/year based on the population of 9.79 million and irrigation area of 44,898 ha as presented in Chapter 3. Listed below are the existing water resources structures/facilities except for the direct intake facilities from the rivers that satisfy the present water demands. Locations of the dams and water transfers are shown in Figure 4.6.1.

Existing Water Resources Structures/Facilities (ACA)

Existing Structures/ Facilities	Name of Structures/ Facilities	Purposes	Notes
Dam	Ruiru Dam	Domestic water supply to Nairobi	Storage volume of 3 MCM
Dam	Bathi Dam	Domestic water supply	Storage volume of 1 MCM
Dam	Mulima Dam	Domestic water supply	Storage volume of 1 MCM
Dam	Manooni Dam	Domestic water supply	Storage volume of 1 MCM
Dam	Muoni Dam	Domestic water supply	Storage volume of 1 MCM
Dam	Kikoneni Dam	Domestic water supply	Storage volume of 1 MCM
Dam	Maruba Dam	Domestic water supply	Storage volume of 2 MCM
Intra-basin Water Transfer	Kikuyu Springs, Ruiru Dam, Nol Turesh,	Domestic water supply to Nairobi	Total 10 MCM/year (27,500 m^3/day)
Intra-basin Water Transfer	Mzima Springs, Marere Boreholes, Tiwi Boreholes, Baricho shallow wells (Sabaki)	Domestic water supply to Mombasa and other coastal towns	Mzima Springs (35,000 m^3/day), Marere (12,000 m^3/day), Tiwi (13,000 m^3/day), Baricho (90,000 m^3/day), Total 55 MCM/year (150,000 m^3/day)
Inter-basin Water Transfer	From Sasumua and Thika dams (TCA) to Nairobi	Domestic water supply to Nairobi	Total 181 MCM/year (496,900 m^3/day)
Inter-basin Water Transfer	From Maruba Dam	Domestic water supply to Machakos	2 MCM/year or 5,000 m^3/day
Small Dam/ Water Pan	1,326 in total	Mainly for domestic and livestock water supply and partly for irrigation	Total storage volume of 11.6 MCM, average volume per facility of 9,000 m^3
Borehole	5,351 in total	Mainly for domestic water supply	Total abstraction volume of 230 MCM/year

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

The total storage volume of the existing water resources structures/facilities in ACA is approximately 22 MCM summing the volumes of dams and small dams/ water pans listed in the above table. Out of the 26 existing dams nationwide as described in Chapter 2 of the Sectoral Report (G), there are seven dams in ACA, which are all for domestic water supply purposes.

Kiserian Dam with an intra-basin water transfer facility is under construction for domestic water supply purpose (storage volume of 1 MCM). Thwake Dam (domestic and irrigation water supply and hydropower) and Ruaka Dam (domestic water supply) completed their designs. Dams under planning and/or designing stages in the catchment area are as follows; Rare Dam (domestic water supply), Lake Chala Dam (domestic water supply and flood control), and Ruiru-A, Ndarugu, Mwachi, Stony Athi, and Kamiti 1 dams (all for domestic water supply purpose), and Munyu Dam (irrigation water supply and hydropower). The water transfer schemes under planning stage are the Second Mzima and Sabaki Extension schemes.

Both small dams/water pans and boreholes have been exploited to satisfy large water demands in the catchment area. There are 1,326 small dams/water pans and their total storage volume is 11.6 MCM, which is 53% of the total storage volume in the catchment area. There are 5,351 boreholes in the catchment area, which is approximately 43% of the national total 12,444 boreholes (MWI). These boreholes supply around 44% of the domestic water demands in ACA.

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. The water supply reliability of 1/1 or 1/2 means that the present water demands are satisfied with the available water resources with existing water resources structures under drought condition with probability of once in 1 or 2 years.

4.6.2 Development Strategy

The water demands projection for 2030 as well as the estimated present water demands in ACA are explained in Chapter 3 and summarised as follows:

Present and Future Water Demands (ACA)

(Unit: MCM/year)

Sub-Sector	Present Water Demand (2010)	Future Water Demand (2030)
Domestic	519	941
Industrial	93	153
Irrigation	498	917
Livestock	25	59
Wildlife	3	3
Fisheries	7	12
Total	1,145	2,085

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

The projected 2030 water demands show an increase of about 1.8 times compared with the present demands due to increase in population to 20.54 million including Nairobi and Mombasa and increase in irrigation areas to 91,006 ha as mentioned in Chapter 6 of the Main Report Part A.

Judging from the estimated 2030 water deficits discussed in Section 3.4 (1), it is certain that existing water resources structures/facilities will not be able to satisfy the great increase of water demands in 2030; therefore, new structures/facilities are required to be developed. As the total estimated available surface water of 1,334 MCM/year and the groundwater of 300 MCM/year in the catchment area is below the amount of water demands in 2030, water resources development should focus not only on maximum exploitation of surface water and groundwater within the catchment area but also water transfer from the adjacent catchment area such as TCA.

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

a) The inter-basin water transfer facilities from dams in the TCA to ACA will 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 the above table for ACA.

b) Dam development is essential and required to be promoted in the northwestern part of the catchment area, along the Athi River and in the coastal areas including Mombasa to satisfy the sharp increase in future large water demands expected in these areas such as domestic, industrial and irrigation water demands. Candidate dam development projects for the 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.

c) Dams identified in the most upstream area of the Athi River will be developed only for 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 Athi River, and/or desalination will be studied to incorporate them into the development plan for domestic water supply to Mombasa and coastal areas.

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

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

4.6.3 Proposed Water Resources Development Plan

(1) Water Balance Study

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

The water balance study followed the policies of the water allocation as stated in Section 7.2 of the Main Report Part A, a summary of which are tabulated as follows:

Prioritisation of Water Allocation

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

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

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

Conditions of the surface water balance study are explained in Section 4.3 of the Sectoral Report (G) and are summarised as follows; i) the model consists of 33 sub-basins, water demand points, and the existing water resources infrastructures and candidates for future development such as dams and water transfer facilities; ii) monthly mean values of the naturalised water resources and demands are applied; iii) an amount of the reserve is determined as the 95% value of the naturalised present daily flow duration curve in Figure 4.6.4 with the probability of once in 10 years as shown in Table 4.6.3; and iv) return flow rates of 25%, 5%, and 100% for urban domestic water supply, paddy irrigation, and hydropower generation are applied.

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

(2) Proposed Water Resources Development Plan

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

1) Dams

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

Proposed Dams (ACA)

(Unit: MCM)

Name of Dams	Storage Volume for Domestic/ Industrial	Storage Volume for Irrigation	Total Storage Volume		Remarks
Upper Athi (Mbagathi) Dam	24.0	0.0	24.0		
Stony Athi Dam	23.0	0.0	23.0	*	F/S and M/P ongoing (AWSB)
Kikuyu Dam	31.0	0.0	31.0		
Ruaka (Kiambaa) Dam	4.0	0.0	4.0		D/D completed (AWSB)
Kamiti 1 Dam	16.0	0.0	16.0	*	F/S and M/P ongoing (AWSB)
Ruiru-A (Ruiru 2) Dam	18.0	0.0	18.0		Flagship Project, F/S and M/P ongoing (AWSB)
Ndarugu Dam	300.0	0.0	300.0	*	Flagship Project, F/S and M/P ongoing (AWSB)
Munyu Dam	0.0	575.0	575.0		Flagship Project, F/S done (NWCPC)
Mbuuni Dam	10.0	0.0	10.0		
Kiteta Dam	16.0	0.0	16.0		Pre-F/S done (NWCPC)
Thwake Dam	176.0	418.0	594.0	*	Flagship Project, Final design completed (NWCPC)
Olkishunki Dam	1.2	0.0	1.2	*	Pre-F/S done (ENSDA)
Pemba Dam	19.0	0.0	19.0		
Lake Chala Dam	6.0	0.0	6.0		D/D ongoing (MORDA)
Rare Dam	36.0	0.0	36.0		Flagship Project, D/D ongoing (NWCPC)
Mwachi Dam	16.0	0.0	16.0		Flagship Project, Preliminary design completed (NWCPC)
Total	696.2	993.0	1,689.2		

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

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

The respective total storage volumes of Stony Athi, Kamiti 1, Ndarugu, Thwake and Olkishunki dams followed completed design, ongoing feasibility studies and master plans, and pre-feasibility study as shown in the above table.

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

2) Water Transfers

The proposed amounts of intra-basin water transfers from Mzima Springs to Mombasa/ Kwale/ Ukunda, and from Athi River to Mombasa/ Malindi/ Kilifi/ Mtwapa as mentioned below followed study results made by CWSB. The proposed amount of inter-basin water transfer from TCA to Nairobi followed study results of AWSB.

Proposed Water Transfers (ACA)

(Unit: MCM/year)

Structures	Amount for Domestic	Total Water Transfer Amount	Remarks
Intra-basin Water Transfer from Mzima Springs to Mombasa/ Kwale/ Ukunda (Extension)	37	37	(equivalent to 100,000 m^3/day), CWSB
Intra-basin Water Transfer from Athi River to Mombasa/ Malindi/ Kilifi/ Mtwapa (Extension)	31	31	(equivalent to 85,000 m^3/day), CWSB
Inter-basin Water Transfer from the TCA to Nairobi (Extension)	168	168	(AWSB)

Source: JICA Study Team and Feasibility Study by AWSB and CWSB, 2012

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

3) Small Dams/Water Pans

The proposed storage volumes of small dams/water pans for irrigation use were estimated considering the conditions of the irrigation subsector.

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

Proposed Small Dams/Water Pans (ACA)

(Unit: MCM)

Structures	Volume for Domestic	Volume for Irrigation	Volume for Livestock	Volume for Wildlife/ Fisheries	Total Storage Volume	Remarks
Small Dam/ Water Pan	0	20	59	15	94	Total No. of small dams/ water pans = 1,880

Note: Excluding the 12 MCM storage volume of the existing small dams and water pans.
Source: JICA Study Team

The total number of the small dams / water pans of 1,880 was estimated by applying the volume per dam/ pan of 50,000 m^3 as the minimum capacity following the volume applied in NWMP (1992) and assumed based on the existing volumes.

4) Boreholes

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

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

Proposed Boreholes (ACA)

(Unit: MCM/year)

Facilities	Volume for Domestic/Industrial	Volume for Irrigation	Total Abstraction Volume	Remarks
Borehole	0	35	35	Total No. of boreholes = 350

Note: Excluding the 230 MCM/year abstraction of existing boreholes.
Source: JICA Study Team

The total number of the boreholes of 350 was estimated by applying the capacity per borehole of 100,000 m^3/year assumed based on the existing data.

5) Desalination

Desalination of an additional 93 MCM/year will be required in Mombasa.

(3) Evaluation of Proposed Water Resources Development Plan

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

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

Water Supply Reliability at Reference Point (ACA)

Reference Point	Present (2010) Water Supply Reliability	Future (2030) Water Supply Reliability
Athi River, middle reach (3DB01), Wamunyu	1/2	1/5
Athi River, lower reach (3HA12), Epiya Chapeyu	1/1	1/10

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

The future water supply reliability at the reference point of Wamunyu in Middle Athi River is estimated at 1/5, since water demand downstream of the reference point is irrigation use mainly. The future water supply reliability at the reference point of 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 surface water resources, reserves, water demands, yields of the water resources development structures, and water supply reliabilities estimated at the reference points are tabulated in Table 4.6.8.

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

4.7 Water Resources Management Plan

4.7.1 Current Situation of Water Resources Management

ACA has densely populated cities including the largest city- Nairobi, Kiambu, Machakos, and surrounding areas, the second largest city- Mombasa. The area is expected to have water demand and supply balance in the future. In Nairobi City and surrounding areas, decrease of groundwater resources due to over abstraction is one of the major issues.

In the middle part of the catchment, there are many springs near Chyulu Hills like Mzima Spring, which are major sources of water. It is important to establish a system to enable a sustainable use of the spring water.

The Water Resources Management Authority has its Athi River Catchment Area Regional Office in Machakos. Under the regional office, there are five subregional office, namely:

(i) Kiambu that covers the northern suburbs of Nairobi;
(ii) Nairobi subregion that covers Nairobi metropolitan area and its southern suburbs;
(iii) Kibwezi that covers the middle part of ACA;
(iv) Oloitokitok that covers catchments of the Norteursh and Lumi rivers, both tributaries of the Athi River; and
(v) Mombasa that covers the coastal part of ACA.

Figure 4.7.1 shows the Management Unit Boundary and Subregional Office Management Boundary.

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

Current Monitoring Situations of Water Resources (ACA)

(Unit: nos)

Item	Surface Water (SW) Level	Groundwater (GW) Level	Surface Water Quality	Groundwater Quality	Rainfall
Target	31	71	31	18	50
Operational	18	25	26	18	33
Achievement (%)	58	35	84	100	66

Source: WRMA Performance Report 1 (July 2010)

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

Current Situations of Water Permits Issuance (ACA)

(Unit: nos)

Item	Application	Authorised	Issued Permits	Valid Permits	Ratio of Validity (%)
Surface Water	2,999	2,751	470	199	42
Groundwater	7,449	5,895	571	217	38
Total	10,448	8,646	1,041	416	40

Source: WRMA Performance Report 1 (July 2010)

As for the watershed conservation of ACA, it is important to conserve the Aberdare Range which are major water sources of the Athi River. Deforestation and forest degradation are rampant in the gazetted forest and private forest in the southern part of the Aberdare Range, as well as private forests in the upstream reach of Lokerish River, Kaiti River, and in the west of Voi Town. According to the results of satellite image analysis in this study[1], the forest area in ACA in 2010 was about 120,000 ha which corresponded to 2.0% of the forest cover in ACA. The deforested areas during the last two decades were about 133,000 ha, which meant there was a decrease of 52.5% of the forest areas in 20 years since 1990.

According to the interviews with stakeholders of watershed conservation including WRMA and KFS in ACA, there were deteriorations on small water sources such as 20 springs and 17 wetlands. Such issues affect badly the availability of water resources in the catchment area as there were many semi-arid lands in ACA that highly depend on the small water sources. However, as detailed information on deterioration of small water sources such as location, magnitude, water use, water quality, vegetation, and method of management are unknown, further study is required.

On the other hand, issues on soil erosion are not significant in ACA.

4.7.2 Management Strategy

Based on overall planning concept and framework as mentioned in Section 7.8 of the Main Report Part A: water resources management strategy for ACA was set for major components of i) Monitoring, ii) Evaluation, iii) Water Permit Issuance and Control, and iv) Water shed Conservation as shown below:

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

(1) Monitoring

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

1) Surface Water Level

The Athi River and its major tributaries were selected as representative rivers for capturing runoff characteristics of the basin. In addition, rivers with relatively small catchment area that flow into the Indian Ocean, international rivers of Namanga and Lumi were also regarded as representative rivers as well as for major international lakes of Chala and Jipe. Major springs of Mzima and Kibwezi were selected for monitoring. Surface water level monitoring stations are reviewed to capture major points of these three rivers, major lakes, and major springs (refer to Figure 4.7.1).

2) Surface Water Quality

The surface water quality monitoring points were also selected from representative rivers, lakes, and springs.

For the three rivers, selected monitoring points should be located at the downstream of pollution sources, such as major cities and irrigation schemes. Such points should be monitored monthly.

One location for lake water quality and spring water quality should be monitored on a quarterly basis as lake water quality does not change so frequently compared with river water quality.

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

3) Groundwater Level

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

4) Groundwater Quality

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

5) Rainfall

The rainfall station density should be considered by climatic regions for arid, semi-arid, or other areas. Most of the catchment area belongs to semi-arid area except the north-western part of the catchment in Nairobi and surrounding areas. For the semi-arid areas in most of the catchment area, a criterion of one station in 3,000 km^2 to 5,000 km^2 is applied. For the rest of the basin in the north-western part, that belongs to other areas, a criterion of one station in 500 km^2 to 1,000 km^2 is applied for selection of rainfall monitoring stations.

(2) Evaluation

1) Water Resources Quantity Evaluation

The water resources quantity evaluation is conducted annually based on i) monitoring data for surface water, groundwater, and rainfall and ii) records of water permit issuance. Abstraction survey data will be used as necessary to determine the status of actual water use. For surface water resources evaluation, major rivers of Athi and its tributaries should be focused as these are representative rivers in ACA. In the major cities of Nairobi and Mombasa including the surrounding areas, evaluation of groundwater resources is also important.

2) Water Resources Quality Evaluation

The water resources quality evaluation is conducted annually based on the monitoring data for surface water and groundwater quality. Currently, there is only one water quality test laboratory in Machakos located in the catchment area. For timely analysis of monitored water quality, especially in the coastal area, additional water quality test laboratory should be established.

(3) Water Permit Issuance and Control

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

(4) Watershed Conservation

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

1) Recovery of Forest Areas

Forest recovery will be implemented through reforestation focusing on the Aberdare Range of the Five Water Towers and gazetted forests in the coastal areas.

2) Conservation of Small Water Sources

Conservation of small water sources in the catchment area will be considered.

4.7.3 Proposed Water Resources Management Plan

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

(1) Monitoring

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

1) Surface Water Level

Surface water level is observed twice a day by an honorarium gauge reader. Observed water levels are submitted to WRMA regional offices once a month. In addition, WRMA staff conducts discharge measurement by current meter once a month. Based on the overall concept, the current monitoring network was reviewed mainly for the Athi River and its tributaries, there were six monitoring points selected for the Athi River, five in the tributaries of the Athi River in its upper reach, two in the tributary of Athi in its middle reach, two in the major springs of Mzima and Kibwezi, one each for international rivers and lakes, namely, Lumi and Namanga rivers, Lakes Jipe and Chala, and five locations for rivers flowing into the Indian Ocean. In total, 25 monitoring points were selected for daily monitoring. For major rivers, the following reference points were selected as follows:

a) 3DB01 is located in the middle reach of the Athi River. Monitoring started in 1980.
b) 3HA12 is located in the lower reach of the Athi River. Monitoring started in 1980 but is currently suspended. The point is used for checking whether sufficient river reserve is available in case water transfer from Mzima Spring to Mombasa increases in the future.

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

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. Sectral Report (G), Sub-section 4.4.3 (3) and Table 4.4.4)

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

2) Surface Water Quality

Stations with monthly basis monitoring

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

a) 3DB01 (located in the lower reach of the Athi River, as the Reference Point): To monitor the impact on the river water quality caused by urban effluent from Nairobi and surrounding areas.
b) 3HA12 (located in the lower reach of the Athi River, as the Reference Point): To monitor the impact on the river water quality caused by effluent from irrigation schemes in the upper and middle Athi. In addition, to check river water quality in case water transfer from Mzima Spring to Mombasa increases in the future.

Stations with quarterly basis monitoring

Apart from the above two monitoring stations, water quality of other surface water monitoring stations (24 points) should be monitored on a quarterly basis (January, April, July, and October every year). Such data are used as reference when WRMA issues water permits. These 24 monitoring stations are:

3AA06, 3BA10, 3BA29, 3BC08, 3BD05, 3CB05, 3EA02, 3F02, 3F06, 3F09, 3F11, 3G01, 3G02 , 3HA13, 3J02, 3J12, 3J15C, 3KB01, 3KD06, 3KG01, 3LA05, 3MH26, New (Namanga), New (Lokerish)

3) Groundwater Level

Based on the management strategy, the following 24 points, namely, Karui, Limuru, Kikuyu, Ngong, Ongata Rongai, Kitengela, Kiambu, Ruiru, Nairobi City, Juja, Mavoko, Kangundo, Machakos, Malindi, Kilifi, Mtwapa, Mombasa, Kwale, Ukunda, Kiserian, Taveta, Mariakani, Voi, and Kajiado were selected for groundwater level monitoring by dedicated boreholes for monthly basis monitoring. These points are located near the urban centres where both water supply and sanitation plans are built with expected high growth of groundwater demand in the future.

4) Groundwater Quality

Groundwater quality is monitored at the same location where groundwater level monitoring stations are located. As groundwater quality does not change so frequently compared with surface water, monitoring is conducted twice a year (once in the rainy season and once in the dry season).

5) Rainfall

Based on the management strategy, distribution of current rainfall monitoring stations was reviewed. As a result, 38 rainfall monitoring stations were selected for daily basis monitoring.

(2) Evaluation

1) Water Resources Quantity Evaluation

Based on the management strategy, water resources quantity evaluation is conducted annually based on i) monitoring data for surface water, groundwater and rainfall and ii) water permit issuance data. For this, a water resources evaluation team is formed composed of: i) one chief hydrologist in the Machakos Regional Office and ii) one assistant hydrologist each for subregional office of Kiambu, Nairobi, Kibwezi, Loitoktok, and Mombasa. Water resources evaluation works are done for the whole catchment area of ACA on both surface water and groundwater.

2) Water Resources Quality Evaluation

Based on the management strategy, water resources quality evaluation is also conducted annually based on the monitoring data for surface water and groundwater quality.

Additional water quality test laboratory should be established in Mombasa for timely analysis of water quality sample especially in the coastal region. For the management of laboratory and evaluation of water quality, a chief water quality expert with appropriate staffs should be assigned in the water quality test laboratories in Machakos and Mombasa.

(3) Water Permit Issuance and Control

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

a) Controlling the latest version of issued water permits
   - Periodical updating of water permit database
   - Establishment and enhancement of notification system for expired permits
b) Revision of guidelines for water allocation
   - Formulation of water allocation plans considering future water demand
c) Increase of the number of water rights officers shown below for smooth implementation of water permit issuance and control.

Number of Required Water Rights Officers (ACA)

Offices	Number of Water Right Officers		
	Current	Required	Future
Athi RO	1	+2	3
Kiambu SRO	1	+1	2
Nairobi SRO	1	+2	3
Kibwezi SRO	1	+1	2
Loitoktok SRO	1	+1	2
Mombasa SRO	1	+3	4
Total	6	+10	16

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

(4) Watershed Conservation

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

1) Recovery of Forest Areas

As to the forest recovery for watershed conservation, about 870,000 ha of forestation is proposed in ACA to achieve the targets of the Kenya Vision 2030. Current situations of the forest areas in the ACA and potential areas for forestation are shown in Figure 4.7.3.

The followings steps were applied for the preparation of Figure 4.7.3.

a)Identify the present forest areas and deforested areas (in this master plan, the satellite image analysis was used), and overlay the gazetted forest areas,

b)Identify the important forest areas including deforested areas as water source forests,

c)Delineate the potential forestation areas and the areas mentioned above (b), and formulate the area with consideration of significant forest area, and

d)Connect the isolated small gazette forest areas by corridor and delineate the potential forestation area with combination of these two areas.

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

2) Conservation of Small Water Sources

As to the conservation of small water sources, it is proposed to carry out a survey on small water sources, which includes location, scale, water use, water quality, vegetation condition, management method, major issues, etc.

4.8 Flood and Drought Disaster Management Plan

4.8.1 Current Situation of Flood Disaster Management

(1) Flood Situation

Coastal areas in ACA suffered from flood damages nearly every year due to heavy rains. It is recorded that the flood occurred in the coastal area in September 1997 caused 86 deaths and 900,000 displaced people in total for Kilifi, Mombasa, and Kwale.

In the Lumi River that flows near the border of Tanzania, flood damages has continuously occurred since before the NWMP (1992) was formulated, with the occurrence of floods involving mudslides in Taita Taveta District in 2008. Most affected areas by the Lumi River-induced flood are located at the downstream side of Taveta urban area. These villages are smaller compared to Taveta urban area. Also in the affected area, there is the Njoro Spring, which is an important water source for this area.

On the other hand, large cities such as Nairobi and Mombasa that are respectively located in the upstream and downstream parts of the Athi River have suffered from urban floods. Once heavy rains occur in these cities, accumulated rainwater frequently results in traffic jam. In December 2009, thunderstorms, heavy rains, and winds occurred in Nairobi. These natural phenomenon caused floods in the Central Business District (CBD) and in several slum areas.

(2) Flood Disaster Management

At present, it could be said that systematic flood management has not been implemented in Athi because setting of warning water levels even at major river gauge stations have not been confirmed.

4.8.2 Current Situation of Drought Disaster Management

(1) Drought Situation

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

Drought damage in ACA is relatively not severe compared to the RVCA or ENNCA. However, it was reported that the drought that happened in January 2011, created a remarkable decreased in agricultural production and an outbreak of livestock disease due to deterioration of water quality. These were caused by exceptionally poor rainfall in localised parts of Malindi and Taita Taveta where only 10%-20% of normal rains were received.

(2) Drought Disaster Management

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

On the other hand, as for drought management at the catchment level, in times of drought, WRMA Athi Regional Office conducts water use restriction. However, reference water levels for restriction are not 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, namely, Ruiru, Bathi, Mulima, Manooni, Muoni, Kikoneni, Maruba, and Kiserian (under construction) dams. However, drought disaster management including water use restriction of the reservoirs has not been implemented.

4.8.3 Flood Disaster Management Strategy

As explained in the concept and framework e) mentioned in Section 7.9 of the Main Report Part A, the proposed examination areas in Athi are Downmost Athi, Lumi River mouth, Nairobi City, Kwale, and Mombasa.

Downmost Athi, which is also known as lower Sabaki, experienced frequent inundation at the lower reach where there are a lot of seasonal small-scale migratory settlements, according to the interview with WRMA Mombasa Subregional Office. In this case, flood control measures will not be required because there are scarce densely-populated areas. Therefore, the basic strategy for Downmost Athi is to develop a community-based disaster management system by installing a simplified flood forecasting system based on water level observation in the upper reaches of the Athi River.

Floods in Taita Taveta County frequently occur in the small villages along the Lumi River on the south side of the Taveta urban area. Similar to the case of Downmost Athi mentioned above, it is appropriate for Lumi River mouth to consider developing a community-based disaster management system. This strategy is also in line with the policy of JICA Technical Assistance Project on Capacity Development for Effective Flood Management in Flood Prone Areas, which is being implemented from 2011 to 2014.

In Kwale County, the most flood-prone area is Vanga, located at lower reach of the Umba River near the border with Tanzania, according to the interview with WRMA Mombasa Subregional Office. In this area, it is confirmed from satellite imagery that built-up area has been formed. Therefore, Vanga shall be protected by river structural measures.

The type of floods occurred in Nairobi and Mombasa is not river-induced floods, but rather an urban drainage issue. In particular severe drainage issue is found in the Kisauni area, which is located out of Mombasa Island. In consideration of the very high population density in Nairobi and Mombasa, the drainage systems should be improved.

The following are basic policy to formulate the flood disaster management plan in Athi:

a) Establishment of community-based disaster management system in Downmost Athi.
b) Establishment of community-based disaster management system in Lumi River mouth.
c) Implementation of flood control measures as well as preparation of hazard map in Vanga of Kwale.
d) Implementation of urban drainage measures in Nairobi.
e) Implementation of urban drainage measures in Mombasa.

4.8.4 Drought Disaster Management Strategy

Based on the overall concepts mentioned in Section 7.9 of the Main Report Part A, drought management strategy for ACA will be as follows; i) preparation of water use restricted rules for existing and proposed reservoir, ii) establishment of a Basin Drought Conciliation Council, and iii) establishment of drought early warning system.

4.8.5 Proposed Flood Disaster Management Plan

In line with the above management strategies, the proposed flood disaster management plan for ACA is shown below. The proposed measures are illustrated in Figure 4.8.1.

(1) Establishment of CBDM System in Downmost Athi and Lumi River mouth

In Downmost Athi and Lumi River mouth, community-based disaster management system is proposed in reference to the system that has already been developed in the Nyando River basin.

It is proposed that CBDM system includes various community involvement and activities, namely, i) systematisation of communities and establishment of a flow of monitoring, information dissemination, and evacuation in cooperation with WRMA Athi Regional Office, Mombasa/ Loitokitok subregional offices and local government offices, ii) construction of evacuation centres and evacuation routes through community involvement, iii) voluntary monitoring by community using simple rain gauge and water level gauge, iv) community involvement in flood fighting activities, and v) construction of small-scale structural measures such as a small revetment and culvert.

As to the flood forecast, these areas shall basically adopt a simplified flood forecasting system by using river water level observation in the upper reaches. The communities themselves will recognise the occurrence of flood and carry out necessary activities in accordance with the hazard map and evacuation plan, which should be prepared in advance by themselves.

(2) Implementation of Flood Control Measures in Vanga of Kwale

In order to protect the built-up areas of Vanga, it is proposed to implement measures combining construction of new dike along the river, widening of low water channel by excavation, construction of ring dike around the built-up area, etc.

In addition, flood hazard map should be prepared and notified to the public. This map is assumed to be more accurate compared to simplified hazard map prepared by communities and to show probable flood areas for several kinds of probable return periods and probable maximum flood. To create the map, the WRMA Athi Regional Office should make a flood analysis by using hydrological and topographical data.

(3) Implementation of Urban Drainage Measures in Nairobi and Mombasa

It is proposed to implement urban drainage measures in Nairobi and Mombasa. The work is the responsibility of the local authorities, namely, Nairobi/Mombasa Urban Centre. In the following section of cost estimates, preliminary estimated cost of the drainage works composing of gravity drains based on NWMP (1992) are presented. However, it is noted that drainage work involves some major cases or associated works such as pumping station, retarding basin, improvement of receiving river channels, etc., which should be planned in details in the future.

4.8.6 Proposed Drought Disaster Management Plan

(1) Preparation of the Water Use Restriction Rule for Reservoirs

1) Target Dam

It is proposed to prepare the water use restriction rule for the respective reservoirs. The names of target dams are shown in the table below. There are eight existing and 16 proposed dams in ACA.

Target Dams for Water Use Restriction Rules (ACA)

River System	No.	Dam Name	Status	
			Existing	Proposed
Athi	1	Kikuyu		O
	2	Ruaka (Kiambaa)		O
	3	Kamiti 1		O
	4	Kiserian	O	
	5	Upper Athi		O
	6	Stony Athi		O
	7	Bathi	O	
	8	Ruiru	O	
	9	Ruiru A (Ruiru 2)		O
	10	Ndarugu		O
	11	Munyu		O
	12	Muoni	O	
	13	Mbuuni		O
	14	Maruba	O	
	15	Mulima	O	
	16	Kiteta		O
	17	Manooni	O	
	18	Thwake		O
	19	Olkishunki		O
Lumi	20	Lake Chala		O
Ramisi	21	Kikonen	O	
Rare	22	Rare		O
Shimba	23	Pemba		O
Mwachi	24	Mwachi		O
Total			8	16

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

2) Setting of Reference Reservoir Water Level

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

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

3) Determination of Reduction Rate

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

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

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

(2) Establishment of a Basin Drought Conciliation Council

1) Jurisdiction of Council

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

The previous table shows all the dams, which are incorporated into the water resources development plan of NWMP 2030, and their river systems. One council shall be established for each river system. The number of councils to be established in ACA will be six for Athi, Lumi, Ramisi, Rare, Shimba and Mwachi river systems as illustrated in Figure 4.8.1.

The council shall be basically composed of WRMA regional office, relevant counties, representative of water users (WRUAs), etc. The council shall be established with legal status to avoid water conflict at drought time.

(3) Drought Early Forecast

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

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

4.9 Environmental Management Plan

4.9.1 Current Situation of the Environmental Management

The main water resources of ACA are the Athi River, which is the main river, and its tributaries. WRMA is monitoring the river flow and water quality of these rivers. However, the current data are insufficient to confirm the secular change of water environment.

Nairobi City is located in the uppermost area of ACA. The Athi River and the tributary of the Nairobi River are affected by the negative impacts such as inadequate wastewater treatment and illegal dumping of waste from the city. The excessive use of groundwater also is a serious challenge in the city. Mombasa City, the second largest city of Kenya, is located in the coastal area of ACA. There is a fear that inadequate management of sewage and waste coming from urban areas causes water pollution and mangrove forest degradation in marine reserve area. It is necessary to monitor the environmental impact by conducting environmental monitoring to avoid any further degradation in the surrounding areas of the cities.

There are 18 national parks/reserves including nine marine parks/reserves in ACA. Tsavo East National Park and Tsavo National Reserve are located in the middle part of the catchment area. Tova area is the largest national protected area in Kenya. The Mzima Spring is situated in the Tsavo East National Park. It provides drinking water to Mombasa City by a pipeline and also serves as water resources of the Tsavo River. Nine marine national parks/reserves are situated in the coastal zone. These protected areas comprise the sea waters, mangroves, sea grasses, and seaweeds. Among them, the Malindi-Watamu National Park/reserves are designated as biosphere reserve by UNESCO.

ACA has two international lakes such as Lake Jipe and Lake Chala. In Lake Jipe, salinity has been increasing, while its depth and biodiversity have been decreasing. Hippopotamus and crocodiles have migrated upstream due to salinity. The lake is of global importance and the only place on earth where *Oreochromis jipe* is found, and these endemic fishes are on the verge of extinction. Lake Chala is in between Kenya and Tanzania. The lake is home to the endemic Lake Chala tilapia (*Oreochromis hunteri*), which is now considered as critically endangered on the IUCN Red List of threatened species. Crocodiles were raised in Lake Chala in the early 1900s, and in 2002. The lake is fed by groundwater flows, which come from Mount Kilimanjaro, fed and drained underground with a rate of about 10 million m^3/year. In addition, the Amboseli National Park is located near the border of Tanzania. The park has Lake Amboseli, where water level of the lake changes in dry season and rainy season, and has unique ecosystem based on the change of season.

Natural Environmental Resources (ACA)

Protected Area		Total Area	Number of Wildlife Species	Location
National Park (N.P.)				
1	Chyulu Hills N.P	736 (km^2)	205	Kibwezi District, Eastern Province
2	Nairobi N.P.	117 (km^2)	196	Only 7 km from Nairobi City centre
3	Amboseli N.P.	392 (km^2)	193	Loitoktok district, Rift Valley Province
4	Tsavo West N.P.	9,065 (km^2)	215	South East Kenya, inland from the coast
5	Tsavo East N.P.	11,747 (km^2)	226	South East Kenya, inland from the coast
6	Oldonyo Sabuk N.P.	18 (km^2)	174	Machakos District , Eastern Province
7	Arabuko Sokoke N.P.	6 (km^2)	No information	110 km northern from Mombasa
National Reserve (N.R.)				
8	Nasalot N.R	194 (km^2)	160	The north bordered by a section of the Turkwel River
Marine National Park (N.P.)				
9	Malindi Marine N.P,	6 (km^2)	No information	North coast, Malindi Town
10	Mombasa Marine N.P.	26.093 (km^2)	152	In Mombasa Town along the Kenyan coast
11	Mpunguti Marine N.P	28 (km^2)	No information	Near Ukunda town, Msambeni District
12	Watamu Marine N.P	10 (km^2)	150	North coast, Malindi
Marine National Reserve (N.R.)				
13	Diani-Chale Marine N.R	165 (km^2)	158	South of Mombasa
14	Malindi Marine N.R.	213 (km^2)	No information	South-eastern coast
15	Watamu Marine N.R.	32 (km^2)	No information	North coast, Malindi
16	Mpunguti Marine N.R.	11 (km^2)	No information	Lamu District, Coast Province
17	Mombasa Marine N.R.	200 (km^2)	152	In Mombasa Town along the Kenyan coast
Five Water Towers				
18	Aberdare Range	250,000(ha)	No information	Central Kenya, on the eastern edge of the RVCA

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

4.9.2 Management Strategy

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

Water resource development projects of ACA are proposed on the Athi, Nairobi, Lumi, Mwachi, and Kaiti rivers. Appropriate environmental flow rate should be set for these rivers in the future. It is proposed that an environmental flow rate should be set to carry out environmental monitoring for the Athi and Lumi rivers being representative rivers. Lake Chala and Lake Jipe are also proposed to have environmental 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 keeps important natural resources.

Sewage and industrial wastewater from Nairobi and Mombasa cities have already affected the surrounding environment. Therefore, an environmental monitoring is proposed for these two cities as well as to the Nairobi River which is directly affected by Nairobi City.

4.9.3 Proposed Environmental Management Plan

Based on the abovemenitoned management strategy and point selection criteria mentioned in the overall concept and framework, target points of environmental flow rate and environmental monitoring of environmental management plan for ACA are shown in the following table. Locations of target points are shown in Figure in 4.9.1.

Environmental Flow Rate/Water Level Setting Points (ACA)

<table>
<tr><th>Target</th><th colspan="2">Environmental Flow Setting Point</th><th>Proposed Major Development Projects</th><th>Vegetation</th><th>Reserve * (m^3/s)</th><th>Monitoring Point of WRM</th></tr>
<tr><td rowspan="3">Athi River</td><td>ACA-F1</td><td>Reference point (Confluence point with the Tsavo River)</td><td rowspan="3">Upper Athi, Ruiru A, Kamiti1, Kikuyu, Stony Athi, Ndarugu, and Thwake dams</td><td rowspan="3">Deciduous bushland and thicket</td><td>8.9</td><td>3HA12</td></tr>
<tr><td>ACA-F2</td><td>Upstream of Tsavo national parks</td><td>9.8</td><td>3F09</td></tr>
<tr><td>ACA-F3</td><td>Reference point (Kangunda Town)</td><td>8.6</td><td>3DB01</td></tr>
<tr><td>Lumi River</td><td>ACA-F4</td><td>Reference point</td><td>Lake Chala Dam and Taita Taveta Irrigation</td><td rowspan="2">Deciduous bushland and thicket / Evergreen bushland with wooded grassland</td><td>0.0</td><td>3J15</td></tr>
<tr><td>Lake Chala</td><td>ACA-F5</td><td>Representative point</td><td>-</td><td>-</td><td>3J12</td></tr>
<tr><td>Lake Jipe</td><td>ACA-F6</td><td>Representative point</td><td>Lake Chala Dam and Taita Taveta Irrigation</td><td>Evergreen bushland with wooded grassland</td><td>-</td><td>3J02</td></tr>
</table>

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

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

In addition, the environmental survey for setting the environmental flow rate (current river flow rate, water quality, and river ecosystem) shall be conducted in the Athi and the Lumi rivers, Lake Chala, and Lake Jipe. Lake Amboseli is also one of the targets in the environmental survey. However, there will be no environmental water level setting since the lake water level change drastically in dry season and wet season. Thus, environmental survey is conducted only to confirm the ecosystem of the lake.

Environmental Monitoring Points (ACA)

Target	Monitoring Point		Reserve* (m^3/s)	Monitoring Point of WRM	Selection Criteria
Athi River	ACA-M1	Reference point (Confluence point with the Tsavo River)	8.9	3HA12	a) Representative point to monitor the river ecosystem
	ACA-M2	Upstream of Tsavo national parks	9.8	3F09	b) Points where rare or characteristic ecosystem exists (Mau Forest Complex)
	ACA-M3	Reference point (Kangunda Town)	8.6	3DB01	a) Representative point to monitor the river ecosystem
Lumi River	ACA-M4	Reference point	0.0	3J15	a) Representative point to monitor the river ecosystem, and f) International rivers and lakes.
Nairobi River	ACA-M5	Downstream of Nairobi City	1.1	3BA29	c) Points where large city or town is located, and d) Upstream points from the protected area
Lake Chala	ACA-M6	Representative point	-	3J12	e) Major lakes in the catchment area, and f) International rivers and lakes
Lake Jipe	ACA-M7	Representative point	-	3J02	e) Major lakes in the catchment area, and f) International rivers and lakes
Lake Amboseli	ACA-M8	Representative point	-	-	e) Major lakes in the catchment area, and d) Points upstream from the protected area
Nairobi and Mombasa cities	ACA-M9	Nairobi City (Main discharge point)	-	-	c) Points where large city or town is located, and d) Points upstream from the protected area
	ACA-M10	Mombasa City (Main discharge point)	-	-	

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

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

CHAPTER 5 COST ESTIMATES

5.1 Basic Conditions and Methodologies for Cost Estimates

5.1.1 Conditions and Methodologies of Cost Estimates for Development Plans

Costs of the projects proposed in the development plans formulated for ACA in this study including water supply, sanitation, irrigation, hydropower and water resources development plans were estimated to know the overall cost in general, as well as to evaluate the general economic viability. A general idea or scheme of financing for the implementation of the proposed projects is all discussed.

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

(1) Water Supply Development Projects

a) For the urban water supply system, the project costs were estimated by applying the unit cost of US\$250/m^3 of water supply capacity for rehabilitation, US\$375/m^3 for expansion/new development of source works and water transmission system, and US\$1875/m^3 for expansion/new development of treatment works and distribution pipe networks. The unit costs were derived from the data in the existing reports prepared by WSBs and the Aftercare Study Report with adjustments. The used data include direct construction costs and indirect construction costs (administration and engineering services). Land acquisition costs were not estimated due to the marginal amount for water supply projects.

b) For the dams and bulk water transfer systems required for the urban water supply system, the project costs were estimated separately as described in paragraph e) below.

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

d) Rural, boreholes

(2) Sanitation Development Projects

a) For the sewerage system, the project costs were estimated by applying the unit cost of US\$600/m^3 for treatment capacity in the rehabilitation, US\$1250/m^3 for expansion/new development of wastewater collection system, and US\$750/m^3 for expansion/new development of wastewater treatment works. The unit costs were derived from the data in the existing reports prepared by the WSBs and the Aftercare Study Report with adjustments. The used data include direct construction and indirect construction costs (administration and engineering services). Land acquisition costs were not estimated due to the marginal amount for sewerage projects.

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

c) Other sanitation projects

(3) Irrigation Development Projects

a) For the large- and small-scale irrigation projects proposed by the government or local authorities, the project costs were estimated by summing the direct construction costs estimated by the government or authorities with adjustments and indirect construction costs, as calculated below.

The indirect construction costs were calculated by summing the administration, engineering services and soft component costs assumed as 3%, 15%, and 3% of the direct construction costs, respectively, and land acquisition costs calculated by applying an assumed unit cost of KSh100,000/ha based on the actual data.

b) For the new large and small scale irrigation projects without existing cost data, the project costs were estimated by summing the direct construction costs calculated by applying the unit costs per ha and indirect construction costs as calculated above. The unit costs were assumed to be between KSh150,000/ha and KSh900,000/ha depending on the type of water sources such as weirs, dams, groundwater and water harvesting.

c) For private irrigation projects, the project costs were estimated by summing the direct construction costs calculated by applying the unit cost of KSh1.5 million/ha and indirect construction costs as calculated above. The unit cost was assumed referring to the actual investment cost data for drip irrigation system invested by private sectors. Among components of the indirect cost, administration and soft component costs were not included for the private projects due to their nature.

d) The annual O&M costs were estimated by applying the amount of 0.3% of the direct construction costs for the water source facilities and 1% for the irrigation systems. The replacement costs for electromechanical works were estimated by applying 20% of the direct construction costs. The replacement was assumed to be conducted every 20 years.

e) Small dams , boreholes

(4) Hydropower Development Projects

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

b) Annual O&M costs were estimated by applying the amount of 0.5% of the project costs including Replacement costs.

(5) Water Resources Development Projects

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

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

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

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

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

Other basic conditions applied for cost estimates are as follows.

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

The project costs estimated in this study are primarily used to grasp the financial status, therefore, these costs should not be used for specific purposes of financial arrangements of the projects.

5.1.2 Conditions and Methodologies of Cost Estimate for Management Plans

Costs for the respective proposed management plans for ACA were estimated for water resources management, flood and drought disaster management, and environmental management plans. These costs shall be discussed to determine the general idea for financing the implementation of the plans.

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

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

a) For water resources management plan, both the development and recurrent costs were estimated by applying the unit costs for management activities derived from interviews with WRMA staff in charge of related management activities.
b) For flood and drought disaster management plan, the development costs were estimated referring to the existing master plan studies such as the Nyando Flood Management Master Plan (2009) and NWMP (1992) with adjustments. The annual recurrent costs were assumed to be 0.5% of the development costs.
c) For environmental management plan, both the development and recurrent costs were estimated by applying the unit costs for management activities in terms of required manpower, meetings, surveys, and monitoring.

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

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

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

Other basic conditions applied in the cost estimates are as follows:

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

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

5.2 Cost Estimate for Proposed Plans

5.2.1 Cost Estimate for Proposed Development Plans

(1) General Scopes of Proposed Plans for Cost Estimate

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

1) Water Supply Development Plan

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

2) Sanitation Development Plan

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

3) Irrigation Development Plan

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

4) Hydropower Development Plan

Of the 14 hydropower schemes, 13 schemes are multipurpose dam projects and one scheme is a single purpose project.

5) Water Resources Development Plan

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

(2) Estimated Costs

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

Estimated Costs for Proposed Projects in Development Plans (ACA)

(Unit: KSh million)

Development Plan	Proposed Project	Type	Project Cost	Annual O&M Cost
Water Supply*	Urban Water Supply (32 UCs)	Rehabilitation	40,251	-
		New construction	490,879	21,865
		Sub-total	531,130	21,865
	Rural Water Supply (10 Counties)	Rehabilitation***	0	-
		New construction	39,543	1,637
		Sub-total	39,543	1,637
	Sub-total		570,673	23,502
Sanitation*	Sewerage System (25 UCs)	Rehabilitation	12,482	-
		New construction	195,222	10,688
	Sub-total		207,704	10,688
Irrigation**	Large-scale Irrigation (37,280 ha)	New construction	33,977	102
	Small-scale Irrigation (6,484 ha)	New construction	4,190	21
	Private Irrigation (2,344 ha)	New construction	4,544	45
	Sub-total		42,711	168
Hydropower	2 projects	New construction	7,961	40
Total			829,049	34,398

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.

*** It is assumed that rehabilitation of LSRWSS in ACA is to be carried out as a part of UWSS rehabilitation projects.

Source: JICA Study Team (Ref. Tables 5.2.1 – 5.2.5)

The costs for the proposed water resources development were estimated to be KSh123,598 million for project cost and KSh618 million for O&M cost, which include the costs of 16 dams and two water transfer systems. The costs had been allocated to those for water supply, irrigation, and hydropower subsectors.

5.2.2 Cost Estimate for the Proposed Management Plans

(1) General Scopes of Proposed Plans for Cost Estimate

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

1) Water Resources Management Plan

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

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

2) Flood and Drought Disaster Management Plan

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

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

3) Environmental Management Plan

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

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

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

Estimated Costs for Proposed Management Plans (ACA)

(Unit: KSh million)

Management Plan	Proposed Plans	Development Costs	Annual Recurrent Costs*
Water Resources Management	Monitoring	128	137
	Evaluation	54	-
	Permitting	27	-
	Watershed Conservation (868,000 ha)	68,572	-
	Operation of Catchment Forum	-	1
	Sub-total	68,781	138
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	-
	Sub-total	495	2.2
Environmental Management	Setting of Environmental Flow Rate including Survey (6 locations)	67	-
	Environmental Monitoring (10 locations)	-	1.6
	Sub-total	67	1.6
Total		69,343	141.8

Note: *Recurrent cost includes operation and maintenance costs
CBDM = Community-based Disaster Management

Source: JICA Study Team (Ref. Tables 5.2.7 – 5.2.9)

CHAPTER 6 ECONOMIC EVALUATION

6.1 Basic Conditions and Methodology for Economic Evaluation

The overall economic evaluation was performed for four sectors; 1) urban water supply (for 31 UCs, excluding rehabilitation works), 2) sewerage (for 25 UCs, excluding rehabilitation works), 3) large-scale irrigation (with 35,280 ha), and 4) hydropower (with two dams) in ACA at the master plan level. The following assumptions were made for economic analysis:

a) Price Level

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

b) Social Discount Rate

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

c) Economic Life of Facilities

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

d) Cost Allocation for Multipurpose Dams

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

e) Economic Cost

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

f) Economic Benefit

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

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

Estimated Economic Benefits (ACA)

Subsector	Items of Economic Benefits	Benefit at Net Present Value
a) Water Supply	- Cost saving for water users - Increase of water supply amount	KSh454.0 billion (30 years)
b) Sewerage	- Cost saving for users - Affordability to pay - Improvement of public health	KSh231.3 billion (30 years)
c) Irrigation	- Crop production increase	KSh28.6 billion (50 years)
d) Hydropower	- Capacity increase - Energy increase	KSh11.3 billion (50 years)

Source: JICA Study Team

The details of the calculations are described in the sectoral reports.

6.2 Economic Evaluation for the Proposed Plan

The following table shows the estimated economic and financial costs and the results of economic evaluation in ACA.

Summary of Economic Evaluation Results (ACA)

(Unit: KSh billion)

Subsector	Scope	Estimated Financial Cost	Estimated Economic Cost	Net Present Value		B/C	EIRR
				Cost	Benefit		
Water Supply	31 UCs	480.9	455.8	538.4	454.0	0.84	7.70%
Sewerage	25 UCs	195.2	183.5	225.1	231.3	1.03	10.40%
Irrigation	35,280 ha	35.4	33.1	28.1	28.6	1.02	10.20%
Hydropower	2 projects	7.9	7.5	6.1	11.3	1.82	16.90%

Source: JICA Study Team

The total economic costs for water resources development is estimated at KSh 680.6 billion, of which urban water supply projects are largest (KSh 455.8 billion), followed by urban sewerage projects (KSh 183.5 billion). In terms of economic viability, the sewerage, irrigation and hydropower subsectors were found to be economically feasible with more than 10% of EIRR, while the water supply subsector had a low efficiency from the economic point of view. The results of economic analysis for the four subsectors are summarised as follows:

a) Water supply projects in ACA require high cost of structures for water sources, such as large-scale dams and a long length of water transmission system for Nairobi and Satellite Towns, Mombasa, and the surrounding coastal area, which resulted in low economic viability in this subsector. The water supply projects around the Nairobi and Mombasa areas should be planned/reviewed carefully before implementation, and promoted as basic human needs.

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

c) The irrigation projects in ACA are economically viable due to low construction cost in this catchment by using the existing weir irrigation system.

d) The hydropower projects in ACA are economically efficient, with a high EIRR of 16.9%. However, the potential for hydropower development in this catchment is rather small.

CHAPTER 7 IMPLEMENTATION PROGRAMMES

7.1 General

Implementation programmes were prepared for the projects proposed in the water supply, sanitation, irrigation, hydropower, and water resources development plans and for the management plans proposed for water resources management, flood and drought disaster management, and environmental management plans. The prepared implementation programmes will serve as 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 technically, economically, and environmentally viable.

7.2 Criteria for Prioritisation for Implementation

7.2.1 Criteria for Prioritisation of Development Plans

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

(1) Prioritisation by Project Status

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

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

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

(2) Prioritisation by Subsector

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

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

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

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

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

3) Irrigation:

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

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

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

4) Hydropower:

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

5) Water resources:

a) Water resources development such as dams, water transfers, small dams, water pans, boreholes will be implemented according to the requirements of the water supply and irrigation development.

7.2.2 Criteria for Prioritisation of Management Plans

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

(1) Criteria for Water Resources Management Plan

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

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

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

(2) Criteria for Flood and Drought Disaster Management Plan

1) For Flood Disaster Management Plan

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

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

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

2) For Drought Disaster Management Plan

a) Drought disaster management plans such as preparation of water use restriction for reservoirs and establishment of a Basin Drought Conciliation Council should be implemented, as early as possible, wherever applicable.

(3) Environmental Management Plan

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

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

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

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

7.3 Implementation Programmes of Proposed Plans

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

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

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

Tables

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

(m^3/s)

Sub-basin	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Des	Annual (MCM/year)
3AA	2.1	3.1	3.6	2.4	2.5	2.5	2.1	2.1	2.7	3.1	2.8	3.1	84
3AB	0.1	1.9	2.7	1.5	2.3	1.3	0.1	0.1	1.2	2.3	0.8	1.8	43
3AC	0.1	1.3	2.0	0.1	0.1	0.3	0.1	0.1	0.7	1.7	0.7	0.6	21
3BA	15.6	20.1	23.1	15.6	15.6	16.4	15.6	15.6	18.0	21.7	18.0	17.5	559
3BB	0.7	3.2	4.4	2.6	3.7	2.4	0.7	0.7	2.3	3.8	1.6	3.1	76
3BC	1.6	7.5	10.3	3.4	4.1	4.0	1.6	1.6	5.0	7.7	5.7	7.5	158
3BD	0.4	3.5	5.7	0.4	0.4	1.0	0.4	0.4	2.1	4.7	2.1	1.8	60
3CB	1.0	4.9	7.6	1.0	1.0	1.7	1.0	1.0	3.1	6.4	3.1	2.7	91
3DA	0.1	1.9	2.7	0.8	1.0	0.9	0.1	0.1	1.1	2.0	1.4	1.8	37
3DB	0.1	1.1	1.6	0.5	0.6	0.5	0.1	0.1	0.7	1.1	0.8	1.1	22
3EA	2.5	3.6	4.3	3.8	3.9	3.3	2.5	2.5	3.2	3.8	3.1	3.1	104
3EB	0.2	1.7	2.7	2.0	2.1	1.2	0.2	0.2	1.1	1.9	1.0	1.0	40
3EC	0.3	2.1	3.2	2.4	2.5	1.5	0.3	0.3	1.3	2.3	1.3	1.2	49
3ED	0.1	1.7	2.7	2.0	2.1	1.2	0.1	0.1	1.0	1.9	1.0	1.0	39
3FA	1.1	18.3	29.6	22.3	23.2	13.0	1.1	1.1	11.2	20.7	10.7	9.7	424
3FB	0.3	11.4	18.7	14.0	14.5	8.0	0.3	0.3	6.8	12.9	6.5	5.9	261
3G	0.3	18.5	30.0	24.8	26.1	15.1	0.3	0.3	10.9	22.3	17.1	11.7	464
3HA	0.0	3.9	6.6	5.3	5.4	3.1	0.0	0.0	2.2	4.4	3.7	2.5	97
3HB	0.1	6.4	10.7	8.7	8.9	5.0	0.1	0.1	3.6	7.2	6.1	4.1	159
3HC	0.1	1.5	2.6	2.0	1.7	1.0	0.1	0.1	0.9	1.6	1.5	1.1	37
3HD1	0.0	0.3	0.5	0.4	0.0	0.1	0.0	0.0	0.2	0.3	0.3	0.3	7
3HD2	0.0	0.2	0.3	0.2	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.2	4
3J	0.2	12.2	16.1	10.0	11.5	8.6	0.2	0.2	7.4	14.6	12.0	10.7	271
3K	0.9	2.8	4.4	2.8	1.7	1.6	0.9	0.9	1.8	2.7	2.8	2.5	67
3LA	0.8	18.2	29.9	24.4	24.8	14.4	0.8	0.8	10.4	20.2	17.2	11.8	455
3LB	1.1	1.4	1.6	1.5	1.5	1.3	1.1	1.1	1.3	1.4	1.4	1.3	42
3MA-1	0.1	10.9	19.7	15.8	14.6	8.7	0.1	0.1	6.1	12.3	10.8	11.7	291
3MA-2	0.1	10.5	18.9	15.1	14.0	8.3	0.1	0.1	5.9	11.9	10.4	11.2	279
3MB	0.2	0.7	1.2	1.0	0.9	0.6	0.2	0.2	0.5	0.8	0.7	0.8	21
3MC	0.2	0.5	0.8	0.7	0.6	0.5	0.2	0.2	0.4	0.5	0.5	0.5	15
3MD1	6.3	6.7	7.1	6.9	6.9	6.6	6.3	6.3	6.5	6.7	6.7	6.7	209
3MD2	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.1	2
3N	0.1	3.7	6.5	5.3	5.0	3.1	0.1	0.1	2.2	3.9	3.9	3.5	98
Total	37.0	185.7	281.7	199.9	203.6	137.3	37.0	37.0	122.0	209.3	155.9	143.6	4,586

Source: JICA Study Team

Table 4.2.1 Water Service Providers (WSPs) in Nairobi and Satellite Towns

WSPs	Service Towns/Areas	Service Population in 2010	Capacity (m^3/day)	NRW
[Urban]				
Kiambu WSC	Kiambu, Riambai, Ndumberi,	21,630	602	58%
Ruiru-Juja WSC	Ruiru, Juja, Membley	69,740	3,000	31%
Karuri WSC	Karuri	13,896	975	45%
Thika WSC	Thika	2,465,749	509,400	39%
Nairobi WSC	Nairobi, Thika, Kikuyu, Ngong', Machakos, Athi River			42%
Limuru WSC	Limuru, Kimende, Thigio	59,590	5,300	33%
Kikuyu WSC	Kikuyu, Thogoto, Muguga, Karai	32,868	10,558	54%
Runda WSC	Runda	13,180	-	35%
Mavoko EPZA WSC	Mlolongo, Katani, Syokimau, Athi River, Lukenya, Chumvi, JKIA	47,571	2,921	37%
Oloolaiser WSC	Ongata Rongai, Kiserian, Matasia, Ngong	116,025	6,082	44%
Machakos WSC	Machakos	13,412	3,464	48%
[Rural]				
Gatundu South WSC	Gatundu, Ndarugo	68,784	9,000	69%
Karimenu Community WSC	Karimenu	21,000	7,500	89%
Githunguri WSC	Githunguri, Komothai, Mihugo	20,844	10,020	30%
Kathiani WSC	Kathiani	N.A	362	N.A
Mbooni WSC	Mumbuni, Mulima, Tawa, Kikima	N.A	122	N.A
Mwala WSC	Mwala, Mbiuni, Wamunyu, Kibauni	N.A	717	N.A
Matunglu Kangundo WSC	Kangundo, Tala, Matungulu	N.A	240	N.A
Total		2,964,289	570,262	

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

Table 4.2.2 Water Service Providers (WSPs) in Mombasa Coastal Area

WSPs	Service Towns/Areas	Service Population in 2010	Capacity (m^3/day)	NRW
[Urban]				
Mombasa WSC	Mombasa, Changamwe, Kisauni, Mtwapa, Nyali, Shanzu	708,054	63,700	35%
Malindi WSC	Malindi, Gede	186,300	11,500	25%
Kilifi Mariakani WSC	Kilifi, Mariakani, Kaloleni, Mtwapa	418,307	6,400	39%
Kwale WSC	Kwale, Ukunda, Lunga Lunga, Msambweni, Kinango	149,344	5,920	50%
Total		1,462,005	87,520	

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

Table 4.2.3 Water Service Providers (WSPs) in Remaining Area of ACA

WSPs	Service Towns/Areas	Service Population in 2010	Capacity (m^3/day)	NRW
[Urban]				
Kibwezi Makindu WSC	Kibwezi, Mtito Andei, Makindu, Kalama, Kibarani	38,999	2,951	40%
Wote WSC	Wote	9,610	225	29%
Nol Turesh Loitokitok WSC	Loitokitok Central, Kimana, Ramba, Marhuru, Sultan Hamud, Malili, Kilome	14,630	5,258	59%
Olkejuado WSC	Kajiado, Isinya, Bissil	9,762	625	24%
Tavevo WSC	Taveta, Voi, Mwatate, Wundanyi	30,971	1,400	49%
Others			5,593	
Total		103,972	16,393	

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

Table 4.2.4 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)	Proposed Projects: Expansion Works (m^3/day)	Proposed Projects: New Construction (m^3/day)
Greater Nairobi								
1	Nairobi	6,085,297	888,453	570,263	33,420	603,683	961,207	0
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					
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	86,620	0	86,620	449,919	0
2	Malindi	443,811	52,814					
3	Ukunda	234,651	27,924					
4	Kilifi	183,228	21,804					
5	Mtwapa	182,474	21,714					
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 was 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 was counted as service population.

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

Table 4.2.5 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 4.2.6 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 4.3.1 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	Kitengeia	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 4.3.2 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 4.4.1 Large Scale Irrigation Projects Selected for Implementation by 2030 (ACA)

No	Name of Project	County	Sub-basin Code	Irrigation Area (ha)	Project Type*1	Water Source Facilities*2		Present Status*3	Estimated Cost*4 (KSh mil.)	Executing Agency
						Type	Name of Dam			
1.	Kanzalu Irrigation Exteision	Makueni	3DA	15,000	Ext	Multi-dam	Munyu	Proposed	6,050	NIB
2.	Kibwezi Irrigation Extention	Makueni	3FA	17,000	New+Ext	Multi-dam	Thwake	Proposed	6,600	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

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

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

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

	Surface Water (m^3/s)													Groundwater
Sub-basin	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average	(MCM/year)
3AA	3.8	3.6	2.5	5.5	7.4	3.0	1.5	1.3	1.3	1.3	2.6	4.3	3.2	1.6
3AB	2.7	2.5	1.1	3.0	3.8	1.1	0.2	0.1	0.1	0.1	0.7	2.1	1.5	9.5
3AC	2.1	1.4	0.7	2.8	3.9	1.0	0.2	0.1	0.0	0.0	1.2	2.8	1.4	6.1
3BA	1.5	1.2	0.9	2.4	3.5	1.1	0.4	0.3	0.3	0.4	1.3	2.1	1.3	4.4
3BB	1.3	1.1	0.9	2.5	3.1	1.0	0.5	0.4	0.3	0.5	1.4	1.8	1.2	2.5
3BC	4.7	4.0	3.5	7.5	10.2	4.6	2.8	2.4	2.2	2.4	5.0	6.2	4.6	1.8
3BD	1.9	1.7	1.4	3.4	4.4	1.8	1.0	0.8	0.8	0.8	2.1	2.6	1.9	3.5
3CB	3.6	3.2	2.8	5.0	6.2	3.3	2.5	2.3	2.2	2.3	3.7	4.3	3.5	1.8
3DA	3.1	1.9	1.4	4.6	4.0	1.0	1.3	1.5	1.5	1.4	3.6	5.2	2.6	5.8
3DB	3.1	1.0	0.4	3.3	2.9	0.7	0.1	0.0	0.0	0.0	3.0	6.1	1.7	6.9
3EA	4.0	1.8	0.8	5.0	3.5	0.6	0.1	0.0	0.0	0.0	3.2	6.1	2.1	5.2
3EB	4.0	1.6	0.8	5.4	3.5	0.4	0.0	0.0	0.0	0.0	3.6	7.0	2.2	5.8
3EC	3.8	1.4	0.8	5.3	3.5	0.4	0.0	0.0	0.0	0.0	3.4	6.9	2.1	4.1
3ED	1.7	0.5	0.2	1.8	1.4	0.2	0.0	0.0	0.0	0.0	1.0	3.2	0.8	4.6
3FA	14.3	5.0	1.7	7.5	6.1	2.2	1.2	1.1	1.1	1.0	3.5	14.8	5.0	39.9
3FB	9.2	3.4	0.4	2.5	2.4	0.8	0.0	0.0	0.0	0.0	0.4	13.5	2.7	12.6
3G	5.3	3.5	0.9	6.3	1.9	0.4	0.0	0.0	0.0	0.0	0.1	2.9	1.8	15.9
3HA	0.6	0.6	0.0	0.2	0.3	0.1	0.0	0.0	0.0	0.0	0.0	1.1	0.2	2.6
3HB	0.9	1.0	0.0	0.0	0.5	0.1	0.0	0.0	0.0	0.0	0.1	1.9	0.4	15.6
3HC	0.4	0.0	0.0	0.0	0.4	0.4	0.0	0.0	0.0	0.0	0.6	1.0	0.2	10.8
3HD1	0.2	0.3	0.0	0.0	0.8	0.7	0.2	0.0	0.0	0.0	1.3	1.0	0.4	13.8
3HD2	0.1	0.2	0.0	0.0	0.5	0.4	0.1	0.0	0.0	0.0	0.8	0.6	0.2	1.0
3J	1.0	0.9	0.0	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2	9.6
3K	1.8	1.2	0.6	1.5	8.4	1.4	0.6	0.2	0.1	1.5	6.3	1.4	2.1	20.6
3LA	0.8	0.2	0.0	0.0	1.5	0.2	0.0	0.0	0.0	1.9	4.6	0.4	0.8	26.0
3LB	0.1	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.2	0.5	0.0	0.1	2.6
3MA-1	0.9	0.5	0.1	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.7	0.8	0.3	18.2
3MA-2	0.4	0.2	0.0	0.0	0.7	0.1	0.0	0.0	0.0	0.1	1.2	0.1	0.2	7.6
3MB	0.3	0.0	0.0	0.0	2.2	0.2	0.1	0.0	0.0	1.3	2.4	0.2	0.6	10.3
3MC	0.0	0.0	0.0	0.0	0.8	0.1	0.0	0.0	0.0	0.6	0.8	0.0	0.2	6.4
3MD1	0.6	0.1	0.0	0.1	8.3	1.2	0.4	0.0	0.0	2.5	2.5	0.2	1.3	12.6
3MD2	0.0	0.0	0.0	0.0	0.5	0.1	0.0	0.0	0.0	0.2	0.2	0.0	0.1	1.3
3N	0.0	0.3	0.1	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	9.1

Source: JICA Study Team

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

(m^3/s)

Sub-basin	Domestic		Industrial		Irrigation		Livestock		Wildlife		Fisheries	
	2010	2030	2010	2030	2010	2030	2010	2030	2010	2030	2010	2030
3AA	0.80	1.89	0.18	0.17	0.16	0.17	0.01	0.03	0.00	0.00	0.00	0.00
3AB	0.32	0.05	0.04	0.00	0.37	0.40	0.03	0.07	0.00	0.00	0.01	0.01
3AC	1.30	0.04	0.24	0.00	0.01	0.02	0.03	0.06	0.00	0.00	0.00	0.01
3BA	6.06	12.67	1.40	2.79	0.03	0.05	0.04	0.09	0.00	0.00	0.02	0.04
3BB	0.97	0.55	0.18	0.08	0.18	0.19	0.01	0.03	0.00	0.00	0.00	0.01
3BC	0.39	1.46	0.02	0.07	0.18	0.19	0.03	0.07	0.00	0.00	0.01	0.02
3BD	0.31	0.29	0.02	0.03	0.02	0.02	0.01	0.03	0.00	0.00	0.01	0.02
3CB	0.38	0.84	0.05	0.12	0.03	0.09	0.01	0.03	0.00	0.00	0.01	0.02
3DA	0.38	0.06	0.02	0.00	0.05	2.08	0.02	0.06	0.00	0.00	0.01	0.02
3DB	0.05	0.07	0.00	0.00	0.03	0.18	0.02	0.04	0.00	0.00	0.00	0.00
3EA	0.46	2.22	0.05	0.21	0.10	0.16	0.03	0.06	0.00	0.00	0.01	0.03
3EB	0.10	0.09	0.01	0.00	0.11	0.16	0.02	0.05	0.00	0.00	0.00	0.01
3EC	0.13	0.23	0.01	0.01	0.10	0.15	0.02	0.04	0.00	0.00	0.01	0.03
3ED	0.06	0.10	0.00	0.00	0.09	0.12	0.01	0.03	0.00	0.00	0.00	0.00
3FA	0.34	0.77	0.01	0.03	1.17	8.32	0.12	0.29	0.01	0.01	0.00	0.01
3FB	0.11	0.24	0.00	0.01	0.71	0.87	0.03	0.07	0.01	0.01	0.01	0.01
3G	0.07	0.15	0.00	0.00	2.23	2.30	0.05	0.12	0.01	0.01	0.01	0.02
3HA	0.01	0.01	0.00	0.00	0.45	0.48	0.00	0.01	0.00	0.00	0.00	0.00
3HB	0.06	0.04	0.01	0.00	0.67	0.80	0.01	0.02	0.00	0.00	0.00	0.00
3HC	0.17	0.09	0.02	0.00	0.53	0.66	0.01	0.03	0.00	0.00	0.00	0.00
3HD1	0.04	0.02	0.00	0.00	0.09	0.24	0.00	0.01	0.00	0.00	0.00	0.00
3HD2	0.02	0.01	0.00	0.00	0.11	0.12	0.00	0.00	0.00	0.00	0.00	0.01
3J	0.04	0.16	0.00	0.01	0.97	1.05	0.01	0.04	0.00	0.00	0.01	0.01
3K	0.37	0.66	0.01	0.02	0.10	0.24	0.07	0.16	0.00	0.00	0.01	0.02
3LA	0.45	0.67	0.02	0.02	1.90	1.98	0.05	0.11	0.01	0.01	0.01	0.02
3LB	0.06	0.95	0.00	0.11	0.21	0.22	0.00	0.01	0.00	0.00	0.01	0.02
3MA-1	0.06	0.06	0.00	0.00	0.89	0.92	0.02	0.05	0.00	0.00	0.00	0.00
3MA-2	0.03	0.07	0.00	0.00	1.27	1.29	0.02	0.04	0.00	0.00	0.00	0.00
3MB	0.07	0.11	0.00	0.00	0.05	0.06	0.02	0.05	0.00	0.00	0.00	0.00
3MC	0.03	0.14	0.00	0.01	0.03	0.04	0.01	0.02	0.00	0.00	0.00	0.01
3MD1	2.22	5.04	0.51	1.14	0.02	0.03	0.03	0.07	0.00	0.00	0.01	0.01
3MD2	0.54	0.02	0.13	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00
3N	0.03	0.06	0.00	0.00	0.77	0.87	0.03	0.08	0.00	0.00	0.00	0.00

Source: JICA Study Team

Table 4.6.3 Reserve Quantity by Sub-basin for Water Balance Study

Sub-basin	Catchment Area (km^2)	Accumulated Catchment Area (km^2)	River Name	Reserve *1 (m^3/s)	Node *2
3AA	724		Athi River	1.2	9
3AB	1,790			0.1	11
3BB	258			0.3	25
3BC	491			2.0	37
3BD	306			0.7	39
3BA	889	4,457		4.8	46
3AC	843	5,300		6.1	48
3CB	394			1.5	51
3DA	775	6,470		8.5	63
3DB	822	7,292		8.9	68
3EA	867			0.0	82
3EB	829	1,696		0.0	92
3EC	702			0.0	98
3ED	545	2,943		0.0	103
3FA	9,924	20,159		10.1	113
3FB	4,181	24,340		9.1	120
3G	6,543			0.0	126
3HA	916	31,799		8.9	131
3HB	2,317	34,116		5.8	135
3HC	2,979			0.0	138
3HD1	654	37,750		2.5	146
3J	2,804		Lumi River	0.0	152
3K	3,234		Ramisi River	0.0	158
3LA	7,625			0.0	165
3MA-1	3,997			0.0	167
3MC	763		Shimba River	0.0	175
3MA-2	2,199			0.0	177
3MB	1,676			0.0	185
3MD1	1,347			0.0	192
3MD2	212			0.0	194
3N	3,155			0.0	196
3LB	781			0.0	200
3HD2	393			0.0	202

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

Source: JICA Study Team

Table 4.6.4 Dam Candidates (ACA) (1/2)

(1) Priority Dams proposed in NWMP (1992)

Catchment Area		NWMP (1992) Proposed Dams	Sub-basin	Stage	Purpose	Current Status Related Agency/ Owner	Status/ Construction Year	Source of Information	Remarks
4.	Athi	14. Upper Athi (Mbagathi)	3AA	Pre-F/S	W	AWSB	No further study is done.	-	
		15. Ruaka (Kiambaa)	3BA	D/D	W	AWSB	Construction not started.	NWCPC	
		16. Ruiru-A (Ruiru 2)	3BC	M/P	W	AWSB	F/S, M/P ongoing (to be completed in 2012)	AWSB	2008-12 Flagship Projects under Vision 2030, F/S and M/P for Developing New Water Sources for Nairobi and Satellite Towns
		17. Kikuyu	3BA	M/P	W	AWSB	No further study is done.	NWCPC	
		18. Ndarugu (Ndarugu 1)	3CB	M/P	W, I	AWSB/ NWCPC	F/S, M/P ongoing (to be completed in 2012)	AWSB	2008-12 Flagship Projects under Vision 2030, F/S and M/P for Developing New Water Sources for Nairobi and Satellite Towns
		19. Yatta	3FB	M/P	I	NWCPC	No further study is done.	NWCPC	2008-12 Flagship Projects under Vision 2030
		20. Rare	3LA	F/S	W	NWCPC	F/S, D/D (to be completed in 2013)	NWCPC	2008-12 Flagship Projects under Vision 2030
		21. Mwachi	3MB	M/P	W	CDA/ MORDA	Preliminary Design done (2011)	MORDA	MORDA 18 Projects
						NWCPC	Preliminary Design done (2008)	NWCPC	2008-12 Flagship Projects under Vision 2030
		22. Pemba	3HC	M/P	W	CWSB	No further study is done.	NWCPC	

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

Catchment Area		NWMP (1992) Future Development Potential Dams		Sub-basin	Purpose	Current Status Related Agency/ Owner	Status/ Construction Year	Source of Information	Remarks
4.	Athi	24	Munyu	3DA	W, I, P	NWCPC	F/S done (2007)	NWCPC	2008-12 Flagship Projects under Vision 2030
						TARDA	Concept paper (2008) prepared for F/S	TARDA	MORDA 18 Projects
		25	Mbuuni	3EA	W				No information is found.
		26	Kiteta	3EB	W	NWCPC	Pre-F/S done (2008)	NWCPC	NWCPC Plans for Vision 2030
		27	Thwake	3FA	I, W	Tanathi WSB/ NWCPC	Final Design done (2009)	NWCPC	2008-12 Flagship Projects under Vision 2030
		28	Tsavo	3G	W				No information is found.
		29	Baricho	3HD	W				No information is found.

Table 4.6.4 Dam Candidates (ACA) (2/2)

(3) Dam Schemes Studied by Government

Catchment Area			Dams not in NWMP (1992)	Sub-basin	Purpose	Related Agency/ Owner	Status/ Construction Year	Source of Information	Remarks
		Identified Dams				Current Status			
4.	Athi	11	Stony Athi	3AB	W	AWSB	F/S, M/P ongoing (to be completed in 2012)	AWSB	F/S and M/P for Developing New Water Sources for Nairobi and Satellite Towns
		12	Kamiti 1	3BB	W	AWSB	F/S, M/P ongoing (to be completed in 2012)	AWSB	F/S and M/P for Developing New Water Sources for Nairobi and Satellite Towns
		13	Maruba	3EA	W	NWCPC / Tanathi WSB	Rehabilitation was completed in 2009 including raising of dam and rehabilitation of spillway.	NWCPC	NWCPC Plans for Vision 2030
		14	Olkishunki	3FA	W, I	ENSDA	Pre-F/S done.	ENSDA	
		15	Lake Chala	3J	I, W	CDA/ MORDA	F/S & D/D ongoing	MORDA	MORDA 18 Projects
		16	Olkejuado	-	I, F, P	ENSDA/ MORDA	No study is started.	MORDA	MORDA Strategic Plan 2008-12

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

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

Table 4.6.5 Water Transfer Candidates (ACA) (1/2)

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

a) Intra-basin Bulk Water Transfer Schemes

Catchment Area		NWMP (1992) Intra- basin Water Transfer						Current Status			
		No.	Sub-basin	Water Source		Sub-basin	Notes	Related Agency / Owner	Status/ Construction Year	Source of Information	Remarks
4.	Athi	R10	3AA	Upper Athi Dam		3AA		AWSB	No further study is done.	AWSB	
		R11	3BA	Kikuyu Dam		3BA		AWSB	No further study is done.	AWSB	
		R12	3BA	Ruaka (Kiambaa) Dam		3BA		AWSB	Construction not started.	AWSB	
						3BA		AWSB	Construction not started.	AWSB	
		R13	3BC	Ruiru-A Dam		3AA		AWSB/ NWCPC	F/S, M/P ongoing	AWSB	
		R14	3CB	Ndarugu Dam		3BA		AWSB/ NWCPC	F/S, M/P ongoing	NWCPC, AWSB	
		R15	3AC	Munyu Dam		3BA	Alternative for Ndarugu Dam	NWCPC	F/S done.	NWCPC, AWSB	
								TARDA	Concept paper for F/S prepared.	TARDA	
		R16	3DA	Athi River	without dam	3EA		MWI/ NWCPC	No further study is done.	WRMA	
		R17	3DA	Athi River	without dam	3EA		MWI/ NWCPC	No further study is done.	WRMA	
		R18	3DA	Athi River	without dam	3EA		MWI/ NWCPC	No further study is done.	WRMA	
		R19	3FA	Athi River	without dam	3FB		MWI/ NWCPC	No further study is done.	WRMA	
		R20	3MC	Pemba Dam		3MD2		CWSB	No further study is done.	CWSB	
		R21	3MB	Mwachi Dam		3MD1		CDA/ MORDA	Preliminary design done.	MORDA	
								NWCPC	Preliminary design done.	NWCPC, CWSB	
		R22	3LA	Rare Dam		3LB	Alternative for Sabaki P/L	NWCPC	F/S, D/D ongoing	NWCPC, CWSB	

b) Inter-basin Bulk Water Transfer Schemes

Catchment Area		NWMP (1992) Inter- basin Water Transfer						Current Status			
		No.	Sub-basin	Water Source		Sub-basin	Notes	Related Agency / Owner	Status/ Construction Year	Source of Information	Remarks
4.	Athi	E7	3AA	Kiserian Dam		3FA		NWCPC	Under construction	NWCPC, WRMA	
		E8	3G	Second Mzima	without dam	3LA		CWSB	Studies ongoing.	CWSB	Flagship Projects, Water Supply M/P for Mombasa and Other Towns
						3MD2		CWSB	Studies ongoing.	CWSB	Flagship Projects, Water Supply M/P for Mombasa and Other Towns
		E9	3HC	Sabaki Extension	without dam	3MD2	Alternative for Mwachi Dam	CWSB	Studies ongoing.	CWSB	Water Supply M/P for Mombasa and Other Towns
						3LB	Alternative for Rare Dam	CWSB	Studies ongoing.	CWSB	Water Supply M/P for Mombasa and Other Towns

Table 4.6.5 Water Transfer Candidates (ACA) (2/2)

(2) Water Transfer Schemes Studied by Government

a) Intra-basin Bulk Water Transfer Schemes

Catchment Area		No.	Sub-basin	Water Source	Sub-basin	Related Agency / Owner	Status/ Construction Year	Source of Information	Remarks
			3BA	Kikuyu Springs	3BA		Operational	AWSB	Nairobi Bulk Water Supply
			3BB	Ruiru Dam	3BB		Operational	AWSB	Nairobi Bulk Water Supply
			3BD	Others	3AA		Operational	AWSB	Nairobi Bulk Water Supply
			3CB	Others	3AC		Operational	AWSB	Nairobi Bulk Water Supply
4.	Athi		3G	Nol Turesh	3AC/3EA/ 3FA/3G		Operational	Tanathi WSB	
			3G	Mzima Springs	3LA/3MB/ Island		Operational	CWSB	Coast Bulk Water Supply
			3MC	Marere Boreholes	3MD2/ Island		Operational	CWSB	Coast Bulk Water Supply
			3K	Tiwi Boreholes	3MD2		Operational	CWSB	Coast Bulk Water Supply
			3HB/3HC /3HD1	Baricho Shallow Wells	3LB/3MD1		Operational	CWSB	Coast Bulk Water Supply

b) Inter-basin Bulk Water Transfer Schemes

Catchment Area		No.	Sub-basin	Water Source	Sub-basin	Related Agency / Owner	Status/ Construction Year	Source of Information	Remarks
4.	Athi		3EA	Maruba Dam*	3EA	NWCPC/ Thanathi WSB	Operational	NWCPC	

Note:
Project Stage: M/P=master plan, Pre-F/S=prefeasibility study, F/S=feasibility study, D/D=detailed design, T/D=tender documents, U/C=under construction
* = Listed by NWCPC as “Inter-basin Transfer Schemes.”

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

Table 4.6.6 Proposed Dams and Water Transfer (ACA) (1/2)

(1) Proposed Dams

No.	Name of Dam	Sub-basin	Relevant County	Purpose [1)]	Effective Storage Volume (MCM)	Storage Volume Allocation (MCM)			
						Domestic and Industrial	Irrigation	Hydro-power	Flood Control
28	Upper Athi	3AA	Machakos	W (Nairobi)	24.0	24.0	0.0		
29	Stony Athi	3AB	Machakos	W (Nairobi)	2) *23.0*	23.0	0.0		
30	Kikuyu	3BA	Nairobi	W (Nairobi)	31.0	31.0	0.0		
31	Ruaka (Kiambaa)	3BA	Nairobi	W (Nairobi)	4.0	4.0	0.0		
32	Kamiti 1	3BB	Kiambu	W (Nairobi)	*16.0*	16.0	0.0		
33	Ruiru-A (Ruiru 2)	3BC	Kiambu	W (Nairobi)	18.0	18.0	0.0		
34	Ndarugu (Ndarugu 1)	3CB	Kiambu	W (Nairobi)	*300.0*	300.0	0.0		
35	Munyu	3DA	Machakos	I (15,000 ha), P (40 MW)	575.0	0.0	575.0		
36	Mbuuni	3EA	Machakos	W (Machakos, Kangundo Tala)	10.0	10.0	0.0		
37	Kiteta	3EB	Makueni	W	16.0	16.0	0.0		
38	Thwake	3FA	Makueni, Kitui	W, I (17,000 ha), P (20 MW)	*594.0*	4) 176.0	418.0		
39	Olkishunki	3FA	Kajiado	W	*1.2*	*1.2*	*0.0*		
40	Pemba	3HC	Kwale	W (Kwale)	19.0	19.0	0.0		
41	Lake Chala	3J	Taita Taveta	W (Taveta), F	6.0	6.0	0.0		
42	Rare	3LA	Kilifi	W (Mombasa)	36.0	36.0	0.0		
43	Mwachi	3MA	Kwale	W (Mombasa, Mtwapa)	16.0	16.0	0.0		
	Total				1,689.2	696.2	993.0	0.0	0.0

Note:
1) W=Domestic and industrial water supply, I=Irrigation, P=Hydropower, F=Flood control
2) Figures in Italic Font are those proposed by the Kenyan Government.
3) An adjustment is made to the effective storage volume by deducting dead storage volume from the reservoir storage volume indicated in the existing reports.
4) Allocated storage volumes are estimated by the JICA Study Team, since these are not available in the existing design reports.
Source: JICA Study Team

Table 4.6.6 Proposed of Dams and Water Transfer (ACA) (2/2)

(2) Proposed Water Transfer

Wter Transfer Scheme		Relevant County	Purpose	Capacity, Dimensions
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
6	Sabaki Scheme (Expansion)	Kilifi	W	Capacity of 85,000 m^3/day (31 MCM/year), Pipeline

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

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

(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	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							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	72.7	300.3	0.0	0.0	37.3	142.0	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 4.6.8 Naturalised River Flow, Reserve, Water Demand, Yield and Water Supply Reliability at Reference Points (ACA)

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			
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

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

Source: JICA Study Team

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

	Urban Centre	Service Population in 2030	Water Demand in 2030 (m^3/day)	Rehabilitation Works (m^3/day)	Development Capacity (m^3/day)	Project Cost (KSh million)					O&M Cost (KSh million/year)
						Total	Rehabilitation Works	Major Dam/ Major Transmission	Intake/ Minor Transmission	Distribution	
Greater 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	603,683	961,207	219,084	34,734		30,725	153,625	8,972
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	86,505	16,785	194	0	2,765	13,826	807
	Major Water Sourece Works										
	Upper Athi					2,813		2,813			14
	Kikuyu					4,117		4,117			21
	Kiambaa (Ruaka)					1,961		1,961			10
	Ruiru-A					6,998		6,998			35
	Ndarugu					5,345		5,345			27
	Maragua 8					7,058		7,058			35
	Ndiara					7,058		7,058			35
	Chania-B					14,082		14,082			70
	Mbuuni					2,566		2,566			13
	Transmission of Norther Collectior and Others					74,244		74,244			371
	sub-total	1	1,654,769	607,056	1,047,713	362,109	34,928	126,240	33,490	167,451	10,410
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	449,919	91,274	4,984		14,382	71,908	4,199
6	Mariakani	90,271	10,742								
7	Kwale	74,303	8,842								
8	Watamu	37,639	4,479								
9	Masambweni	17,731	2,110								
	Major Water Sourece Works										
	Rare Dam					3,648		3,648			18
	Mwachi Dam					4,398		4,398			22
	Pemba					5,472		5,472			27
	Disalination Plants							0			6,342
	Transmission (from Mzima)					35,289		35,289			176
	Transmission (from Sabaki)					15,002		15,002			75
	sub-total	3,908,701	536,539	92,200	444,339	155,085	4,984	63,811	14,382	71,908	10,860
Other Area											
1	Wundanyi	185,136	22,031	1,400	30,906	6,008	81		988	4,939	288
2	Voi	86,340	10,274								
3	Taveta	99,997	11,900	0	11,900	2,282	0		380	1,902	111
	Lake Chala					1,551		1,551			8
4	Kajiado	74,803	8,902	1,000	7,902	1,573	58		253	1,263	74
5	Loitoktok	56,530	6,727	0	6,727	1,290	0		215	1,075	63
6	Wote	49,709	5,915	525	5,390	1,064	30		172	862	50
7	Mitto Andei	22,753	2,708	2,951	0	170	170		0	0	0
	sub-total	575,268	68,457	5,876	62,824	13,939	338	1,551	2,008	10,041	594
Total		4,483,970	2,259,765	705,132	1,554,876	531,130	40,251	191,602	49,880	249,397	21,865

Source: JICA Study Team

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

	Item	Service Population in 2030	Water Demand in 2030 (m^3/day)	Rehabilitation Works (m^3/day)	Development Capacity (m^3/day)	Project Cost (KSh million)					O&M Cost (KSh million/year)
						Total	Rehabilitation Works	Major Dam/ Major Transmission	Intake/ Minor Transmission	Distribution	
1	Other Urban Pop.	1,235,080	146,975	12,960	134,015	25,703	0		4,284	21,419	1,251
2	Rural Pop.	810,576	61,604	23,800	37,804	7,250	0		1,208	6,042	353
	Major Water Sourece Works										
	Kiteta					3,009		3,009			15
	Thwake					2,199		2,199			11
	Olkishunki					1,381		1,381			7
	Total	2,045,656	208,578	36,760	171,818	39,543	0	6,589	5,492	27,462	1,637

Source: JICA Study Team

Table 5.2.3 Cost Estimate for Proposed Sewerage Development (ACA)

Major Urban Area		Service Population in 2030	Required Capacity in 2030 (m^3/day)	Current Capacity in 2010 (m^3/day)	Capacity to be developed (m^3/day)	Project Cost (KSh million)			O&M Cost (KSh million/year)
						Total	Rehabilitation Works	Expansion/ New Construct.	
1	Nairobi	6,085,297	568,367	192,000	376,367	73,982	9,820	64,162	3,513
2	Mombasa	2,644,591	247,005	17,100	229,905	40,069	875	39,194	2,146
3	Ruiru	896,358	68,302	0	79,868	13,616	0	13,616	745
4	Juja	151,781	11,566						
5	Kikuyu	875,242	66,693	0	66,693	11,370	0	11,370	623
6	Kangundo-Tala	820,175	62,497	0	62,497	10,655	0	10,655	583
7	Machakos	755,281	57,552	2,000	55,552	9,573	102	9,471	519
8	Mavoko	514,909	39,236	12,960	26,276	5,142	663	4,480	245
9	Malindi	443,811	33,818	0	33,818	5,765	0	5,765	316
10	Karuri	404,224	30,802	0	30,802	5,251	0	5,251	287
11	Ngong	402,242	30,651	0	36,131	6,160	0	6,160	337
12	Kiserian	71,913	5,480						
13	Kiambu	315,807	24,064	10,000	14,064	2,909	511	2,398	131
14	Limuru	298,455	22,742	10,000	12,742	2,684	511	2,172	119
15	Ukunda	234,651	17,880	0	17,880	3,048	0	3,048	167
16	Kitengela	218,282	16,633	0	16,633	2,836	0	2,836	155
17	Wundanyi	185,136	14,107	0	14,107	2,405	0	2,405	132
18	Kilifi	183,228	13,962	0	13,962	2,380	0	2,380	130
19	Mtwapa	182,474	13,905	0	13,905	2,370	0	2,370	130
20	Ongata Rongai	150,775	11,489	0	11,489	1,959	0	1,959	107
21	Taveta	99,997	7,620	0	7,620	1,299	0	1,299	71
22	Mariakani	90,271	6,879	0	6,879	1,173	0	1,173	64
23	Voi	86,340	6,579	0	6,579	1,122	0	1,122	61
24	Kajiado	74,803	5,700	0	5,700	972	0	972	53
25	Kwale	74,303	5,662	0	5,662	965	0	965	53
Total		16,260,348	1,389,193	244,060	1,145,133	207,704	12,482	195,222	10,688

Source: JICA Study Team

Table 5.2.4   Cost Estimate for Proposed Irrigation Development (ACA)

Category	Irrigation Area in 2030 (ha)	Project Cost* (KSh million)			Annual O&M Cost (KSh million)
		Irrigation System	Multipurpose Dam Cost Allocation**	Total Project Cost	
Large Scale Irrigation	37,280	19,580	14,397	33,977	102
Small Scale Irrigation	6,884	4,190	-	4,190	21
Private Irrigation	2,344	4,544	-	4,544	45
Total	46,508	28,314	14,397	42,711	168

Note: *: Project cost includes direct construction cost, physical contingency, engineering services and indirect costs.
**: Refer to Sectoral Report (G)
Source: JICA Study Team, based on data from relevant government authorities

Table 5.2.5 Cost Estimate for Proposed Hydropower Projects (ACA)

Catchment Area	No.	Name of Plan	Installed Capacity	Estimated Cost				Purpose
				Dam Allocation Cost (KSh million)	Hydropower Component cost (KSh million)	Total Project Cost (KSh million)	Annual O&M Cost (KSh million)	
ACA	11	Munyu Multipurpose Dam Development Plan	40 MW	2,148	2,685	4,833	24	Irrigation, Hydropower
	12	Thwake Multipurpose Dam Development Plan	20 MW	895	2,233	3,128	16	Water Supply, Irrigation, Hydropower
	Total		60 MW	3,043	4,918	7,961	40	

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

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

Dams

	Name of Dam	Sub-basin	Purpose 1)	Effective Storage (MCM)	Study Stage 2)	Cost (KSh million)
28	Upper Athi	3AA	W	24.0	NWMP 2030	2,813
29	Stony Athi	3AB	W	23.0	F/S and M/P ongoing	4,006
30	Kikuyu	3BA	W	31.0	NWMP 2030	4,092
31	Ruaka (Kiambaa)	3BA	W	4.0	D/D completed	1,961
32	Kamiti 1	3BB	W	16.0	F/S and M/P ongoing	6,308
33	Ruiru-A (Ruiru 2)	3BC	W	18.0	F/S and M/P ongoing	6,990
34	Ndarugu (Ndarugu 1)	3CB	W	300.0	F/S and M/P ongoing	5,029
35	Munyu	3DA	I, P	575.0	F/S done	10,229
36	Mbuuni	3EA	W	10.0	NWMP 2030	2,557
37	Kiteta	3EB	W	16.0	Pre- F/S done	2,983
38	Thwake	3FA	W, I, P	594.0	Final Design completed	8,439
39	Olkishunki	3FA	W	1.2	Pre- F/S done	1,364
40	Pemba	3HC	W	19.0	NWMP 2030	5,455
41	Lake Chala	3J	W, F	6.0	D/D ongoing	1,534
42	Rare	3LA	W	36.0	D/D to be completed in 2013	3,580
43	Mwachi	3MA	W	16.0	Preliminary Design completed	4,262
	Total			1,689.2		71,602

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

Water Transfer

	Wter Transfer Scheme	Purpose	Capacity, Dimensions	Cost (KSh million)
5	Second Mzima Pipeline from Mzima Springs to Mombasa	W	Capacity of 100,000 m^3/day (37 MCM/year), Pipeline	35,289
6	Sabaki Scheme (Expansion)	W	Capacity of 85,000 m^3/day (31 MCM/year), Pipeline	15,002
	Total			50,291

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

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

Development Cost (Unit: KSh thousand)

No.	Item	ACA			
		Unit cost	Cost	Unit of Q'ty	Cost
1) Monitoring					**128,300**
	Installation/Rehabilitation of River Gauging Stations	240	10	nos.	2,400
	Installation/Rehabilitation of Rainfall Gauging Stations	100	15	nos.	1,500
	Installation of Dedicated Boreholes for Groundwater Monitoring	2,000	24	nos.	48,000
	Replacement of iron post for river gauge to concrete post	100	26	nos.	2,600
	Upgrade manual gauge to automatic (surface water level)	1,000	26	nos.	26,000
	Upgrade manual gauge to automatic (groundwater level)	200	24	nos.	4,800
	Upgrade manual gauge to automatic (rainfall)	1,000	38	nos.	38,000
	Flood Discharge Measurement Equipment (each sub-region)	1,000	5	nos.	5,000
2) Evaluation					**53,855**
	Hydromet DB Upgrade (Software + Hardware) including training	2,500	18	nos.	45,000
	Establishment of additional Water Quality Test Laboratory (Lodwar, Kapenguria, Mombasa, Garissa, Marsabit, Wajir) - Building and Utility	6,750	1	nos.	6,750
	Laboratory Equipment and Reagents	2,105	1	nos.	2,105
3) Permitting					
	PDB Upgrade (Software + Hardware) including training	1,500	18	nos.	27,000
4) Watershed Conservation					
	Forestation to achieve 10% of Forest Cover	79	868,000	ha	68,572,000
	Total				**68,781,155**

Recurrent Cost (Annual) (Unit: KSh thousand)

No.	Item	ACA			
		Unit cost	Cost	Unit of Q'ty	Cost*
1) Monintoring and Analysis					**136,992**
	Surface Water Monitoring (Daily)	12	312	nos.	3,744
	River Discharge Measurement (Monthly)	80	312	nos.	24,960
	Groundwater Monitoring (Monthly)	12	288	nos.	3,456
	Rainfall Monitoring (Daily)	12	456	nos.	5,472
	Flood Discharge Measurement (Three times a year)	100	936	nos.	93,600
	Surface Water Quality Monitoring (Monthly)	30	60	nos.	1,800
	Surface Water Quality Monitoring (Quarterly)	30	84	nos.	2,520
	Gruondwater Quality Monitoring (Twice a year)	30	48	nos.	1,440
2) Others					
	Catchment Forum Operation (Venue and Allowances to WRUAs)	500	2	times	1,000
	Total				**137,992**

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

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

CA	No.	Description		Project Cost for Structure (KSh million)	Project Cost for Non-Structure (KSh million)	Recurrent Cost* (KSh million /year)	Source	Remarks
Athi	A1	**Downmost Athi (Kilifi, Lower Sabaki)**		**84.96**	**39.96**	**0.62**		
	F	A1.1	Establishment of Community-based Flood Management System	84.96	39.96	0.62	Nyando MP	
	A2	**Lumi River (Taveta)**		**124.91**	**58.76**	**0.92**		
	A	A2.1	Construction of Multipurpose Dam	-		-		Lake Chala Dam
	F	A2.2	Establishment of Community-based Flood Management System	124.91	58.76	0.92	Nyando MP	
	A3	**Nairobi City**		**0.00**	**0.00**	**0.00**		
	H	A3.1	Implementation of Urban Drainage Measures	(38,270.73)		-	NWMP (1992)	US$360.0 million in 1992
	A4	**Kwale (Vanga)**		**155.93**	**30.00**	**0.15**		
	B	A4.1	River Training Works	155.93		-		
	D	A4.2	Preparation of Hazard Map		30.00	0.15		10M/M
	A5	**Mombasa**		**0.00**	**0.00**	**0.00**		
	H	A5.1	Implementation of Urban Drainage Measures	(4,948.62)		-	NWMP (1992)	US$46.55 million in 1992

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

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

Table 5.2.9 Cost Estimate for Proposed Environmental Management Plan (ACA)

Description		Development Cost		Recurrent Cost* (KSh million /year)
		River and Lake Environment Survey (KSh million)	Setting of Environmental Flow Rate (KSh million)	
1.Environmental River Flow				
1.1	Athi River	26.1	2.7	-
1.2	Lumi River	6.5	1.1	-
1.3	L.Chala	7.3	1.1	-
1.4	L.Jipe	7.3	1.1	-
1.5	L.Amboseli	7.3	-	-
2.Environmental Monitoring				
2.1	Athi River	-	-	0.0
2.2	Nairobi River	-	-	0.0
2.3	Lumi River	-	-	0.0
2.4	L.Chala	-	-	0.0
2.5	L.Jipe	-	-	0.0
2.6	L.Amboseli	-	-	0.4
2.7	Nairobi City	-	-	0.6
2.8	Mombasa City	-	-	0.6

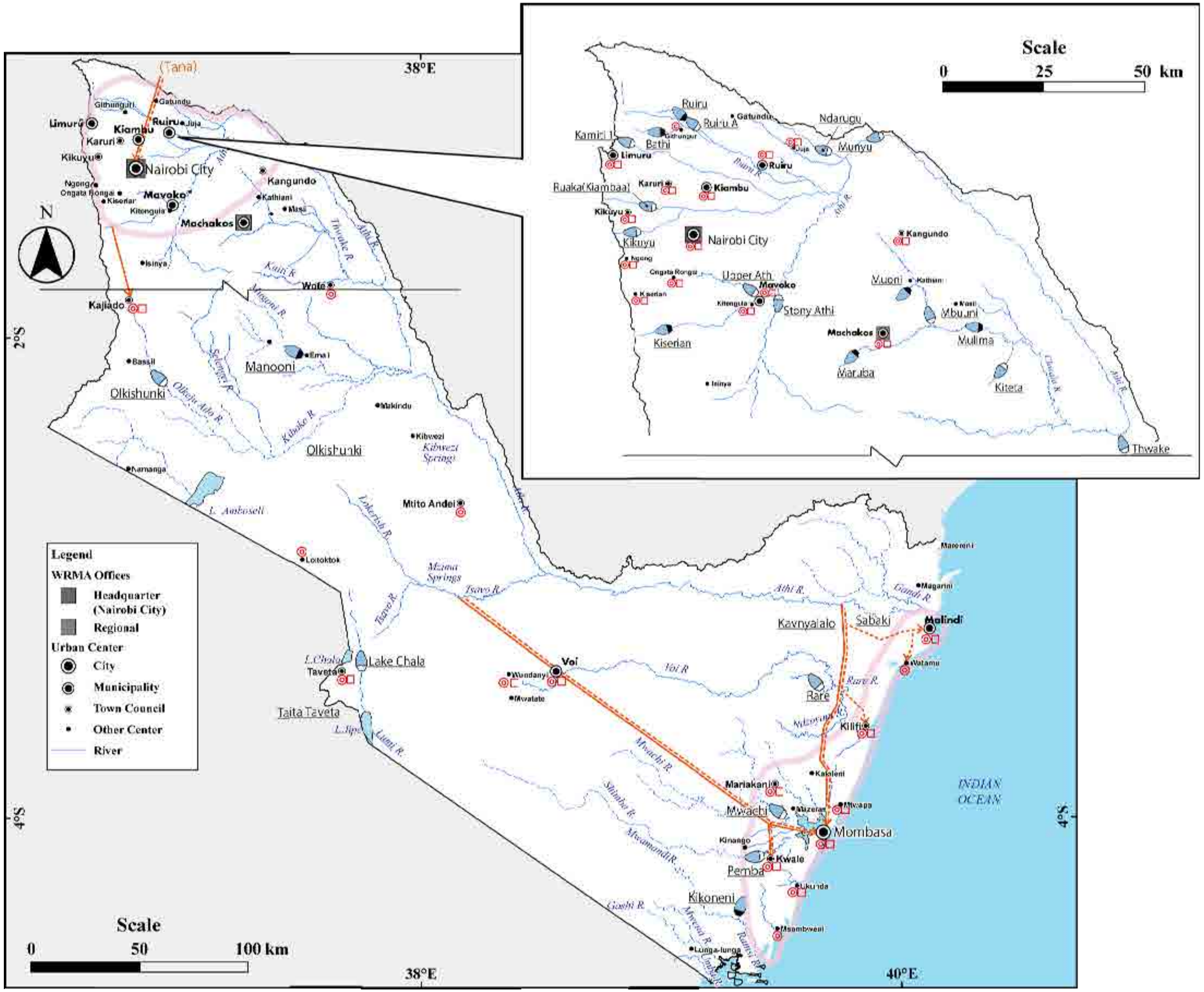
Note: Basic conditions for cost estimate are supposed as follows;

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

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

Figures

Source: JICA Study Team



LEGEND	Urban Water Supply Development	Water Transfer (Existing)	High Population Density Area	Dam (Existing)
	Sewerage Development	Water Transfer (Proposed)		Dam (Proposed)

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

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Source: JICA Study Team

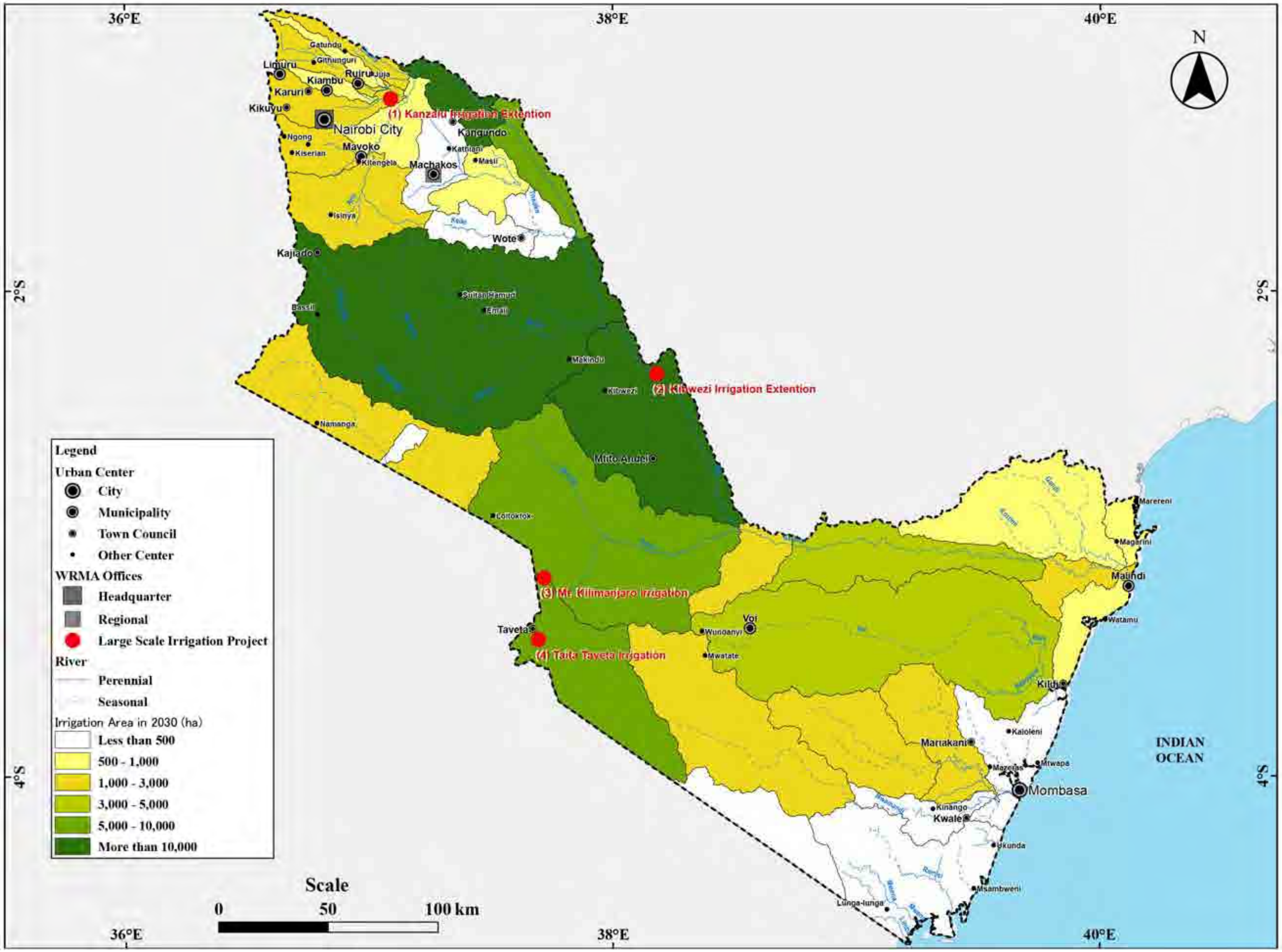
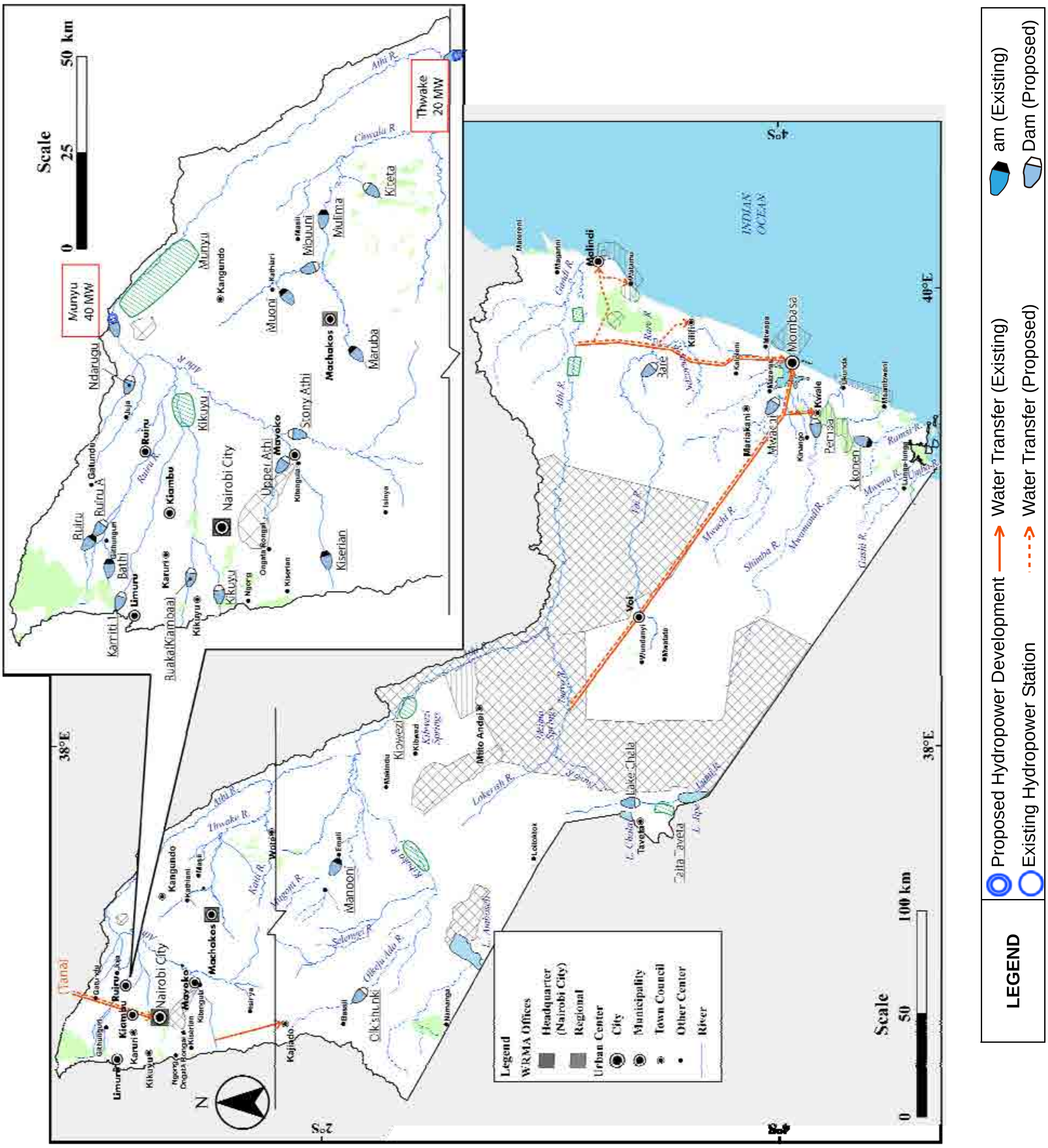


Figure 4.4.1
Proposed Irrigation Development Plan (ACA)



Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 4.5.1 Existing Hydropower Station and Proposed Hydropower Development Plan (ACA)**
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Figure 4.6.1
Existing and Proposed Dams and Water Transfer Facilities (ACA)

Source: JICA Study Team

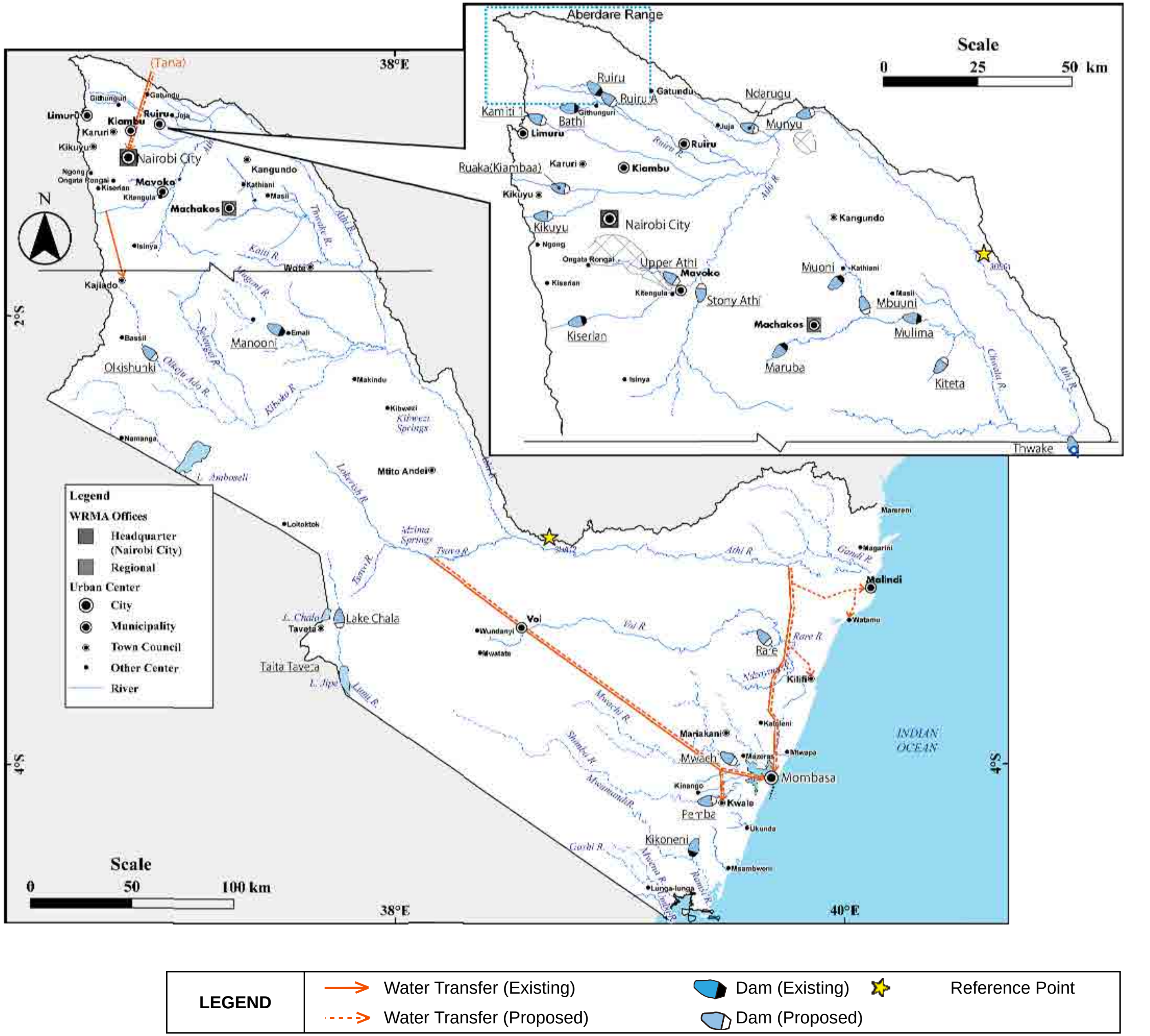

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Figure 4.6.2
Sub-basin Division Map
(ACA)

Source: JICA Study Team

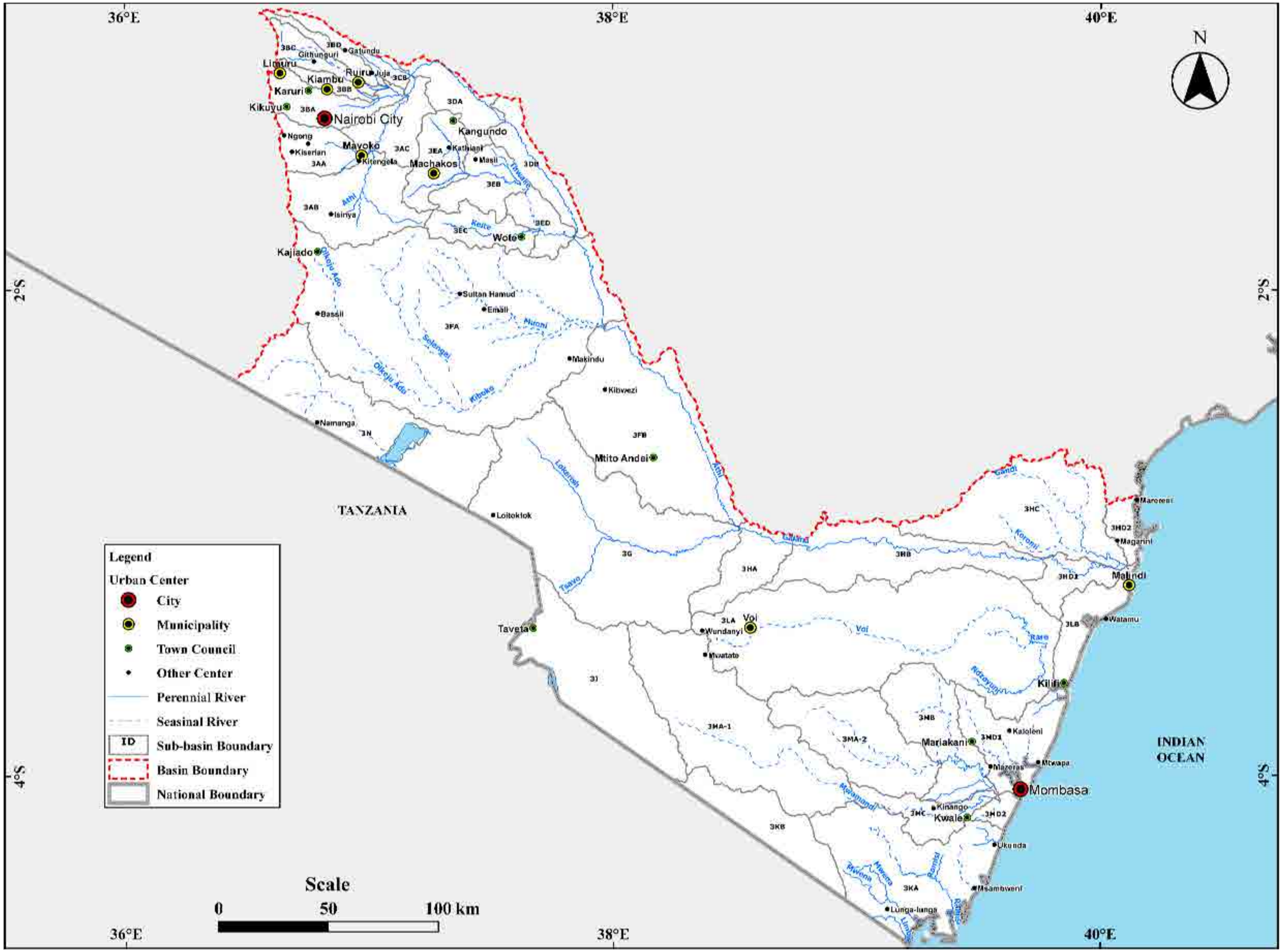

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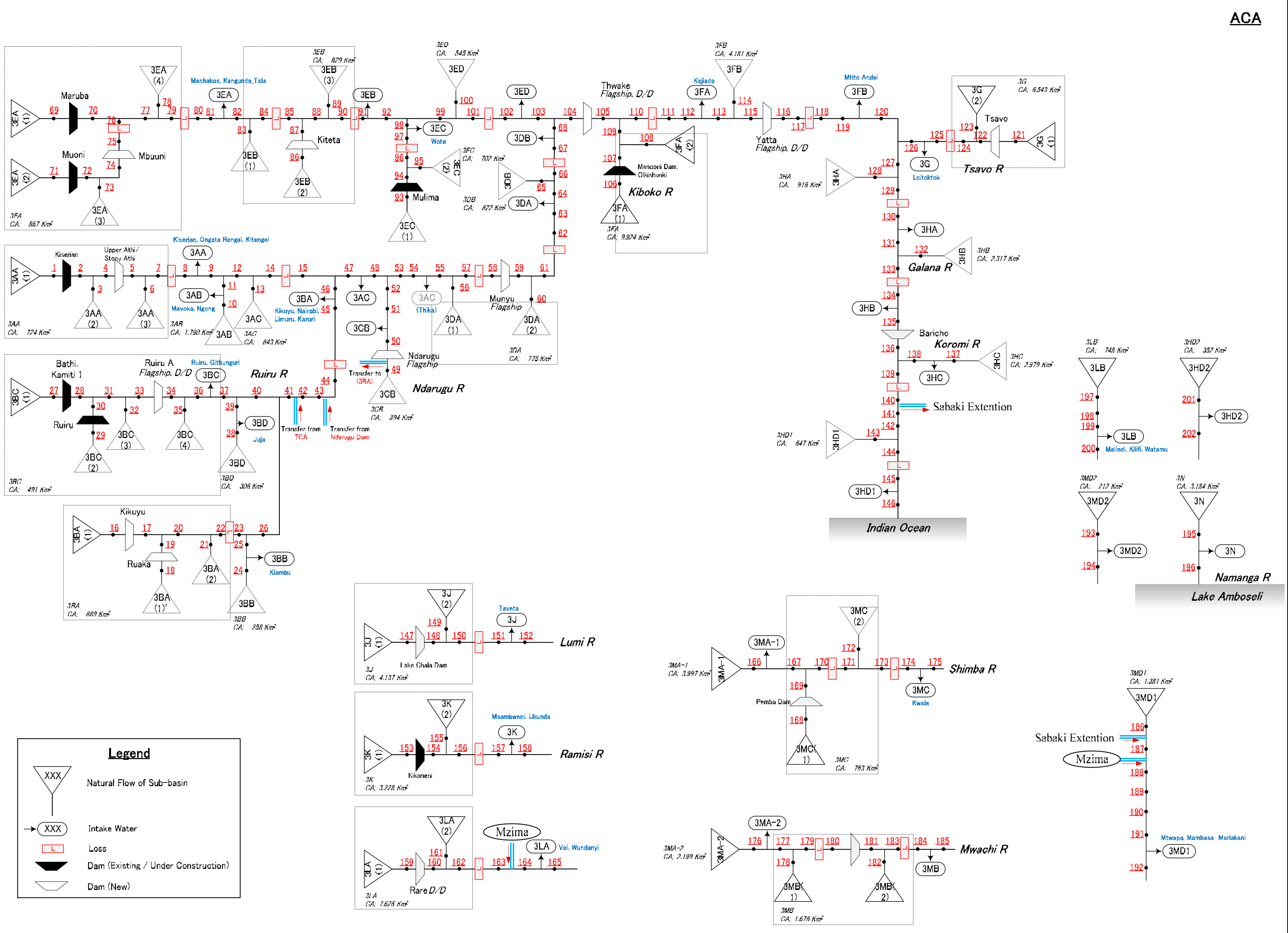
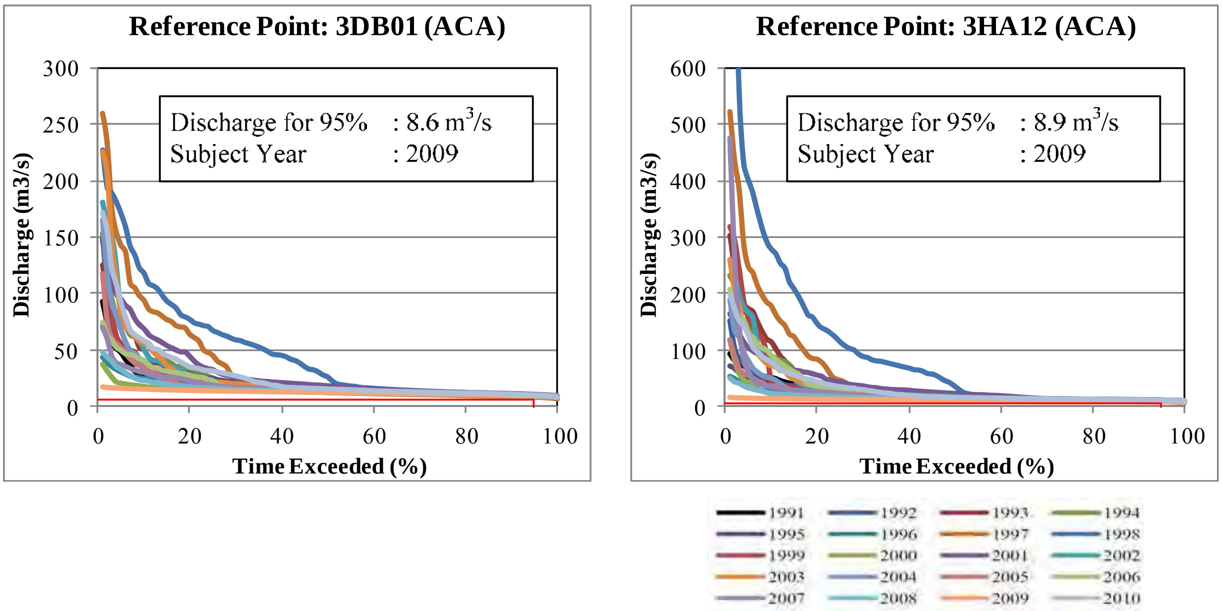
Figure 4.6.3
Surface Water Balance Calculation Model (ACA)



Source: JICA Study Team



Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 4.6.4** **Simulated Flow Duration Curves for Estimate of Reserve at Reference Points (ACA)**
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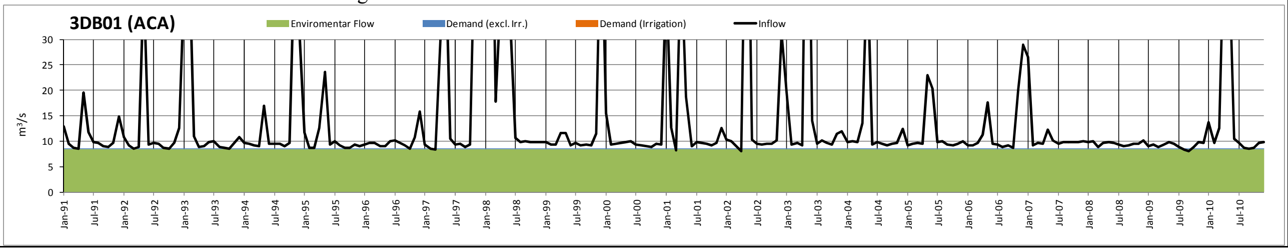
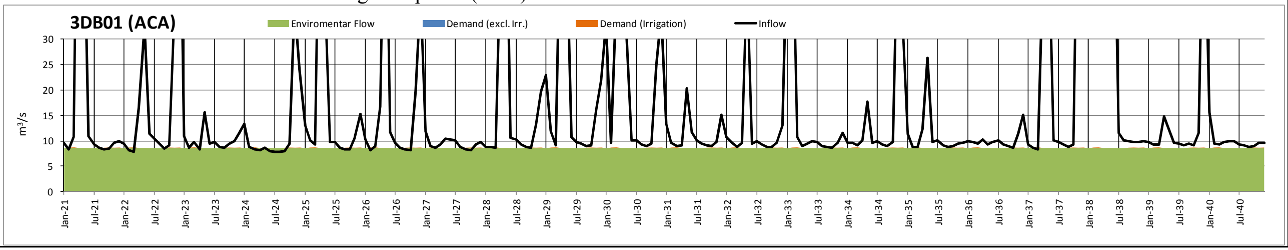
River Name: Athi River (middle) (ACA)
Reference Point: 3DB01

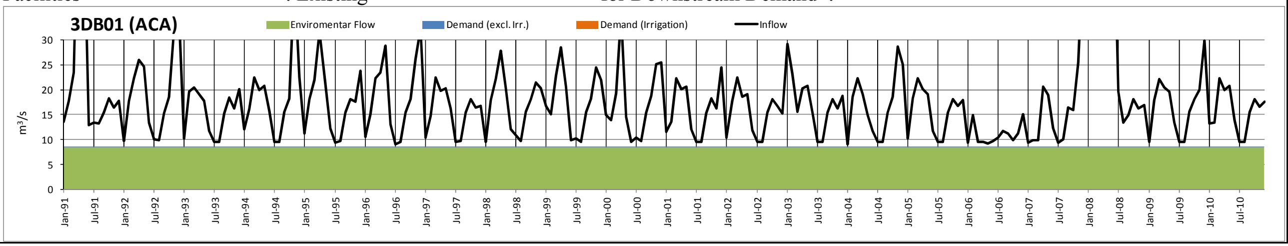
River Flow	: Present (1991-2010)	Reserve:	8.6	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained		
Facilities	: Existing	for Downstream Demand*:	0.1	(m^3/s)



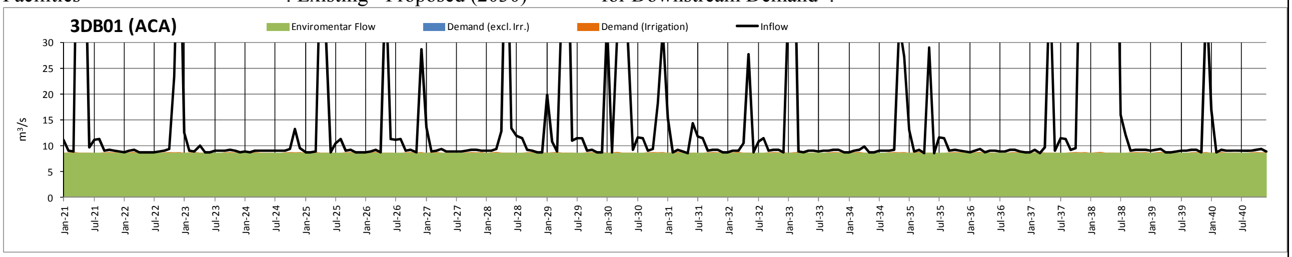
River Flow	: Present (1991-2010)	Reserve:	8.6	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained		
Facilities	: Existing +Proposed (2030)	for Downstream Demand*:	0.1	(m^3/s)



River Flow	: Future (2021-2040)	Reserve:	8.6	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained		
Facilities	: Existing	for Downstream Demand*:	0.1	(m^3/s)



River Flow	: Future (2021-2040)	Reserve:	8.6	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained		
Facilities	: Existing +Proposed (2030)	for Downstream Demand*:	0.1	(m^3/s)



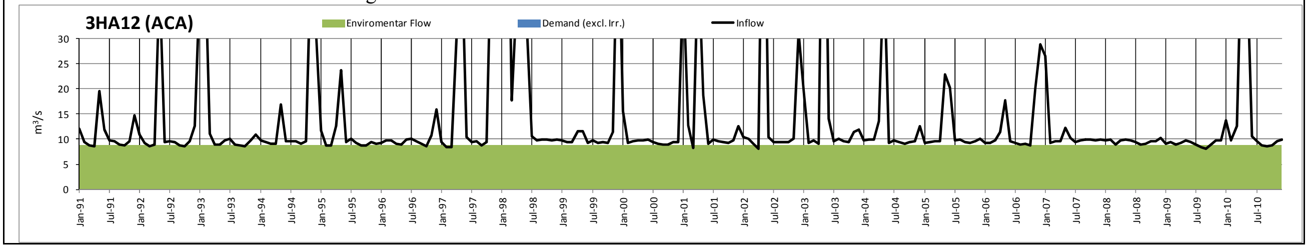
Note: * Irrigation water demand is the average irrigation water demand during April, May, and June.

Source: JICA Study Team

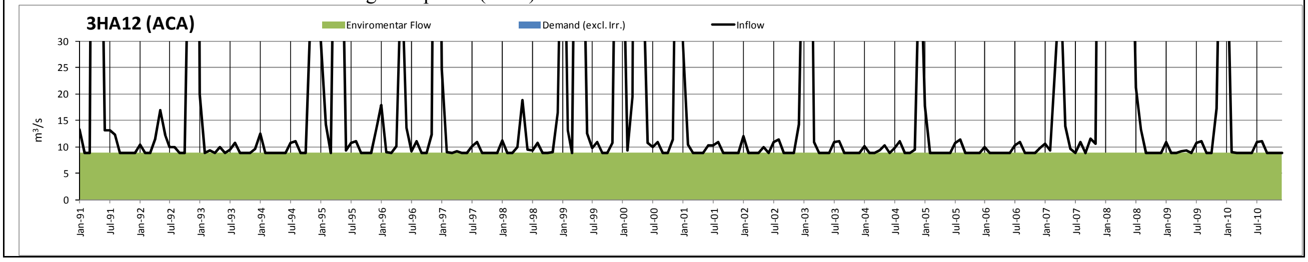
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030 / JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure 4.6.5 River Flow at Reference Point 3DB01 under Present and Future Water Demands and Facilities Conditions (ACA) (1/2)**

River Name: Athi River (lower) (ACA)
Reference Point: 3HA12

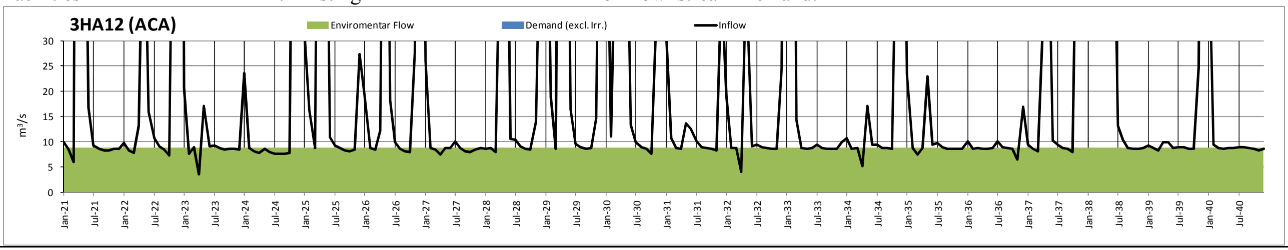
River Flow	: Present (1991-2010)	Reserve:	8.9	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained for Downstream Demand:	0.1	(m^3/s)
Facilities	: Existing			



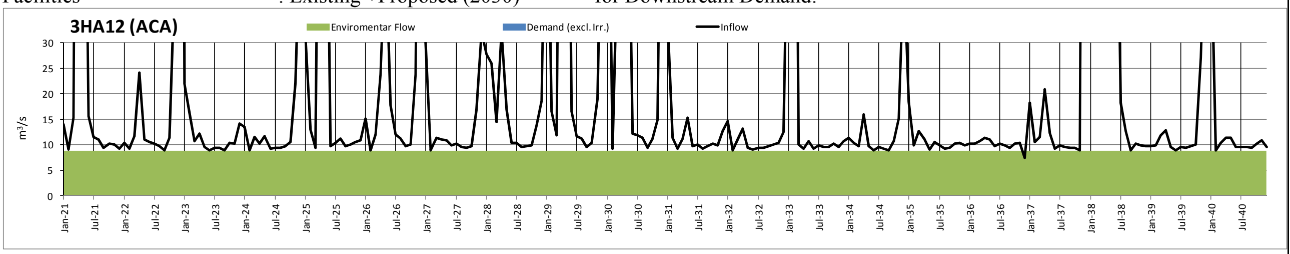
River Flow	: Present (1991-2010)	Reserve:	8.9	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained for Downstream Demand:	0.1	(m^3/s)
Facilities	: Existing +Proposed (2030)			



River Flow	: Future (2021-2040)	Reserve:	8.9	(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:	8.9	(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 4.6.5 River Flow at Reference Point 3HA12 under Present and Future Water Demands and Facilities Conditions (ACA) (2/2)**
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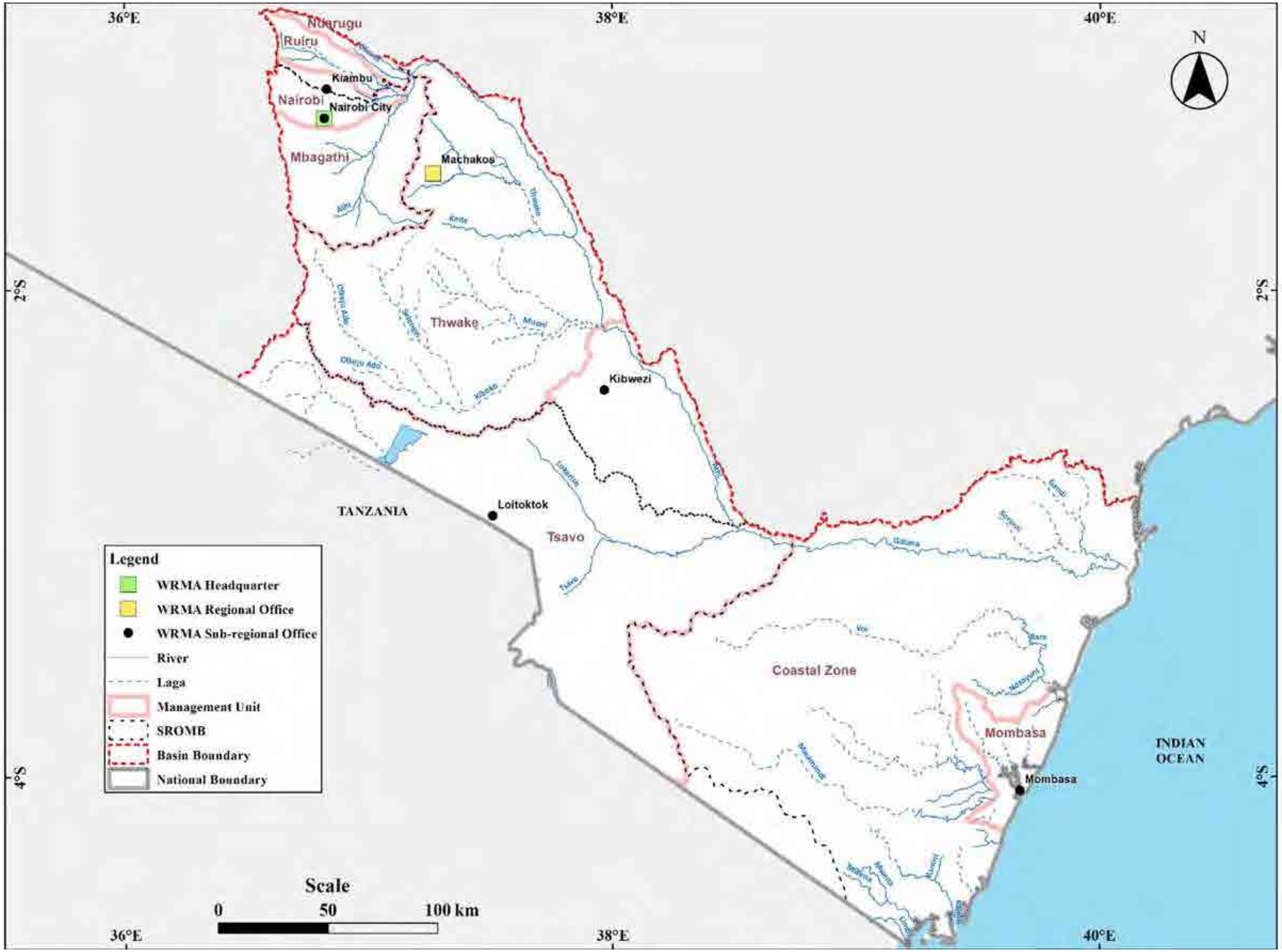

Source: JICA Study Team

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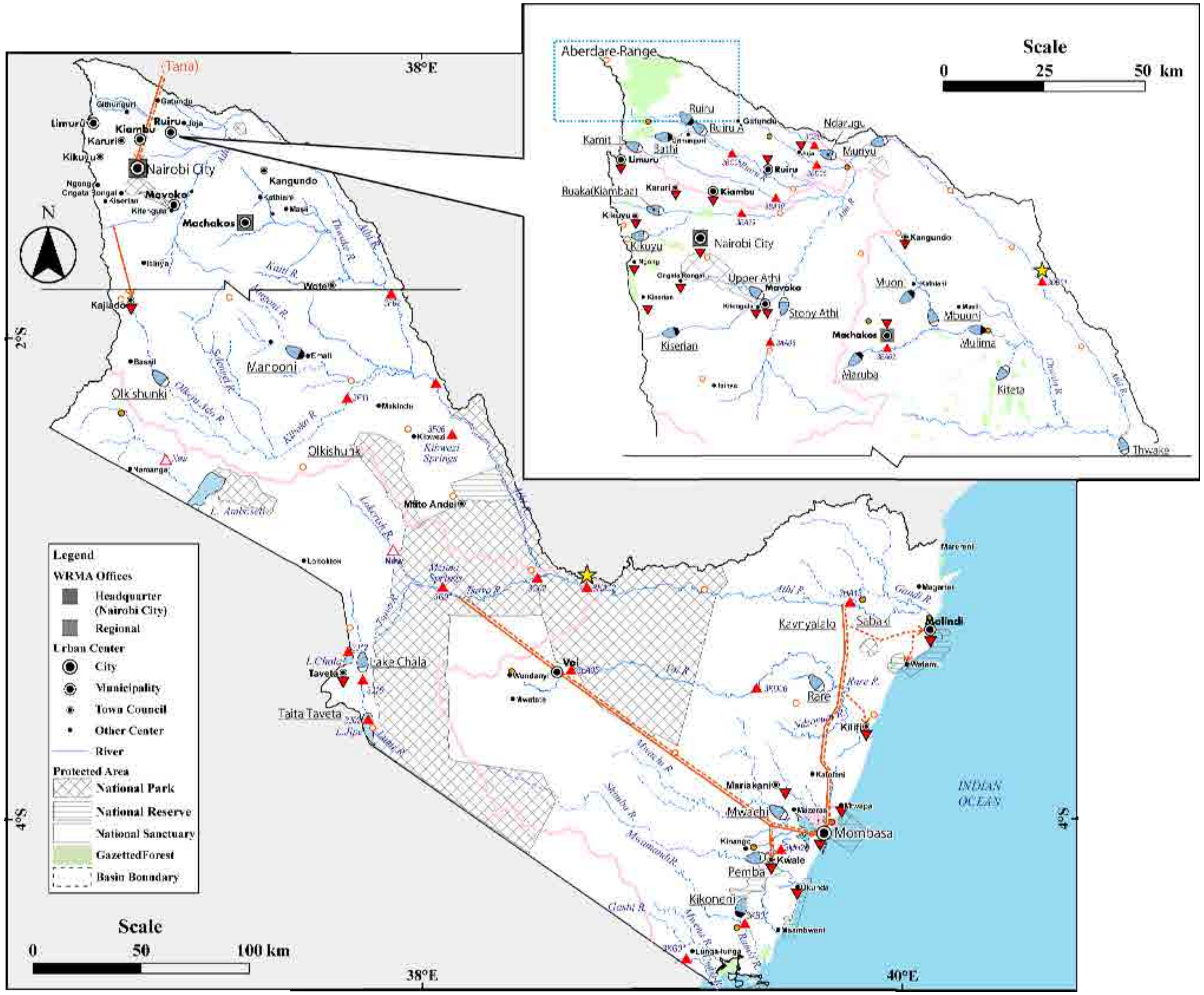
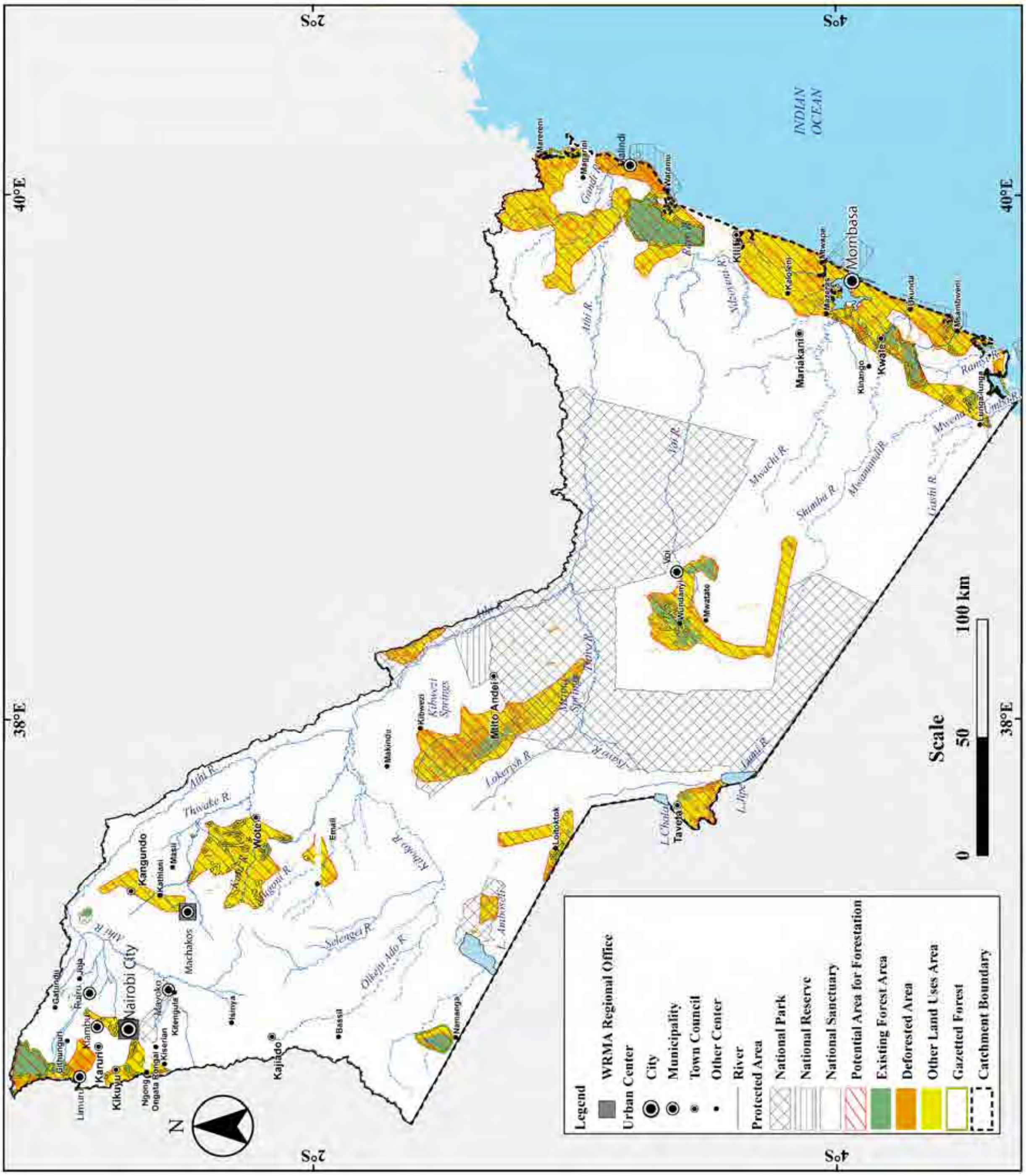
Figure 4.7.1
Rivers and Boundaries for Administration (ACA)

Figure 4.7.2
Proposed Monitoring Stations for Water Resources Management (LVSCA)

Source: JICA Study Team



LEGEND				
	Surface Water Monitoring Station Existing Newly Proposed	26 locations	Groundwater Monitoring Station Proposed Monitoring Station	24 locations
	Rainfall Monitoring Station Existing Newly Proposed	38 locations	Reference Point Proposed Reference Point	2 locations



Source: JICA Study Team, based on satellite images

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 4.7.3** **Current Situation of Forest Areas and Potential Forestation Areas (ACA)**
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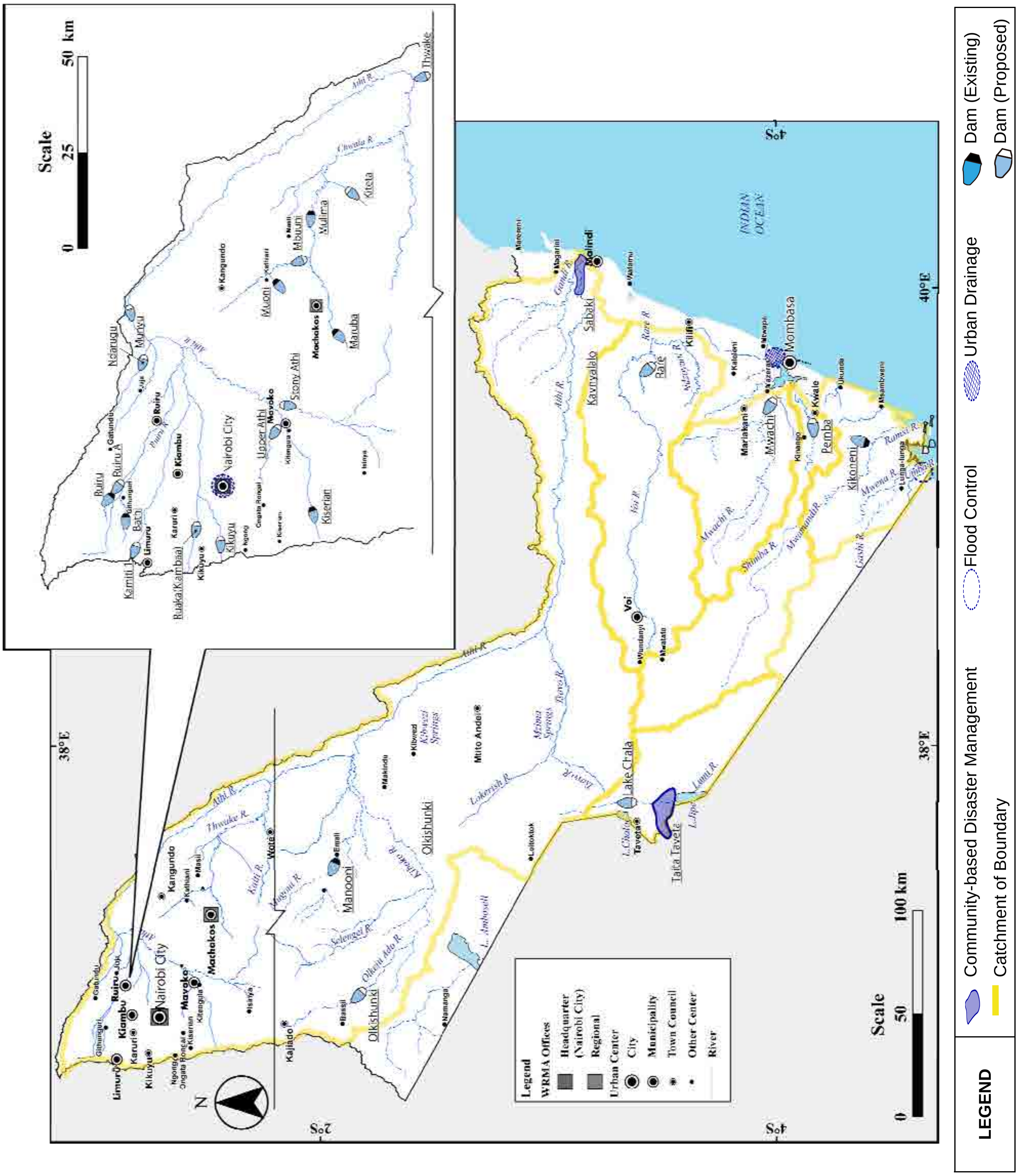

Note: The yellow line shows the boundaries of river basin unit for establishment of Basin Drought Conciliation Council in drought disaster management plan.

Source: JICA Study Team

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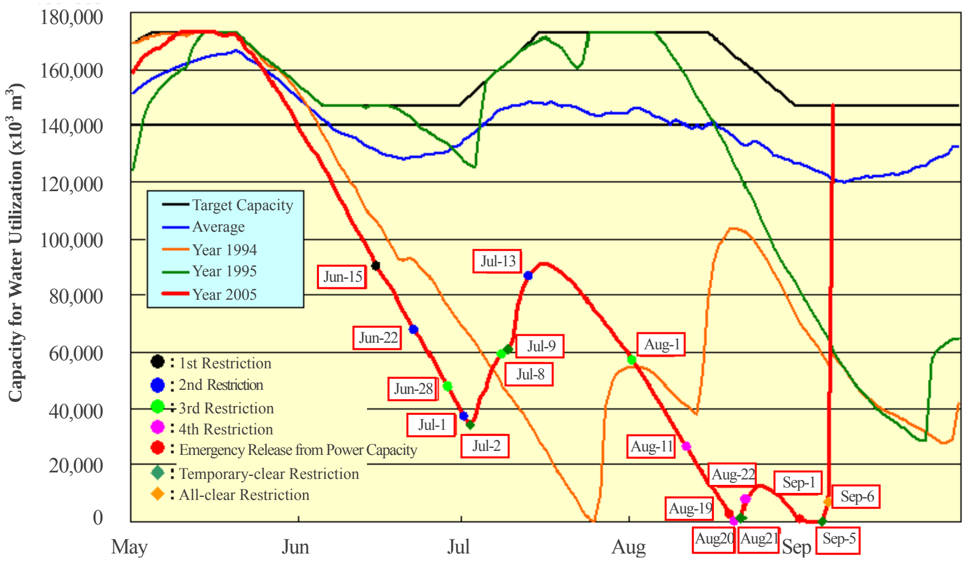
Figure 4.8.1
Proposed Flood and Drought Disaster Management Plan (ACA)

Flow of Water Use Restriction of the Sameura Dam in 2005 Drought

Date	Reserve	Water Use Restriction	Organizational Arrangement
May 26	96.40%		15:00 Setting up a head office of special task force for water restriction in Shikoku Regional Development Bureau (a) 15:00 Setting up a branch office of special task force for water restriction in Integrated Management Office of Dams in Yoshino River (b)
Jun 13	66.60%	0:00 Voluntary water-saving [Tokushima 5.9%]	
Jun 15	61.20%	9:00 The first water restriction [Tokushima 14.1% (new 20%), Kagawa 20%]	9:00 Setting up a branch office of special task force for water restriction in Tokushima River and National Highway Office (c)
Jun 22	46.00%	9:00 The second water restriction [Tokushima 15.9% (new 35%), Kagawa 35%]	
Jun 28	32.40%	9:00 The third water restriction [Tokushima 17.6% (new 50%), Kagawa 50%]	
Jul 1	25.10%	22:00 Ease the second water restriction [Tokushima 17.2% (new 35%), Kagawa 35%]	
Jul 2	22.80%	6:00 Temporary-clear water restriction	
Jul 8	36.80%	0:00 The third water restriction [Tokushima 19.0% (new 50%), Kagawa 50%]	
Jul 9	37.50%	15:00 Temporary-clear water restriction	
Jul 13	51.20%	18:00 The second water restriction [Tokushima 17.2% (new 35%), Kagawa 35%]	
Aug 1	32.90%	9:00 The third water restriction [Tokushima 19.0% (new 50%), Kagawa 50%]	
Aug 11	15.10%	9:00 The forth water restriction [Tokushima 22.0% (new 75%), Kagawa 75%]	9:00 Setting up a head office of emergency task force for extraordinary drought in Shikoku Region (d)
Aug 19 (20:00)	1.5% (0.0%)	20:00 Start emergency release from power generation capacity [Tokushima 1.85 m^3/s, Kagawa 1.81 m^3/s]	
Aug 20	0.00%	22:00 Temporary ease the forth water restriction [Tokushima 22.0% (new 75%), Kagawa 75%] Stop emergency release from power generation capacity	
Aug 21	1.10%	11:00 Temporary-clear water restriction	
Aug 22	4.90%	22:00 Restart the forth water restriction [Tokushima 22.4% (new 75%), Kagawa 75%]	
Sep 1 (8:00)	0.5% (0.0%)	8:00 Start emergency release from power generation capacity [Tokushima 1.85m^3/s, Kagawa 1.81m^3/s]	
Sep 5	0.00%	5:00 Stop emergency release from power generation capacity 9:00 Temporary-clear water restriction	
Sep 6 (20:00)	4.6% (100%)	18:00 All-clear water restriction	18:00 Breaking up the office (a) 18:00 Breaking up the office (d) 18:00 Breaking up the office (c) 20:00 Breaking up the office (b)



Time Series Graph of Water Use Capacity of the Sameura Dam and Restriction Actions in 2005 Drought

Source: Shikoku Regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism, Japan

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Figure 4.8.2
Example for Water Use Restriction of Sameura Dam in 2005 Drought

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Source: JICA Study Team

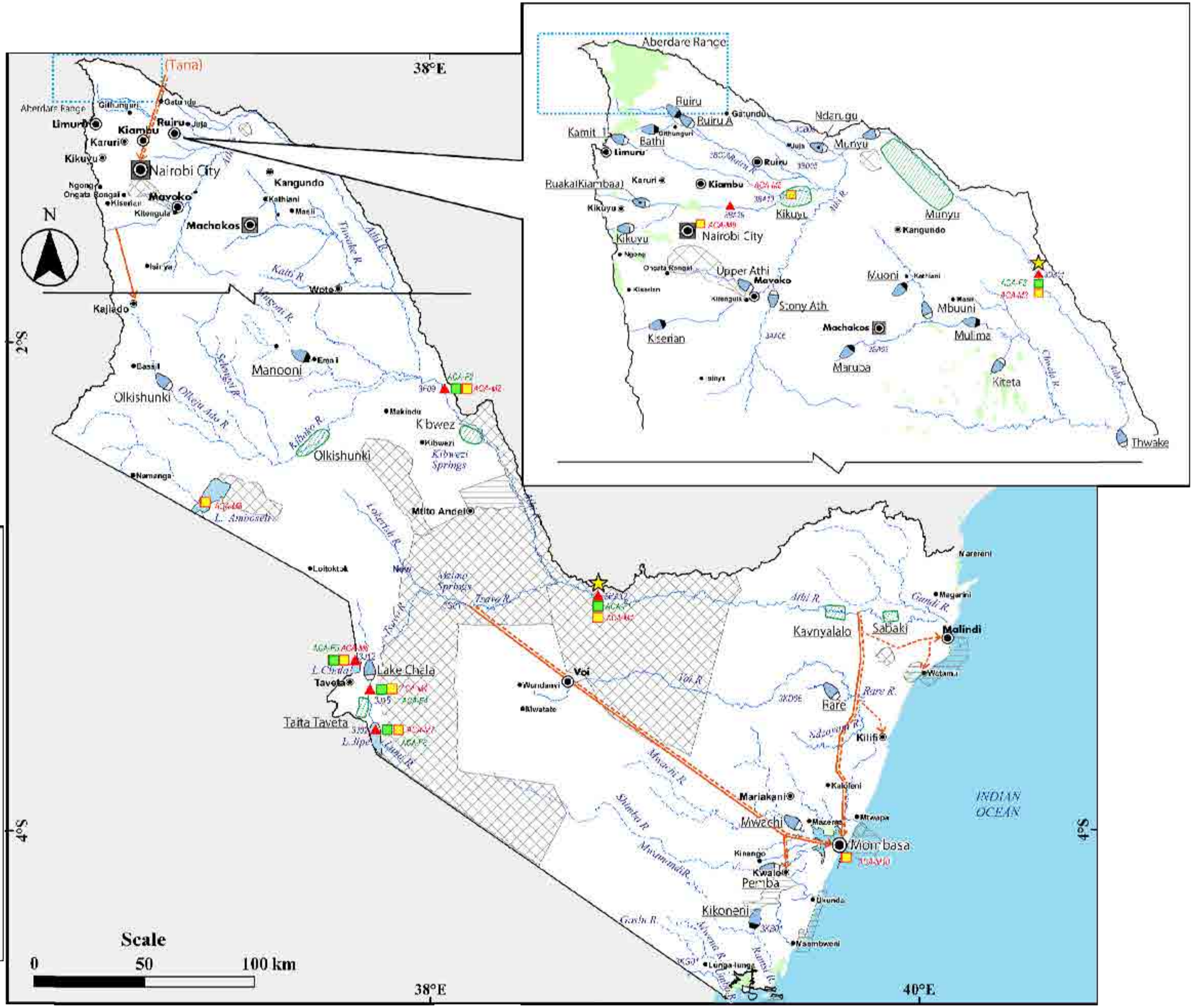
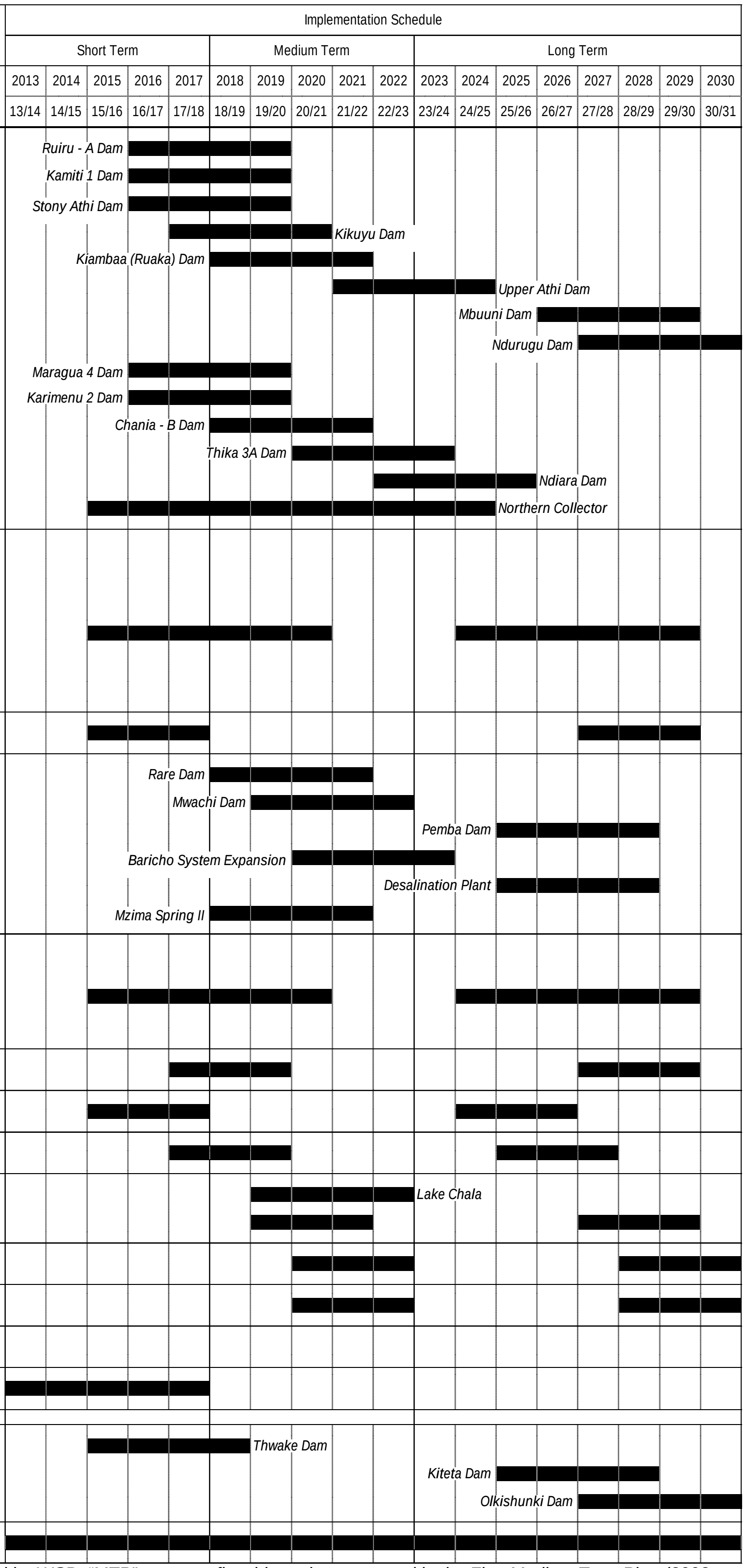


Figure 4.9.1
Proposed Environmental Management Plan (ACA)

WRMA Catchment	No.	Name of Project	Project Status	Capacity to be developed (m^3/day) Total	Initial Develop.	Ratio
Athi	1	Nairobi and Satellite Towns				
		Nairobi				
		Ruiru, Kikuyu, Kangundd-Tala, Mavoko, Thlka, Karuri, Ngong, Kiambu, Limuru, Kitengela, Juja, Ongata Rongai, Kiserian, Githunguri (14UC)	WSB, MTP, F/S*	961,207	635,000	66%
		Machakos	WSB, MTP, F/S	86,505	5,000	6%
	2	Mombasa and Coastal Area				
		Mombasa				
		Mtwapa, Mariakani, Kwale, Malindi, Ukunda, Kilifi, Watamu, Msambweni (8UC)	WSB, MTP, F/S*	449,919	363,000	81%
	3	Kajiado	WSB	7,902	1,000	13%
	4	Wote	WSB, MTP, F/S	5,390	2,000	37%
	5	Wundanyi	-	21,331	6,399	30%
	6	Taveta	-	11,900	3,570	30%
	7	Voi	-	9,574	2,872	30%
	8	Loitoktok	-	6,727	2,018	30%
	9	Mitto Andei	-	0	0	0%
	Rehabilitation for 27 Urban Centres					
	Total Urban Water Supply Projects			1,560,456	1,020,860	65%
	Water Resources Development for Rural Water Supply					
	Rural Water Supply Projects					



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

Source: JICA Study Team

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

WRMA Catchment	No.	Urban Centre	F/S Status	Capacity to be developed (m^3/day)			Implementation Schedule																	
				Total	Initial Develop.	Ratio	Short Term					Medium Term					Long Term							
							2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
							13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29	29/30	30/31
Athi	1	Ruiru	WSB, MTP, D/D	79,868	40,000	50%	■	■	■								■	■	■					
	2	Juja																						
	3	Kikuyu	WSB, D/D	66,693	20,000	30%		■	■	■							■	■	■					
	4	Nairobi	WSB, MTP, F/S	376,367	60,000	22%			■	■	■							■	■	■				
	5	Limuru	WSB, MTP, F/S	12,742	20,000	157%			■	■	■							■	■	■				
	6	Mombasa	WSB, MTP, F/S	229,905	55,325	30%					■	■	■						■	■	■			
	7	Mavoko	WSB, MTP, F/S	26,276	10,000	38%						■	■	■						■	■	■		
	8	Karuri	WSB, MTP	30,802	30,802	100%						■	■	■										
	9	Kiambu	WSB	14,064	24,064	100%						■	■	■										
	10	Ngong	WSB, F/S	36,131	7,500	24%								■	■	■						■	■	■
	11	Kiserian																						
	12	Kajiado	WSB, F/S	5,700	500	9%								■	■	■						■	■	■
	13	Kangundd-Tala	WSB	62,497	62,497	100%											■	■	■					
	14	Machakos	WSB, MTP	55,552	57,552	100%											■	■	■					
	15	Ukunda	WSB	17,880	7,880	100%											■	■	■					
	16	Malindi	_	33,818	33,818	100%													■	■	■			
	17	Kitengela	_	16,633	16,633	100%													■	■	■			
	18	Wundanyi	_	14,107	14,107	100%													■	■	■			
	19	Kilifi	_	13,962	13,962	100%													■	■	■			
	20	Mtwapa	_	13,905	13,905	100%																■	■	■
	21	Ongata Rongai	_	11,489	11,489	100%																■	■	■
	22	Taveta	_	7,620	7,620	100%																■	■	■
	23	Mariakani	_	6,879	6,879	100%																■	■	■
	24	Voi	_	6,579	6,579	100%																■	■	■
	25	Kwale	_	5,662	5,662	1																■	■	■
		Kibwezi	WSB, F/S (additional)	0																				
		Makindu	WSB, F/S (additional)	0																				
		Mtito Andei	WSB, F/S (additional)	0																				
		Emali	WSB, F/S (additional)	0																				
		Sultan Hamud	WSB, F/S (additional)	0																				
		Loitokitok	WSB, F/S (additional)	0																				
		Wote	WSB, F/S (additional)	0																				
	Rehabilitation Works for 5 Urban Centres						■	■	■	■	■													
		Total		1,145,133	526,776	46%																		

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

Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 7.3.2** **Implementation Schedule of Proposed Sewerage System Development Plan (ACA)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

No	Name of Project	County	Irrigation Area (ha)	Multi-purpose Dam	Short Term					Medium Term					Long Term							
					2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
					13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29	29/30	30/31
A.	**Large Scale Irrigation Project (New)**																					
1	Taita Taveta Irrigation Extension	Taita Taveta	3,780	-			P															
2	Mt. Kilimanjaro Spring Irrigation	Kajiado	1,500	-					P		Dam											
3	Kibwezi Irrigation Extension	Makueni	17,000	Thwake							P											
4	Kanzal Irrigation Extension	Makueni	15,000	Munyu									P						Dam			
	Total		37,280				0					5,280						32,000				
B.	**Small Scale Irrigation Project (New)**																					
1	Weir Irrigation		35				35					0						0				
2	Dam Irrigation		0				0					0						0				
3	Small Dam/Pond/Water Pan Irrigation		4,140				828					1,242						2,070				
4	Groundwater Irrigation		2,309				462					693						1,154				
	Total for B		6,484				1,325					1,935						3,224				
C.	**Private Irrigation Project (New)**																					
1	Weir Irrigation		35				35					0						0				
2	Groundwater Irrigation		2,309				462					693						1,154				
	Total for C		2,344				497					693						1,154				
	Total for ACA		46,108				1,822					7,908						36,378				

Note:
- F/S and/or D/D
- P Procurement
- Construction of Irrigation System
- Construction of Multipurpose Dam

Source: JICA Study Team

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 7.3.3
Implementation Schedule of Proposed Irrigation Development Plan (ACA)

WRMA Catchment	No	Name of Project	Purpose	Installed Capacity (MW)	Project Status	Implementation Schedule																	
						Short Term					Medium Term					Long Term							
						2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
						13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29	29/30	30/31
Athi	11	Thwake Dam	W, I, P	20	Flagship D/D done		P	■	■	■	■												
	12	Munyu Dam	I, P	40	Flagship F/S done								▒	▒	P	■	■	■	■				

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

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

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

Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 7.3.4 Implementation Schedule of Proposed Hydropower Development Plan (ACA)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

WRMA Catchment	No.	Name of Project	Purpose	Effective Storage Volume (MCM)	Project Status	Implementation Schedule																	
						Short Term					Medium Term					Long Term							
						2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
						13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29	29/30	30/31
Athi	1	Ruiru-A (Ruiru 2) Dam	W	18	Flagship F/S ongoing			P															
	2	Kamiti 1	W	16	F/S ongoing			P															
	3	Stony Athi	W	23	F/S ongoing			P															
	4	Thwake Dam	W, I, P	594	Flagship D/D done		P																
	5	Kikuyu Dam	W	31					P														
	6	Ruaka (Kiambaa) Dam	W	4	D/D done					P													
	7	Rare Dam	W	36	Flagship D/D ongoing					P													
	8	Mwachi Dam	W	16	Flagship P/D done						P												
	9	Upper Athi (Mbagathi) Dam	W	24									P										
	10	Lake Chala Dam	W, F	6	D/D ongoing							P											
	11	Munyu Dam	I, P	575	Flagship F/S done										P								
	12	Kiteta Dam	W	16	Pre-F/S done											P							
	13	Pemba Dam	W	19													P						
	14	Mbuuni Dam	W	10														P					
	15	Olkishunki Dam	W	1	Pre-F/S done														P				
	16	Ndarugu (Ndarugu 1) Dam	W	300	Flagship F/S ongoing														P				

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

Source: JICA Study Team

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

No.	Description	Implementation Schedule																	
		Short Term					Medium Term					Long Term							
		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
		13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29	29/30	30/31
Development Activities																			
(1)	Monitoring																		
M1	Replacement of iron post for river gauge to concrete post																		
M2	Upgrade manual gauge to automatic (surface water level)																		
M3	Upgrade manual gauge to automatic (groundwater level)																		
M4	Upgrade manual gauge to automatic (rainfall)																		
M5	Installation of Dedicated Boreholes for Groundwater Monitoring																		
M6	Installation/Rehabilitation of River Gauging Stations																		
M7	Installation/Rehabilitation of Rainfall Gauging Stations																		
M8	Flood Discharge Measurement Equipment (Each SRO)																		
(2)	Evaluation																		
E1	Hydromet DB Upgrade (Software + Hardware)																		
E2	Establishment of additional Water Quality Test Laboratory in Mombasa																		
(3)	Permitting																		
P1	PDB Upgrade (Software + Hardware)																		
(4)	Watershed Conservation																		
W1	Forestation (Gazetted Forest Area)																		
W2	Forestation (Non-gazetted Forest Area)																		
Recurrent Activities																			
(1)	Monitoring																		
M1	Surface Water Level Monitoring																		
M2	River Discharge Measurement																		
M3	Groundwaer Level Monitoring																		
M4	Rainfall Monitoring																		
M5	Flood Discharge Measurement																		
M6	Surface Water Quality Monitoring																		
M7	Groundwater Quality Monitoring																		
(2)	Others																		
O1	Catchment Forum Operation (Venue and Allownce to WURAs)																		

Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 7.3.6 Implementation Schedule of Proposed Water Resources Management Plan (ACA)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

Flood Disaster Management Plan

WRMA Catchment	No.	Description	2013 13/14	2014 14/15	2015 15/16	2016 16/17	2017 17/18	2018 18/19	2019 19/20	2020 20/21	2021 21/22	2022 22/23	2023 23/24	2024 24/25	2025 25/26	2026 26/27	2027 27/28	2028 28/29	2029 29/30	2030 30/31	Remarks
			Implementation Schedule																		
			Short Term					Medium Term					Long Term								
Athi	A1	Downmost Athi (Kilifi, Lower Sabaki)																			
		A1.1 Establishment of Community-based Flood Management System																			
	A2	Lumi River (Taveta)																			
		A2.1 Construction of Multipurpose Dam																			Lake Chala Dam
		A2.2 Establishment of Community-based Flood Management System																			
	A3	Nairobi City																			
		A3.1 Implementation of Urban Drainage Measures																			
	A4	Kwale (Vanga)																			
		A4.1 River Training Works					F/S														
		A4.2 Preparation of Hazard Map																			
	A5	Mombasa																			
		A5.1 Implementation of Urban Drainage Measures																			

Note: Construction Schedule for River Training Works (to be determined in the Feasibility Study)

Drought Disaster Management Plan

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

Legend: Establishment Update / Expansion

Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 7.3.7 Implementation Schedule of Proposed Flood and Drought Disaster Management Plan (ACA)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

WRMA Catchment	No.	Name of Project	Target	Related Project (Dams and Irrigation)	Implementation Schedule																	
					Short Term					Medium Term					Long Term							
					2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
					13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29	29/30	30/31
Athi	1	Setting of Environmental Flow	Ahti River	Ruiru-A, Thwake, Kikuyu, Kiambaa, Upper Athi, Munyu, Kiteta, Mbuuni, Olkishunki, and Ndarugu Dams			Set															
			Lumi River	Lake Chala Dam				Set														
			L. Jipe	Lake Chala Dam					Set													
	2	Environmental Monitoring	Athi River	Ruiru-A, Thwake, Kikuyu, Kiambaa, Upper Athi, Munyu, Kiteta, Mbuuni, Olkishunki, and Ndarugu Dams																		
			Nairobi River	-																		
			Lumi River	Lake Chala Dam																		
			L. Chala	-																		
			L. Jipe	Lake Chala Dam																		
			Nairobi City	-																		
			Mombasa City	-																		

(grey bar)	Environmental Survey for Setting Environmental Flow
Set	Setting of Environmental Flow (including Key Stakeholder Meeting)
(black bar)	Environmental Monitoring (including Planning)

Source: JICA Study Team

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 7.3.8
Implementation Schedule of Proposed Environmental Management Plan (ACA)

Part F
Tana Catchment Area

Location Map (TCA)

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

FINAL REPORT
VOLUME - III MAIN REPORT (2/2)

PART F: TANA CATCHMENT AREA

Location Map
Abbreviation

<u>Table of Contents</u>

List of Tables

List of Figures

List of Abbreviations and Acronyms

ALRMP	:	Arid Land Resources Management Project
ASAL	:	Arid and Semi-arid Land
B/C	:	Benefit and Cost
BOD	:	Biochemical Oxygen Demand
CBDM	:	Community-based disaster management
COD	:	Chemical Oxygen Demand
D/D	:	Detailed Design
DO	:	Dissolved oxygen
EIRR	:	Economic Internal Rate of Return
F/S	:	Feasibility Study
JICA	:	Japan International Cooperation Agency
KenGen	:	Kenya Electric Generating Company
KMD	:	Kenya Meteorological Department
LCPDP	:	Least Cost Power Development Plan
LSRWSS	:	Large Scale Rural Water Supply System
LVN	:	Lake Victoria North
LVNCA	:	Lake Victoria North Catchment Area
LVS	:	Lake Victoria South
M/P	:	Master Plan
MDNKOAL	:	Ministry of State for Development of Northern Kenya and Other Arid Lands
MORDA	:	Ministry of Regional Development Authority
MWI	:	Ministry of Water and Irrigation
NRW	:	Non-Revenue Water
NWCPC	:	National Water Conservation and Pipeline Corporation
NWMP	:	National Water Master Plan
O&M	:	Operation and Maintenance
RV	:	Rift Valley
SS	:	Suspended Solids
SSRWSS	:	Small Scale Rural Water Supply System
TARDA	:	Tana and Athi River Development Authority
TCA	:	Tana Catchment Area
UC	:	Urban Centre
WASREB	:	Water Services Regulatory Board
WRM	:	Water Resources Management
WRMA	:	Water Resource Management Authority
WRUA	:	Water Resources Users Association
WSB	:	Water Service Board
WSC	:	Water Service Company / Water and Sewerage Company
WSP	:	Water Service Provider
WWTP	:	Waste Water Treatment Plant

Abbreviations of Measures

Length

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

Area

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

Volume

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

Weight

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

Time

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

Money

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

Energy

kcal	=	Kilocalorie
kW	=	kilowatt
MW	=	megawatt
kWh	=	kilowatt-hour
GWh	=	gigawatt-hour

Others

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

NOTE

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

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

3. Information to be updated

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

   (1) Information on the proposed development projects

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

   (2) Information on the water demand

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

4. Exchange rate for cost estimate

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

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

CHAPTER 1 INTRODUCTION

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

This volume, Main Report Part F, presents the water master plan for the Tana Catchment Area (TCA). The water master plan for TCA consists of the following eight component plans as mentioned in Chapter 7 of the Main Report Part A.

<u>Development plans</u>

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

<u>Management plans</u>

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

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

CHAPTER 2 CATCHMENT CHARACTERISTICS

TCA is located in the south-eastern part of the country. TCA borders the Ewaso Ng'iro North Catchment Area (ENNCA) in the north, Somalia and Indian Ocean in the east, TCA in the southwest and the Rift Valley Catchment Area (RVCA) in the west. Mt. Kenya and the Aberdare Range of the Five Water Towers lie in the western edge of the area. The total area of TCA is 126,026 km^2, corresponding to 21.9% of Kenya's total area. Based on the Census 2009, the population of the area in 2010 was 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 altitude of Mt. Kenya peak of 5,199 m above mean sea level (amsl) to the coastal strip of less than 50 m amsl. The area is roughly divided into three zones, namely, upper zone of more than 1,000 m amsl, middle zone of 300 m to 1,000 m amsl, and lower zone below 300 m amsl.

The Tana River is the largest river in the area and 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 the total gross storage of the reservoirs is 2,331 MCM. They play an important role to meet about 40% of the total annual energy production in the country. After flowing through these reservoirs, the Tana River flows northeastward and then gradually changes its direction to the east. After crossing Garissa Bridge, the Tana River flows southward and pours 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.

In 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 Somali (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), while the central and coast areas as a semi-arid land, and the rest as arid land. The mean annual rainfall ranges between 500 mm in the northeastern 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 by precipitation minus evapotranspiration was estimated at 13.6 BCM/year in 2010 for TCA and the per capita renewable water resources was calculated at 2,369 m^3/year/capita.

The major cities and towns in TCA are Garissa, Thika, Karuri, Nyeri, Embu, Meru, Muranga, and Kitui. The catchment area includes the whole area of Muranga, Kirinyaga, Embu, Tharaka, Kitui, Tana River, and Lamu, parts of Nyeri, Garissa, Kiambu, Machakos, and Nyandarua counties.

Thika, the largest city in TCA, has various kinds of industries such as brewing and beverages, food processing, leather, steel, tea processing, textile, printing, tobacco, car, and light engineering. In Embu, coffee processing is famous.

CHAPTER 3 WATER RESOURCES, WATER DEMANDS AND WATER ALLOCATION

3.1 General

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

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

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

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

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

3.2 Available Water Resources

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

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
Percentage of 2010 values	124%	84%	120%

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

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

The above table shows that the 2030 surface water runoff will increase to 124% of 2010 runoff, while the 2030 sustainable yield of groundwater will decrease to 84% of 2010 yield, both due to climate change impacts, resulting in an increase of 2030 available water resources to 120% of 2010 resources.

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

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

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

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

Water Demands by Subsector (TCA)

(Unit: MCM/year)

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 A, Section 6.10 and Setoral Report (G), Sub-section 3.3.1 (3))

The total projected water demands of 8,241 MCM/year in 2030 is approximately 9.2 times of the present water demand of 891 MCM/year mainly due to increase in population from 5.73 million to 10.37 million and irrigation areas from 64,425 ha to 546,875 ha mentioned in Chapter 6 of the Main Report Part A. Monthly water demands in 2030 by sub-basin are shown in Table 3.3.1.

3.4 Proposed Water Allocation Plan

(1) Water Balance Study

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

Available Water Resources and Water Demands (TCA)

(Unit: MCM/year)

2010			2030		
Water Resources	Water Demands	Percentage	Water Resources	Water Demands	Percentage
6,533	891	14%	7,828	8,241	105%

Source: JICA Study Team

Although the present water demands in 2010 are estimated to be 14% of the available water resources, the water demands for 2030 are expected to increase drastically up to 105% of the available water resources in 2030. The ratio of 105% of water demand to water resources, which is called a water stress ratio, indicates severe situation in the water balance compared with the ratio of 40% regarded to indicate severe water stress.

In order to examine in more detail the situation of future water balance from the spatial and temporal perspectives, a surface water balance study for 2030 was carried out. Since the surface water demands occupy more than 80% of the total demands nationwide, it was judged that the surface water balance would give general situation of water deficits. The catchment area was divided into 39 sub-basins and a study model was applied with the existing dams and water transfers only as discussed in Section 6.11 of the Main Report Part A. Conditions of the water balance study are described in Subsection 4.6.3 of this report and detailed in Chapter 4 of the Sectoral Report (G).

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

Water Demands and Water Deficits (TCA)

(Unit: MCM/year)

2010			2030		
Water Demands	Water Deficits	Percentage	Water Demands	Water Deficits	Percentage
891	336	38%	8,241	5,822	71%

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

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

(2) Modified Future Water Demands

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

The modified water demands are summarised below.

Modified Water Demands Projections for 2030 (TCA)

(Unit: MCM/year)

Year	Domestic	Industrial	Irrigation	Livestock	Wildlife	Fisheries	Total
2030	343	42	2,697	69	1	16	3,168

Source: JICA Study Team

The projected demand following Kenya Vision 2030 in Section 3.3 was reduced to 3,168 MCM/year by reducing the irrigation water demand corresponding to the irrigation area reduction to 226,224 ha.

(3) Proposed Water Allocation Plan

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

Water Resources Allocation Plan in 2030 (TCA)

(Unit: MCM/year)

Subsector	Water Demand	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. Setoral Report (G), Sub-section 4.4.3 (3))

The total amount of allocated surface water is 2,956 MCM/year, which is about 93% of the total water demand and about 41% of the available surface water resources. The total amount of allocated groundwater is 212 MCM/year, which is about 7% of the total water demand and about 37% of the available groundwater resources. The above percentages in terms of water resources imply that the water balance situation in 2030 is expected to be almost severe or severe judging from the water stress ratio.

The above allocation plan should be considered as a guide in the water resources management in TCA.

CHAPTER 4 DEVELOPMENT AND MANAGEMENT PLANS

4.1 General

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

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

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

4.2 Water Supply Development Plan

4.2.1 Current Situation of Water Supply

As shown in Section 3.2 of Main Report Part A, the current population of TCA as of 2010 is estimated to be 5.73 million including 1.04 million of urban population and 4.70 million of rural population. The urban population ratio is relatively low, so there is comparatively low growth in population as compared with other catchment areas. Based on the data of Census 2009, the current situation of water connection in TCA is estimated 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 unimproved drinking water sources. Around 41% of the population get drinking water from such unimproved drinking water sources. Also, around 25% of the population get water from springs, wells, and boreholes. Unprotected wells and springs are categorised as an unimproved drinking water sources as well, but the utilisation ratio of the unprotected sources is unknown.

It is projected that the urban population will increase by 5.30 million while the rural population will decrease by 0.66 million in 2030 as shown in Section 3.2 of Main Report Part A. Hence, the total population is expected to reach 10.37 million in 2030 as shown below.

Projected Population (TCA)

(Unit: million persons)

Year	Urban population	Rural Population	Total
2010	1.04	4.69	5.73
2030	6.34	4.03	10.37

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

Currently, the piped water supply covers 58% of the urban population of TCA. The ratio is relatively high. Large scale urban water supply system developments have been under implementation to meet future water demand. It can be said that water supply system development is well advanced in TCA.

Table 4.2.1 shows the current situations of the seven urban water service providers (WSPs) and seventeen rural WSPs, of which total water supply capacity is 232,000 m^3/day. According to the Performance Report of Kenya's Water Services, No.4, 2011, the registered 11 urban WSPs and 18 rural WSPs carry out water supply services, and the total water supply capacity is 240,358 m^3/day for a service population of 1.41 million The average water supply volume per person is 170 L/p/day including non-revenue water (NRW). It is higher than the national average of urban water supply volume of 65 L/p/day including NRW (36 L/p/day excluding NRW). Out of the 11 urban WSPs, four WSPs have records of more than 50% of NRW.

It should be noted that the water supply capacity of the rural WSPs is 130,972 m^3/day, which is larger than the capacity of the urban WSPs.

4.2.2 Development Strategy

TCA is divided into three areas, namely, the upper Tana, arid area, and the other area for urban water supply system (UWSS) planning considering the characteristics of these three areas.

Characteristics of the Areas (TCA)

Catchment Areas	Features
Tana River Upstream	Out of the 19 urban centres in TCA, there are 15 urban centres in this area. It is estimated that the population is around 60% of the total population in 2030. There are many available water sources, such as surface water of the rivers from Mt. Kenya. The water supply development plan in this area will be considered in the existing plan on surface water use.
Arid Area	Out of the 3 urban centres in the arid area, there are two urban centres supplied by Tana River in this area. Ground water is used for rural water supply system in the arid area, while surface water is used for the water supply system in the area along Tana River.
Other Area	This is outside the abovementioned two areas. There are four urban centres, which plan to use surface water on a priority basis. As for the rural water supply, it is planned to use groundwater on a priority basis.

Source: JICA Study Team

Based on the overall concept mentioned in Section 7.3 of the Main Report Part A, UWSS are planned for 23 urban centres (UCs) in TCA. The water supply capacity required for UWSS in TCA is 543,000 m^3/day in 2030 against the current water supply capacity (including those under construction) which is 106,000 m^3/day. Therefore, an additional capacity of 437,000 m^3/day is to be developed by 2030 through the following projects:

a) Rehabilitation of the existing UWSS

In order to achieve 20% of the NRW ratio, water meters will be installed for all households and existing old pipes of UWSS of 15 UCs, which have a water supply capacity of 106,000 m^3/day will be replaced. In addition, the rehabilitation includes replacement and repair of mechanical and electrical equipment in water treatment plants and pumping stations.

b) Expansion of UWSS

The expansion of UWSS is planned for 14 UCs in the above 15 UCs to meet the water demand in 2030. The total expansion capacity is 349,000 m^3/day and will cover three cities which have no UWSS.

c) Construction of new UWSS

The construction of new UWSS is planned for eight UCs, which have no UWSS. The new construction will provide an additional 88,000 m^3/day.

d) Incorporation of existing plans

According to data from WSBs, there are 10 plans of water supply development projects to cover 18 UCs and surrounding areas, which have 880,000 m^3/day of total water supply capacity. (Refer to Sectoral Report (C), Section 2.4) The planned capacity could cover around two times of the development capacities required in 2030. It seems to be excessive capacity, comparing with the water demand forecast in the Study. The required scales of the projects are to be revised based on the overall concept mentioned in Section 6.3.

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

a) Development of LSRWSS

LSRWSS is proposed mainly in areas with high population density or areas with difficulties extracting groundwater for personal or community use. LSRWSS will be developed for 1.74 million residents in 16 counties under TCA.

b) Development of SSRWSS

SSRWSS is proposed for 2.72 million residents in 16 counties under TCA, and includes the construction and improvement of boreholes, wells, and springs for personal and community use, which will be implemented by individuals or communities.

4.2.3 Proposed Water Supply Development Plan

The proposed UWSS is presented in Table 4.2.2, and the proposed LSRWSS and SSRWSS are shown in Tables 4.2.3 and 4.2.4, respectively. The proposed water supply development plan for TCA is outlined below.

Proposed Water Supply Development Plan (TCA)

Type of Project		Target Area	Target Capacity (m^3/day)	Target 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 based on Tables 4.2.2 to 4.2.4.

Through the above water supply development plan, the water supply situation of TCA in 2030 will be 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 referred to Sectoral Report (C), Section 2.3. Figures for 2030 were based on Tables 4.2.2 to 4.2.4.)

In order to ensure water sources required for the water supply systems mentioned above, it is proposed to construct four new dams and one new intra-basin water transfer system and also expand two existing water transfer systems, as the result of the water balance study. (Ref. Sectoral Report (G), Chapter 4.8)

4.3 Sanitation Development Plan

4.3.1 Current Situation of Sanitation Development

Based on Census 2009, the current situation of access to sanitation facilities in TCA is estimated 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 the current sewerage coverage ratio is only 2%. There are six small-scale waste water treatment plants in six UCs located in Thika, Nyeri, Muranga, etc., of which total treatment capacity is about 32,343 m^3/day. Around 87% of the population use on-site sanitation facilities such as septic tanks. The on-site sanitation facilities include unimproved ones, and the ratio of the unimproved facilities is unknown. Around 11% of the population do not have any treatment facilities, and resort to unsanitary waste disposal.

4.3.2 Development Strategy

Based on the overall concept and framework for planning described in Section 7.4 of the Main Report Part A, the sewerage system development is planned for 18 UCs in TCA. The sewerage system development will be implemented through three types of projects as follows:

a) Rehabilitation of existing sewerage system

The rehabilitation includes repair and replacement of the mechanical and electrical equipment of wastewater treatment plants (WWTPs) and pumping stations and replacement of damaged 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 the existing sewerage systems of six UCs will be expanded. These include expansion and new construction of sewerage pipes, pumping stations, and WWTPs. The expansion will provide an additional capacity of 118,000 m^3/day.

c) Construction of New Sewerage System

There are no sewerage systems in 12 UCs. New sewerage systems will be constructed in these UCs that will provide an additional capacity of 248,000 m^3/day.

d) Incorporation of existing plans

According to data from WSBs, there are 11 plans of sewerage development projects to cover 12 urban centres, which have 98,000 m^3/day of total treatment capacity. (Refer to Sectoral Report (D), Section 2.4) These plans are to be incorporated in NWMP 2030.

For those outside the sewerage service area, the improved on-site treatment facilities will be provided for the remaining 5.88 million residents in 2030. Currently, 5.08 million residents (or 87% of the entire population) are using the existing on-site treatment facilities, while unimproved ones will be improved with new housing. Development of on-site sanitation facilities is planned for 16 counties in TCA.

4.3.3 Proposed Sanitation Development Plan

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

About 82% of the 6.34 million of the urban population in TCA are expected to be covered by the sewerage system. The ratio of TCA is higher than the national target of 80%, because there are not many large-scale UCs prioritised in the sewerage system development. With the above sanitation development plans, 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 above are referred to Sectoral Report (D), Section 2.3, and figures for 2030 above are based on Tables 4.3.1 and 4.3.2.)

4.4 Irrigation Development

4.4.1 Current Situation of Irrigation Development

The Tana River is the largest river in Kenya. Upstream of the Tana River is highland and is densely populated. The lowland area in TCA is huge unused flat lands with an arid or semi-arid climate. The total cropping area in TCA in 2011 was 1.0 million ha. The existing irrigation area in TCA was 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 was 6.4%. Existing public irrigation systems, especially pumping schemes, have deteriorated due to the lack of budget for repair and maintenance for a long time.

4.4.2 Development Strategy

Following the overall concept and framework for irrigation development mentioned in Section 7.5 of the Main Report Part A, the strategy for irrigation development in TCA 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 areas. Furthermore, irrigation weir, small-scale dam irrigation, and groundwater irrigation should be developed where water resources are available;

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

4.4.3 Proposed Irrigation Development Plan

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

Proposed Irrigation Areas in 2030 (TCA)

(Unit: ha)

Category	Existing Irrigation Area in 2010	New Irrigation Area in 2030						Total Irrigation Area in 2030
		Surface Water Irrigation			Ground-water Irrigation (Borehole)	Water Harvesting Irrigation (Small Dam/ Water Pan)	Total New Irrigation Area	
		Weir	Dam	Total				
Large-scale	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. Sectoral Report (E), Section 3.4)

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 7.5 of the Main Report Part A, 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 4.6 due to limitation of available water resources.

As for 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 7.5.1 were taken up for the water balance study, and four projects were selected for implementation by 2030 as suitable projects to contribute to the maximisation of irrigation area in TCA as shown in Table 4.4.1 and their locations are shown in Figure 4.4.1. They are listed as below.

a) High Grand Falls Dam Irrigation Project (106,000 ha, High Grand Falls multipurpose dam);

b) Hola Pump Irrigation Extension Project (800 ha, Weir and pump);

c) Hola Irrigation Greater Extension Project (4,161 ha, Weir); and

d) Kora Dam Irrigation Project (25,000 ha, Kora multipurpose dam).

The irrigation water demands necessary for the abovementioned new irrigation projects were estimated at 2,546 MCM/year for surface irrigation area and 151 MCM/year for groundwater irrigation area as shown in Table 6.5.7 in the Main Report Part A.

4.5 Hydropower Development Plan

4.5.1 Current Situation of Hydropower

(1) Existing Hydropower Station

There are five major power stations in the catchment area in the upstream reach of Tana River, namely, Masinga, Kamburu, Gitaru, Kindaruma, and Kiambere. The total installed capacity of these five power stations is 567.2 MW, which consists of 37% of the total installed capacity in the country. In terms of power generation, these five power stations are in charge of the total 40% power generation in the country.

There are also small hydropower stations farther in the upstream areas of these five major power stations, namely, Sagana, Mesco, Wanji, and Tana power stations. The locations of these existing hydropower stations are shown in Figure 4.5.1.

(2) Multipurpose Dam Development Project by Tana and Athi Rivers Development Authority (TARDA)

There is a multipurpose dam development project proposed by TARDA, namely, High Grand Falls Dam. According to the feasibility study report prepared by MORDA in February 2011, the High Grand Falls Dam was designed for water supply, irrigation, flood control, and hydropower development. The hydropower component of the High Grand Falls Dam has an installed capacity of 500 MW in Stage I (2018-2027) and an additional 200 MW in Stage II of the project.

4.5.2 Development Strategy

Following the overall planning concept and framework discussed in Section 7.6 of the Main Report Part A, the following three strategies are applied for development:

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

Of the above strategies, the development strategies for TCA will be as follows:

c) LCPDP projects: There are three projects proposed in LCPDP, namely, the upgrade of Kindaruma Hydropower Station, Mutonga Hydropower Project, and Low Grand Falls Hydropower Project. The upgrade of Kindaruma Hydropower Station is under construction and is expected to be completed by 2014. By upgrading, Kindaruma will have 32 MW installed capacity in addition to the existing 40 MW. The Mutonga (60 MW) and Low Grand Falls (140 MW) Hydropower projects are scheduled for construction, however, according to TARDA, these schemes will be replaced by the High Grand Falls Multipurpose Dam Project, which will have an installed capacity of 500 MW for Stage 1 (2018-2027) and an additional 200 MW for Stage 2 (after 2027). This information was confirmed with the Ministry of Energy, and will be reflected in the next update of the LCPDP.
d) Multipurpose dam development schemes: As mentioned above, there is one multipurpose dam scheme proposed which is the High Grand Falls Dam.

e) In addition to the above, KenGen has a plan to develop Karura Hydropower Project, which utilises the remnant head between Kindaruma and Kiambere Hydropower stations with an installed capacity of 90 MW.

4.5.3 Proposed Hydropower Development Plan

Based on the development strategy in Subsection 4.5.2, the following hydropower development plans will be taken up in NWMP 2030.

(1) High Grand Falls Multipurpose Dam

As one of the proposed multipurpose dam projects by MORDA, the High Grand Falls Dam is considered as a candidate project of NWMP 2030. The High Grand Falls is planned in the upstream reach of Tana River about 45 km downstream of the existing Kiambere Dam. According to the feasibility study report in February 2011, the High Grand Falls Dam is planned to have an installed capacity of 500 MW for Stage 1 and additional 200 MW for Stage 2.

(2) Karura Hydropower Project

KenGen is currently carrying out the feasibility study for Karura Hydropower Project. Karura Hydropower Project is planned to utilise the remnant head between Kindaruma Hydropower Station and Kiambere Reservoir. The Karura Hydropower Project is expected to have an installed capacity of 90 MW. According to KenGen the feasibility study is expected to be completed by January 2013, and expected to be commissioned in 2018.

The following table shows the summary of the development projects in TCA.

Proposed Hydropower Development Projects (TCA)

No.	Name of Scheme	Installed Capacity (MW)	Purpose	Source of Information
1	High Grand Falls Multipurpose Dam	Stage1: 500 Stage 2: +200	Water Supply, Irrigation, Hydropower	MORDA
2	Kindaruma Upgrade	+32	Hydropower	KenGen
3	Karura Hydropower	90	Hydropower	KenGen
	Total	60		

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

Locations of the proposed hydropower development projects are shown in Figure 4.5.2.

4.6 Water Resources Development Plan

4.6.1 Current Situation of Water Resources Development

TCA has a total catchment area of 126,026 km^2 and an annual average rainfall of 840 mm which is between rather rich rainfall of around 1,300-1,400 mm in the 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 reach area of the Tana River to 1,400 mm in the western mountainous area. The main river in TCA is the Tana River. The available water resources estimated in TCA for 2010 (present) are 5,858 MCM/year for surface water and 675 MCM/year for groundwater.

The present water demands in TCA were estimated to be 891 MCM/year based on the population of 5.73 million and an irrigation area of 64,425 ha as presented in Chapter 3. The existing water resources structures and facilities except for direct intake facilities from rivers that satisfy the present water demands are listed below. The locations of the dams and water transfers are shown in Figure 4.6.1.

Existing Water Resources Structures and Facilities (TCA)

Existing Structures/ Facilities	Name of Structures/ Facilities	Purposes	Notes
Dam	SasumuaDam	Domestic water supply to Nairobi	Storage volume of 16 MCM
Dam	Thika Dam	Domestic water supply to Nairobi	Storage volume of 69 MCM
Dam	Masinga Dam	Hydropower (40 MW), domestic water supply	Storage volume of 1,402 MCM
Dam	Kamburu Dam	Hydropower (94 MW)	Storage volume of 110 MCM
Dam	Gitaru Dam	Hydropower (225 MW)	Storage volume of 20 MCM
Dam	Kindaruma Dam	Hydropower (44 MW)	Storage volume of 16 MCM
Dam	Kiambere Dam	Hydropower (168 MW), domestic water supply	Storage volume of 585 MCM
Intra-basin Water Transfer	From Kiambere Dam	Domestic water supply to Mwingi	0.5 MCM/year
Intra-basin Water Transfer	From Masinga Dam	Domestic water supply to Kitui	3 MCM/year
Inter-basin Water Transfer	From Sasumua Dam	Domestic water supply to Nairobi	21 MCM/year
Inter-basin Water Transfer	From Thika Dam	Domestic water supply to Nairobi	161 MCM/year
Small Dam/Water Pan	Total No. = 622	Domestic and livestock water supply mainly, partly for irrigation	Total storage volume of 26.9 MCM, average volume per facility of 43,000 m^3
Borehole	Total No. = 1,587	Domestic water supply mainly	Total abstraction volume of 68 MCM/year

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

The total storage volume of existing water resources structures and facilities in TCA is approximately 2,277 MCM summing the volumes of dams and small dams/ water pans listed in the above table. Out of the 26 existing dams nationwide as described in Chapter 2 of the Sectoral Report (G), there are seven large-scale dams, among which the Sasumua and Thika dams are for the domestic water supply in Nairobi, and the Masinga, Kamburu, Gitaru, Kindaruma, and Kiambere dams are for hydropower generation purposes (the Masinga and Kiambere dams also have the function to supply domestic water).

The Umaa Dam is under construction and will be for domestic water supply (with a storage volume of 1 MCM). The detailed designs of Thiba Dam (irrigation water supply), High Grand Falls Dam (hydropower, domestic and irrigation water supply, and flood control), and Yatta Dam (domestic water supply) have been completed. The water resources structures that are under planning and/or design in the catchment area are Maragua 4, Karimenu 2, and Thika 3A dams (for domestic water supply), and Komu Transfer Scheme to supply domestic water to Nairobi.

There are 622 small dams/water pans with total storage volume of 26.9 MCM, which is 1% of the total storage volume in the catchment area. There are a total of 1,587 boreholes in the catchment area, which is approximately 13% of the national total of 12,444 boreholes (MWI). These boreholes supply around 47% of the domestic water demands in TCA.

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. The water supply reliability of 1/1, 1/2 or 1/7 means that the present water demands are satisfied with the available water resources with existing water resources structures under drought condition with probability of once in 1, 2 or 7 years.

4.6.2 Development Strategy

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

Present and Future Water Demands (TCA)

(Unit: MCM/year)

Subsector	Present Water Demand (2010)	Future Water Demand (2030)
Domestic	146	343
Industrial	5	42
Irrigation	696	2,697
Livestock	34	69
Wildlife	1	1
Fisheries	9	16
Total	891	3,168

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

The water demand projections for 2030 show an increase by about 3.6 times as compared with the present demand records due to considerable expected increase in population to about 10.37 million and irrigation areas to 226,224 ha as mentioned in Chapter 6 of the Main Report Part A.

Judging from the estimated 2030 water deficits discussed in Section 3.4 (1), it is certain that the existing water resources structures/facilities will not be able to satisfy the great increase in water demand in 2030, therefore, new structures and facilities are required to be developed. As the estimated available 2030 surface water of 7,261 MCM/year is far larger in amount than the groundwater of 567 MCM/year in the catchment area, the development will focus on the surface water. However, surface water is available mostly in the western hilly area of the catchment area while in the eastern area the surface water is scarce. Therefore, the water resources development on the eastern side of the catchment area needs to rely on groundwater.

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

a) Inter-basin water transfer facilities from dams located in the most upstream of the catchment area to ACA will be developed to supply domestic water to Nairobi and satellite towns where heavily concentrated domestic water demands are expected in 2030, however, both surface water and groundwater resources are insufficient. The volume of water transferred from these dams to ACA is included in the water demands mentioned in Sub-section 4.6.2 of the Main Report Part E for ACA.

b) Dam development is essential and will be promoted in the western part of the catchment area where a sharp increase in future large water demands such as domestic, industrial and irrigation water demands are expected in 2030. Candidates of the dam development projects for maximising surface water abstraction include in principle i) dams proposed by the NWMP (1992), and ii) dams being designed and planned by the government including the Kenya Vision 2030 flagship projects.

c) High Grand Falls Dam will 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 will be included in the development plan for water supply from Masinga Dam to Kitui and from Kiambere Dam to Mwingi.

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

f) The available groundwater is abundant in the western part of the catchment area and in the middle reach of the Tana River. The groundwater is to be exploited where the surface water is not available or insufficient.

4.6.3 Proposed Water Resources Development Plan

(1) Water Balance Study

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

The water balance study followed the policies of the water allocation as stated in Section 7.2 of the Main Report Part A. A summary of which are tabulated as follows

Prioritisation of Water Allocation

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

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

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

Conditions of the surface water balance study are discussed in Section 4.3 of the Sectoral Report (G) and summarised as follows: i) the model consists of 39 sub-basins, water demand points, existing water resources infrastructures, and candidates for future development such as dams and water transfer facilities; ii) monthly mean values of the naturalised water resources and demands are applied; iii) the amount of the reserve is determined as 95% value of the naturalised present daily flow duration curve in Figure 4.6.4 with the probability of once in 10 years as shown in Table 4.6.3; and iv) return flow rates of 25%, 5%, and 100% for urban domestic water supply, paddy irrigation, and hydropower generation are applied.

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

(2) Proposed Water Resources Development Plan

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

1) Dams

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

Proposed Dams (TCA)

(Unit: MCM)

Name of Dams	Storage Volume for Domestic/ Industrial	Storage Volume for Irrigation	Storage Volume for Hydropower	Flood Control Space	Total Storage Volume	Remarks
Maragua 4 Dam	33.0	0.0	0.0	0.0	33.0 *	F/S and M/P ongoing (AWSB)
Ndiara Dam	12.0	0.0	0.0	0.0	12.0	
Chania-B Dam	49.0	0.0	0.0	0.0	49.0	
Karimenu 2 Dam	14.0	0.0	0.0	0.0	14.0 *	F/S and M/P ongoing (AWSB)
Thika 3A Dam	13.0	0.0	0.0	0.0	13.0 *	F/S and M/P ongoing (AWSB)
Yatta Dam	35.0	0.0	0.0	0.0	35.0 *	D/D completed (NWCPC)
Thiba Dam	0.0	11.2	0.0	0.0	11.2 *	Flagship Project, D/D completed (NIB)
High Grand Falls Dam	(291.0)	(3,251.0)	3,542.0	1,458.0	5,000.0 *	Flagship Project, D/D completed (MORDA)
Kora Dam	0.0	537.0	0.0	0.0	537.0	Flagship Project
Mutuni Dam	17.0	0.0	0.0	0.0	17.0	
Kitimui Dam	8.0	0.0	0.0	0.0	8.0	
Total	181.0	548.2	3,542.0	1,458.0	5,729.2	

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

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

The respective total storage volumes of Maragua 4, Karimenu 2, Thika 3A, Yatta, Thiba and High Grand Falls dams followed the completed detailed designs, or ongoing feasibility studies and master plans as mentioned in the above table.

The storage volume of hydropower use for High Grand Falls Dam was estimated by summing the volumes of estimated domestic/industrial and irrigation use. Water for domestic/industrial and irrigation use will be supplied from High Grand Falls Dam after hydropower generation.

The flood control space of High Grand Falls Dam was estimated by subtracting the volume of hydropower use from the total storage volume proposed byMORDA, as a space in which floods can be stored.

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

2) Water Transfers

The proposed amounts of intra-basin water transfers from Masinga Dam to Kitui and from Kiambere Dam to Mwingi as mentioned below were derived from the water balance study as the amount to meet domestic water demands in Kitui and Mwingi. The amount of intra-basin water transfer from High Grand Falls Dam to Lamu followed the transfer amount designed by MORDA. The amount of inter-basin water transfer from TCA to Nairobi followed designs of AWSB.

Proposed Water/Transfers (TCA)

(Unit: MCM/year)

Structures	Amount for Domestic	Total Water Transfer Amount	Remarks
Intra-basin Water Transfer from Masinga Dam to Kitui (Extension)	23	23	
Intra-basin Waer Transfer from Kiambere Dam to Mwingi (Extension)	2	2	
Intra-basin Water Transfer from High Grand Falls Dam to Lamu	69	69	(equivalent to 189,000 m^3/day), MORDA
Inter-basin Water Transfer from TCA to Nairobi in ACA (Extension)	168	168	(AWSB)

Source: JICA Study Team based on M/P and F/S by AWSB (2012) and MORDA

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

3) Small Dams/Water Pans

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

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

Proposed Small Dams/Water Pans (TCA)

(Unit: MCM)

Structures	Volume for Domestic	Volume for Irrigation	Volume for Livestock	Volume for Wildlife/ Fisheries	Total Storage Volume	Remarks
Small Dam/Water Pan	26	39	69	17	151	Total No. of small dams/ water pans = 3,020

Note: Excluding the storage volume of the existing small dams and water pans of 27 MCM.
Source: JICA Study Team

The total number of the small dams / water pans of 3,020 was estimated by applying the volume per dam/ pan of 50,000 m^3 as the minimum capacity following the volume applied in NWMP (1992) and assumed based on the existing volumes.

4) Boreholes

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

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

Proposed Boreholes (TCA)

(Unit: MCM/year)

Facilities	Volume for Domestic/Industrial	Volume for Irrigation	Total Abstraction Volume	Remarks
Borehole	0	144	144	Total No. of boreholes = 1,440

Note: Excluding the 68 MCM/year abstraction of existing boreholes.
Source: JICA Study Team

The total number of the boreholes of 1,440 was estimated by applying the capacity per borehole of 100,000 m^3/year assumed based on the existing data.

(3) Evaluation of Proposed Water Resources Development Plan

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

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

Water Supply Reliability at Reference Point (TCA)

Reference Point	Present (2010) Water Supply Reliability	Future (2030) Water Supply Reliability
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. Sectral Report (G), Sub-section 4.4.3 (3) and Table 4.4.4)

The future water supply reliability at the reference points of Tana Rukanga in Upper Tana River and Thika in Thika River is estimated at 1/10, since water demand downstream of the reference points is domestic use only. The future water supply reliability at the reference point of Garissa in Lower Tana River is estimated at 1/5, since water demand downstream of the reference point is mainly irrigation use.

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

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

4.7 Water Resources Management Plan

4.7.1 Current Situation of Water Resources Management

TCA is an area with Tana River (95,884 km^2) as its main river. There are two water supply dams (transfer to Athi Catchment Area) and five hydropower dams in the catchment. The middle reach of Tana River is a semi-arid area with relatively little rainfall. In the downstream area, it rains more as we go closer to the Indian Ocean.

TCA has the largest number of water permit applications among the six catchment areas of WRMA. In the future, as catchment population increases, it is anticipated that water demand and supply balance will be more critical.

The Water Resources Management Authority (WRMA) has its Tana River Catchment Area Regional Office in Embu. Under the regional office, there are five subregional offices as follows:

(i) Muranga that covers upper Tana in the western side which includes Thika, Chania, Mathioya, and Gura river systems that discharges into Masinga Reservoir;

(ii) Kerugoya that covers the middle of upper Tana in particular Thiba River system;

(iii) Meru that covers Upper Tana in the eastern side includes Mutonga, Kazita, Ura, and Rojiwero river systems;

(iv) Kitui that covers part of the middle and lower Tana in the western side including Tiva River systems which is seasonal, plus the lower reservoir areas including Kindaruma, Kamburu, and Kiambere reservoirs; and

(v) Garissa that covers the middle and lower part of TCA in the eastern side including the coastal zone.

Figure 4.7.1 shows the Management Unit Boundary and the Subregional Office Management Boundary.

The following table shows the current monitoring targets of WRMA, numbers of operational stations and their achievement ratio for surface water, groundwater, water quality, and rainfall. The achievement ratio of groundwater level, surface water quality, and groundwater quality monitoring stations are very low.

Current Monitoring Situations of Water Resource (TCA)

(Unit: nos)

Item	Surface Water (SW) Level	Groundwater (GW) Level	SW Water Quality	GW Water Quality	Rainfall
Target	43	41	45	41	35
Operational	30	14	18	14	25
Achievement (%)	70	34	40	38	71

Source: WRMA Performance Report 1 (July 2010)

The current situations on water permit issuance and management by WRMA are as shown below. The ratio of valid permits against issued permits in TCA is the lowest among the six catchment areas of WRMA, especially for surface water permits as shown below:

Current Situations of Water Permits (TCA)

(Unit: nos)

Item	Application	Authorised	Issued Permits	Valid Permits	Ratio of Validity (%)
Surface Water	6,434	3,436	1,622	239	15
Groundwater	1,710	1,057	145	68	47
Total	8,144	4,493	1,767	307	17

Source: WRMA Performance Report 1 (July 2010)

As for the watershed conservation of TCA, it is important to conserve Mt. Kenya and Aberdare Range of the Five Water Towers which are the major water sources of Tana River. The forest areas of Mt. Kenya and the Aberdare Range are relatively well maintained. However, deforestation and forest degradation are significant in the small gazetted forests in the upper reach of Tana River, in the private forests in the middle to lower reach on the right bank of Tana River, and in the low land area located about 50 km north of Lamu Town. According to the results of the satellite image analysis in this study[1], the forest area in TCA in 2010 was about 446,000 ha which corresponded to 3.5% of forest cover in TCA. The deforested areas during the last two decades were about 55,000 ha, which meant the decrease of about 11% of the forest areas in 20 years since 1990.

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

On the other hand, issues on soil erosion caused by deforestation and degradation of forest areas are the issues in TCA. As detailed information on soil erosion areas such as location, magnitude, water use, water quality, vegetation, and method of management are unknown, further study is required.

4.7.2 Management Strategy

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

(1) Monitoring

Monitoring strategies are described for five monitoring items of i) surface water level, ii) surface water quality, iii) groundwater level, iv) groundwater quality, and v) rainfall as discussed below:

1) Surface Water Level

The Tana River and its major tributaries were selected as representative rivers for capturing the runoff characteristics of the basin. As the current surface water level monitoring stations are concentrated in the upper reach and its tributaries, locations of these monitoring stations

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

should be reviewed so that the monitoring points would be the representative for each tributary. (Please refer to Figure 4.7.1).

2) Surface Water Quality

Surface water quality monitoring points were also selected from the representative rivers.

For the three rivers, monitoring points should be selected from those that are located downstream of pollution sources such as major cities and irrigation schemes. Such points should be monitored monthly.

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

3) Groundwater Level

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

4) Groundwater Quality

Groundwater quality is monitored at the same point as groundwater level monitoring.

5) Rainfall

The rainfall station density should be considered by climatic regions for arid, semi-arid or humid areas. In TCA, the eastern half of the catchment is an arid area. For this area, the criterion of one station in 8000 to 10,000 km^2 was applied in reviewing existing stations. The western part in the middle reach near Mwingi and Kitui is a semi-arid area. For this area, the criterion of one station in 3,000 to 5,000 km^2 was applied. The upper reach in the outskirt of Mt. Kenya and Aberdare Range is in a humid area. For this area, the criterion of one station in 500 to 1,000 km^2 was applied for the selection of rainfall monitoring stations.

(2) Evaluation

1) Water Resources Quantity Evaluation

The water resources quantity evaluation is conducted annually based on i) monitoring data of surface water, groundwater, and rainfall and ii) records of water permit issuance. Water abstraction survey data will be used as necessary to grasp actual water use status. For surface water resources evaluation, the major rivers of Tana and its tributaries should be the focus as they are the representative rivers in TCA.

2) Water Resources Quality Evaluation

The water resources quality evaluation is conducted annually based on the monitoring data for surface water and groundwater quality. Currently, there is only one water quality test laboratory in the catchment area in Embu. For the timely analysis of monitored water quality especially in the eastern part of the catchment area, additional water quality test laboratories should be established.

(3) Water Permit Issuance and Control

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

(4) Watershed Conservation

Among the three major items of a) recovery of forest areas; b) conservation of small water sources; and c) control of soil erosion, item b) is not an issue in TCA. Therefore, item a) recovery of forest areas and c) control of soil erosion will be considered in TCA.

1) Recovery of Forest Areas

Forest recovery will be implemented through reforestation focusing on degraded forest areas in the catchment area.

2) Control of Soil Erosion

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

4.7.3 Proposed Water Resources Management Plan

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

(1) Monitoring

The monitoring plan is described in five monitoring items which are surface water level, surface water quality, groundwater level, groundwater quality, and rainfall. Locations of the proposed monitoring stations are shown in Figure 4.7.2.

1) Surface Water Level

Surface water level is observed twice a day by an honorarium gauge reader. Observed water levels are submitted to WRMA regional offices once a month. In addition, WRMA staff conducts discharge measurement by current meter once a month. Based on the overall concept, the current monitoring network was reviewed mainly for Tana River and its tributaries, 16 monitoring points were selected in the Tana River and its tributaries in the upper reach, seven in the middle reach, and three in the lower reach. A total 26 monitoring points were selected for daily basis monitoring. For major rivers, reference points were selected as follows:

a) 4CC03 (Yatta Furrow) located in Thika River, a tributary in the upper reach of the Tana River. There is an inter-basin transfer to Athi Catchment Area in the upstream of this point. Monitoring started in 1961.
b) 4BE10 (Tana Rukanga) located in the upper reach of the Tana River. There is a plan for inter-basin transfer in Maragua River, the upstream tributary. This point monitors the available flow after water use in the upper reach of the Tana River.
c) 4G01 (Garissa) located in the middle reach of the Tana River. Monitoring started in 1934. This point is one of the most important reference points in the Tana River to monitor the discharge after water use in the upper reach and confirm the available discharge for the downstream demands.

Based on the management strategy described in Subsection 4.7.2, normal discharge values are set at the above three reference points as shown below. These normal discharge values are used for low water management.

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. Sectral Report (G), Sub-section 4.4.3 (3) and Table 4.4.4)

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

2) Surface Water Quality

Stations monitoring on monthly basis

Based on the management strategy, the water quality of the following five reference points are monitored on a monthly basis. This monitoring is for watching and detecting possible pollutant sources that may affect water usage in the relevant rivers.

a) 4BE10 (Tana Rukanga) located in the upper reach of the Tana River: To monitor the impact of urban and irrigation effluent in the upper reach on the river water quality.

b) 4G01 (Garissa) located in the middle reach of the Tana River: To monitor the impact of urban effluent from Garissa Town on the river water quality.

c) 4G02 (Garsen) located in the lower reach of the Tana River: To monitor the impact of irrigation effluent in the middle to lower reach on the river water quality. It will also monitor the deterioration of water quality caused by decreased discharge and effects of sea water intrusion.

Stations monitoring on quarterly basis

Apart from the above three monitoring stations, water quality of the other surface water monitoring stations (23 points) should be monitored on a quarterly basis (January, April, July, and October every year). Such data is used as reference data when WRMA issues water permits. The 23 stations to be monitored are: 4AA05, 4AB06, 4AC04, 4AD01, 4BB01, 4BC05, 4BD01, 4BE01, 4BF01, 4CA02, 4CC03, 4DA10, 4DB04, 4DC06 II, 4DD02, 4EA07, 4EB07, 4EC04, 4F09, 4F13, 4F19, 4F28 and New (Hola).

3) Groundwater Level

Based on the management strategy, 18 points were selected for groundwater level monitoring through dedicated boreholes for monthly basis monitoring. These points are located near urban centres where there are both water supply and sanitation plans with expected high growth of groundwater demand in the future. The 18 points are in the towns of: Nyeri, Thika, Muranga, Maragua, Makuyu, Meru, Chogoria, Chuka, Embu, Matuu, Kitui, Garissa, Lamu, Wanguru, Runyenjes, Kerugoya, Maua, and Mwingi.

4) Groundwater Quality

Groundwater quality is monitored at the same locations where groundwater level monitoring stations are located. As groundwater quality does not change so frequently compared with surface water, monitoring is conducted twice a year (once in the rainy season and once in the dry season).

5) Rainfall

Based on the management strategy, distribution of the current rainfall monitoring stations was reviewed. As a result of the review, 47 rainfall monitoring stations were selected for daily basis monitoring.

(2) Evaluation

1) Water Resources Quantity Evaluation

Based on the management strategy, water resources quantity evaluation is conducted annually based on i) monitoring data for surface water, groundwater, and rainfall and ii) water permit issuance data. For this, a water resources evaluation team is formed and composed of: i) one chief hydrologist from Embu Regional Office and ii) one assistant hydrologist each from Muranga, Kerugoya, Meru, Kitui, and Garissa subregional offices. Water resources evaluation works are done for the whole catchment area of TCA on both surface water and groundwater.

2) Water Resources Quality Evaluation

Based on the management strategy, water resources quality evaluation is also conducted annually based on the monitoring data for surface water and groundwater quality.

Additional water quality test laboratories should be established in Garissa for the timely analysis of water quality samples especially in the middle to lower Tana. For the management of laboratories and evaluation of water quality, a chief water quality expert with appropriate staff should be assigned in the water quality test laboratories in Embu and Garissa.

(3) Water Permit Issuance and Control

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

a) Control over the latest version of issued water permits
- Periodical update of water permit database; and
- Establishment and enhancement of the notification system on permit expiry.

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

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

Number of Required Water Rights Officers (TCA)

Offices	Number of Water Rights Officers		
	Current	Required	Future
Tana RO	2	No change	2
Muranga SRO	1	+2	3
Kerugoya SRO	1	+2	3
Meru SRO	1	+2	3
Kitui SRO	1	+1	2
Garissa SRO	1	+1	2
Total	7	+8	15

Note: RO = Regional Office, SRO = Subregional Office

Source: JICA Study Team, based on interview with WRMA Regional Office

(4) Watershed Conservation

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

1) Recovery of Forest Areas

As for the forest recovery for watershed conservation, about 1,370,000 ha of forestation is proposed in TCA to achieve the targets of Kenya Vision 2030. Current situations of the forest areas in TCA and potential areas for forestation are shown in Figure 4.7.3.

The following steps were applied in the preparation of Figure 4.7.3.

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

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

2) Control of Soil Erosion

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

4.8 Flood and Drought Disaster Management Plan

4.8.1 Current Situation of Flood Disaster Management

(1) Flood Situation

Within the middle to lower parts of the Tana River basin, the areas susceptible to flood stretches along the Tana River. Even the arid and semi-arid areas of the lower Tana also experience flash floods. Flood damages in TCA outside Lake Victoria areas is the largest in Kenya, according to the Flood Mitigation Strategy (2009, MWI).

The most severe flooding incidents in Garissa occurred in 1997/1998. Following the 1997/1998 flooding incidents, flooding in 2006 and 2007 also severely affected the Garissa City. In these years, even at built-up areas from 600 m to 700 m away from the left bank of Tana River, houses were inundated more than 1.0 m and the residents around these areas had to evacuate for two to four months. In TCA, Garissa Town is regarded as the area most severely damaged by floods.

On the other hand, during the long rainy season of 2010 there were also flood damages in the Tana Delta area. Some 75 households were affected by the flash floods which occurred in Bura division in April 2010. However, injuries to human are relatively small compared to the damage to agriculture because of enough lead time for evacuation is secured in the Tana Delta area. This is because the Tana River is a gentle slope river, and propagation times of flood are estimated at three days from the Masinga Dam to Garissa Town and two weeks from the dam to Tana Delta near the river mouth.

(2) Flood Disaster Management

Although no official document specifying flood management has been prepared in TCA, there are 43 river gauge stations under the management of WRMA Tana Regional Office. Out of these stations, the Garissa and Garsen stations have three water level warnings, namely, Alert, Alarm, and Flood as shown in the table in Section 2.3.1 (4) 3) of Sectoral Report (J). Once the river water level reaches the the warning level, the WRMA Tana Regional Office will disseminate information to the public in the downstream area through relevant local governments such as county, district, division, location, and sublocation.

On the other hand, there are five units of hydropower dams along the Tana River. Warning information will be provided from KenGen, the hydropower operator, to the public through TARDA, the owner of the dams, and the abovementioned 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 experimental basis based on government information or their own judgement because enough lead time for evacuation is secured.

As for flood structural measures, in recent years, revetment works with a length of 3.0 km along the Tana River has been implemented by NWCPC.

4.8.2 Current Situation of Drought Disaster Management

(1) Drought Situation

Most of TCA except for its most upstream parts in and around Embu and Muranga is categorised as arid land in the downstream parts and semi-arid land in the middle stream parts. TCA is therefore vulnerable to both flood and drought disasters.

During the time of drought in January 2011, less than 20% of normal irrigation water was obtained in irrigated areas from Garissa to Tana Delta, and conflicts over water resources and grazing resources occurred among pastoralist and agricultural farmers particularly in in the lower Tana areas.

(2) Drought Disaster Management

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

On the other hand, as for water resources management during drought, Garissa and Thika river gauge stations have two water level warnings, namely Alert and Alarm. Once the river water level reaches the warning level, the WRMA Tana Regional Office will carry out water use restrictions by regulating water intake.

There are eight existing dams for the hydropower and domestic water supply purposes, namely, Sasumua, Thika, Masinga, Kamburu, Gitaru, Kindaruma, Kiambere, and Umaa (under construction) dams. However, drought management including water use restriction of the reservoirs has not been implemented.

4.8.3 Flood Disaster Management Strategy

As explained in the concept and framework e) mentioned in Section 7.9 of the Main Report Part A, the proposed examination areas in TCA are Lower Tana and Ijara. Since the extent of Lower Tana is not clearly defined in any document, 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; hence, Ijara will be examined together with Lower Tana. Out of this area, the urban area is limited to Garissa (population as of 2009: 116,000 people).

In Garissa where flood damage is severe in the urban area, flood control measures shall be implemented by river structures, taking particular note of the large number of affected people by long-term inundation. In addition, it is more effective to adopt a strategy that will mitigate damages to properties and loss of lives since structural measures alone have limited safety capacity against extraordinary floods exceeding a design level. Hazard maps and evacuation plans should be prepared.

In the lower part of Tana River farther than Garissa, it is intended to mitigate human injuries by the establishment of a community-based disaster management system considering the characteristics of the gradual flooding in the Tana River, the public's evacuation capacity based on their past experiences, and where there is no large-scale settlement along the river. This system is assumed to adopt a simplified flood forecasting system based on water level observations in the upper reach of the Tana River.

In addition, the warning system for discharge release for this area from the existing hydropower dam shall be improved. It is considered important to clearly disseminate warning information to the public because they possess the ability to evacuate by themselves if information reaches on time.

The following basic policies are important to formulate the flood disaster management plan in TCA:

a) Implementation of flood control measures as well as the preparation of hazard maps and evacuation plan in Garissa.
b) Establishment of a community-based disaster management system in the lower part of the Tana River farther than Garissa.
c) Improvement of the warning system for discharge release from the existing hydropower dam.

4.8.4 Drought Disaster Management Strategy

Based on overall concepts and framework mentioned in Section 7.9 of the Main Report Part A, drought disaster management strategy for TCA is to be implemented through the i) preparation of water use restricted rules for existing and proposed reservoir, ii) establishment of the Basin Drought Conciliation Council and iii) establishment of drought early warning system.

4.8.5 Proposed Flood Disaster Management Plan

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

(1) Implementation of Flood Control Measures in Garissa

As to the flood control measures for Garissa, the following alternatives are proposed.

(A) River improvement works alone:
Construction of a new dike, reinforcing or heightening of existing dike, widening of high water channel by realignment of existing dike, widening of low water channel by excavation, etc.

(B) Flood discharge control by multi-purpose dam and river improvement works:
Allocation of flood control capacity in the High Grand Falls Dam, etc.

(C) Flood discharge control by retarding basin and river improvement works.

It should be noted that although it is not allowed to inundate landside-prone area as proposed in the NWMP 2030, it is necessary to consider the possibility of adopting a strategy for natural retarding effects, such as pasture, paddy and dry fields for lands subject to frequent flooding, at the time of detailed planning in the future.

In addition, flood hazard map covering all flood plain areas in Garissa shall be prepared and notified to the public. This map is assumed to be more accurate compared to the simplified hazard map prepared by communities and to show probable flood areas for several kinds of probable return periods and probable maximum flood. The WRMA Tana Regional Office should make a flood analysis by using hydrological and topographical data.

Based on the hazard map, evacuation plan for Garissa should also be formulated with attention to classification of flood warnings and evacuation orders, dissemination method of warnings and orders, clear indication of evacuation place and route, confirmation method of evacuation activities, etc. In particular, it was found from the damage survey that almost half of the residents in Garissa did not receive any warning information during the time of past floods, and 80% of residents evacuated on foot and the average travel time to the evacuation area was four hours. These survey data should be incorporated in the formulation of the plan.

(2) Establishment of CBDM System in the Lower Part of Tana River farther than Garissa

In the lower part of Tana River farther than Garissa, a community-based disaster management system is proposed in reference to the system that has already been developed in the Nyando River basin.

It is proposed that the CBDM system includes various activities by community involvement, namely, i) systematisation of communities and establishment of a flow of monitoring, information dissemination and evacuation in cooperation with the WRMA Tana Regional Office, Lower Tana Subregional Office, and the local government offices, ii) construction of evacuation centres and evacuation routes by community involvement, iii) voluntary monitoring by community using simple rain gauge and water level gauge, iv) community involvement in flood prevention activities, and v) construction of small-scale structural measures such as small revetment and culvert.

As for flood forecast, these areas shall basically adopt a simplified flood forecasting system by using river water level observation in the upper reaches. The communities themselves will recognise occurrence of flood and carry out necessary activities in accordance with the hazard map and evacuation plan, which they should prepare in advance.

(3) Improvement of Dam Discharge Warning

Out of the existing five hydropower dams, improvement of warning system shall be made for the Kiambere Dam, which is located in the most downstream section of the Tana River. In the current system, warning information will be provided from KenGen, the hydropower operator, to the public through TARDA, the owner of the dam, and the local government offices before a large volume of water is released from the reservoir. The contents of the improvement should include but not limited to the following:

- Stipulating TARDA, the owner of the dam, as an authority to issue warning for dam discharge release,
- Improving dissemination method and route from sublocations, which is the lowest local administration, to the public,
- Sharing/providing information with the WRMA Tana Regional Office, which is the implementing organisation on river administration at catchment level, and
- Scrutinizing the timing of warning issuance and information items to be provided to the public.

4.8.6 Proposed Drought Disaster Management Plan

(1) Preparation of the Water Use Restriction Rule for Reservoirs

1) Target Dam

It is proposed to prepare the water use restriction rule for the respective reservoirs. The names of the target dams are shown in the table below. It is noted in the list below that there are eight existing and ten proposed dams in TCA.

Target Dams for Water User Restriction Rules (TCA)

River System	No.	Dam Name	Status	
			Existing	Proposed
Tana	1	Maragua 4		O
	2	Sasumua	O	
	3	Ndiara		O
	4	Chania-B		O
	5	Karimenu 2		O
	6	Thika 3A		O
	7	Thika	O	
	8	Yatta		O
	9	Thiba		O
	10	Masinga	O	
	11	Kamburu	O	
	12	Gitaru	O	
	13	Kindaruma	O	
	14	Kiambere	O	
	15	High Grand Falls		O
	16	Umaa	O	
	17	Kora		O
	18	Kitimui		O
	19	Mutuni		O
Total			8	11

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

2) Setting of Reference Reservoir Water Level

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

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

3) Determination of Reduction Rate

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

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

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

(2) Establishment of a Basin Drought Conciliation Council

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

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

The council shall be composed of the WRMA Regional Office, relevant counties, representative of water users (WRUAs), etc. The council shall be established legally to avoid water conflict during drought time.

(3) Drought Early Forecast

Water use restriction should be considered at the early stage, taking into account the weather conditions, water storage in the reservoirs, social impacts in the worst case scenarios, etc.

Currently, the KMD issues long-term rainfall forecast of 4-day, 7-day, 1-month, and 3-month (seasonal), which are officially released on the website of the KMD or published in the newspaper. This information shall be utilised to commence timely water use restriction.

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

4.9 Environmental Management Plan

4.9.1 Current Situation of the Environmental Management

Tana River is the main river of TCA. Many tributaries originating from the Aberdare Range and Mt. Kenya are flowing into the upper reaches of the Tana River and the abundant water resources have been maintained.

There are 19 national parks/reserves including the Kiunga Marine National Reserve. There is fear that large-scale development projects such as the High Grand Falls Multipurpose Development Project in the upper reaches will affect the Kora and Meru national parks and the Mwingi, Bisanad, and Rahole national reserves, which are situated directly below the said projects. In addition, the Arawale and Tana River Primate national reserves are located in the middle reaches to the lower reaches of the Tana River. Environmental monitoring for the natural resources is required in the middle reaches because negative impacts by future population growth in Garissa Town as the main city of the area is expected. The Tana Delta located near the river mouth is not a national protected area; however, it is receiving attention as an important wetland ecosystem of Kenya. The Tana Delta is the largest, most ecologically and socio-economically important wetlands in Kenya. The delta supports a gallery of ecosystems ranging from forests to swamps. The Kenya Wetland Biodiversity Research Team (KENWEB) Project is being conducted in the area to conserve and conduct sustainable use the wetlands. The Kiunga Marine National Reserve is designated as a biosphere reserve by the UNESCO. World Wide Fund for Nature-Southern Africa Region Programme Office (WWF-ESAPRO) had conducted the Conservation and Development of the Kiunga Marine Reserve Area Programme by January 2011. The purpose is to make a significant contribution to the collaborative efforts for the sustainable conservation of the reserve's habitats and adjacent areas, and of its biodiversity as species, communities, and ecological processes so that their productivities benefit local livelihoods.

Most areas of Mt. Kenya and the Aberdare Range of the Five Water Towers are located in TCA. Deforestation of the Aberdare Range by illegal logging is significant. Thus, urgent action is required for water resources conservation.

Summary of Natural Environmental Resources (TCA)

Protected Area		Total Area	Number of Wildlife Species	Location
National Park (N.P.)				
1	Tsavo East N.P	11,747 (km^2)	215	South Eastern Kenya, inland from the coast
2	Mt Kenya N.P	715 (km^2)	200	East of the Rift Valley
3	Meru N.P	870 (km^2)	141	Meru District, Eastern Province
4	Aberdare N.P	765.5 (km^2)	221	Aberdare Mountain Ranges of Central Kenya
National Reserve (N.R.)				
5	Arawale N.R	533 (km^2)	102	Northeastern Province
6	Kora N.R	1,787 (km^2)	115	Northeastern Province
7	Tana River Primate N.R	169 (km^2)	116	Tana River District, Coast Province.
8	Tsavo Road and Railway N.R	212 (km^2)	-	-
10	Bisanadi N.R	606 (km^2)	124	Northeast boundary of Meru N.P.
11	Mwea N.R	68 (km^2)	154	Mbeere District, Eastern Province
12	Mt Kenya N.R	2,124 (km^2)	No information	East of the Rift Valley
13	Rahole N.R	1,270 (km^2)	104	Northeast of Kora N.P.
14	Boni N.R	1,339 (km^2)	109	Ijara District, North Eastern Province
15	Ngai Dethya N.R	212 (km^2)	No information	Next to Rahole N.R.
16	Dodori N.R	877 (km^2)	114	Northeast coast
17	South Kitui N.R	1,133 (km^2)	125	Northern area from Tsavo east N.P.
18	North Kitui N.R	745 (km^2)	114	Eastern Province
Marine Reserve				
19	Kiunga Marine N.R.	250 (km^2)	106	Lamu District, Coast Province
Five Water Towers				
20	Mt. Kenya	220,000 (ha)	No information	180 km north of Nairobi
21	Aberdare Range	250,000 (ha)	No information	Central Kenya, on the eastern edge of the RVCA

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

4.9.2 Management Strategy

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

The water resource development projects in the NWMP 2030 are mostly proposed in the upper reaches of the Tana River. Therefore, setting of the environmental flow rate and environmental monitoring are proposed for the Tana River and Chania River, a tributary of Tana River with a water transfer plan to ACA.

4.9.3 Proposed Environmental Management Plan

Based on the abovementioned management strategy, and point selection criteria mentioned in the overall concept and framework, target points of environmental flow rate, and environmental monitoring of environmental management plan for TCA are shown in the following table. Locations of target points are shown in Figure 4.9.1.

Environmental Flow Rate/Water Level Setting Points (TCA)

Target	Environmental Flow Setting Point		Proposed Major Development Projects	Vegetation	Reserve* (m^3/s)	Monitoring Point of WRM
Tana River	TCA-F1	Reference point (Downstream of Garissa Town)	Maragua 4, Thiba, and High Grand Falls dams, Masalani and Tana Delta irrigations	Deciduous bushland and thicket	53.5	4G01
	TCA-F2	Upstream of the Meru National Park		Deciduous bushland and thicket	52.1	4F13
	TCA-F3	Reference point (Upstream of Masinga Dam)		Evergreen bush land with wooded grassland	1.5	4BE01
Chania River	TCA-F1	Reference point (Downstream of Thika Town)	Ndiara, Karimenu 2, Thika 3A, Chania-B and Yatta dams	Evergreen bush land with wooded grassland	8.5	4CC03

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

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

In addition, the environmental survey for setting the environmental flow rate (current river flow rate, water quality, and river ecosystem) shall be conducted in the Tana and Chania rivers.

Environmental Monitoring Points (TCA)

Target	Monitoring Point		Reserve* (m^3/s)	Monitoring Point of WRM	Selection Criteria
Tana River	TCA-M1	Tana Delta	42.7	4G02	b) Points where rare or characteristic ecosystem exists (Tana Delta) d) Upstream points from the protected area
	TCA-M2	Upstream of the Tana River Primate National Reserve	-	-	d) Points upstream from the protected area
	TCA-M3	Reference point (Downstream of Garissa Town)	53.5	4G01	a) Representative point to monitor the river ecosystem, b) Points where large city or town is located, and, d) Upstream points from the protected area
	TCA-M4	Upstream of the Meru National Park	52.1	4F13	d) Points upstream from the protected area
	TCA-M5	Reference point (Upstream of Masinga Dam)	1.5	4BE01	a) Representative point to monitor the river ecosystem
Chania River	TCA-M6	Reference point (Downstream of Thika Town)	8.5	4CC03	a) Representative point to monitor the river ecosystem

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

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

CHAPTER 5 COST ESTIMATES

5.1 Basic Conditions and Methodologies for Cost Estimates

5.1.1 Conditions and Methodologies of Cost Estimates for Development Plans

Costs of the projects proposed in the development plans formulated for TCA in this study including water supply, sanitation, irrigation, hydropower, and water resources development plans were estimated to identify the total costs in general to evaluate the general economic viability and to discuss the general idea of financing for the implementation of the proposed projects.

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

(1) Water Supply Development Projects

a) As for the expansion and new construction of water supply systems, the cost estimates were considered separately for three categories, namely, "dams and large scale bulk water transfer systems", "water intake, boreholes, and water transmission lines with pump stations", and "water distribution systems with water treatment plants and pumping stations". Except for "dams and large scale bulk water transfer systems", the project costs were estimated by applying the unit cost of US$2250/m^3. If dams or large-scale water transfer systems are required for water supply system, the costs are estimated separately as described in paragraph e) below. As for the rehabilitation of water supply system, the project costs were estimated by applying the unit cost of US$675/m^3 for water supply capacity of the existing water supply system.

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

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

(2) Sanitation Development Projects

a) As for the expansion and new development of sewerage system, the project costs were estimated by applying the unit cost of US$2000/m^3 of required wastewater treatment capacity. As for the rehabilitation, the project costs were estimated by applying the unit cost of US$600/m^3 for treatment capacity of the existing sewerage system. The unit costs were derived from the data in the existing reports prepared by the WSBs and the Aftercare Study Report with adjustments. The used data included direct construction costs and indirect construction costs (administration and engineering services). Land acquisition costs were not estimated because of the marginal amount for the sewerage projects.

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

c) Other sanitation projects

(3) Irrigation Development Projects

a) For the large- and small-scale irrigation projects, the costs for civil works estimated by the government authorities were used with adjustments, when necessary. The construction costs include the physical contingency at 15% of direct construction costs. The indirect costs were calculated by summing such costs as soft component, engineering services, and government administration costs, assuming as 3%, 10%, and 3% of the direct construction costs, respectively. The land acquisition costs were assumed to be KSh100,000/ha based on the actual data for other projects, when data were not available.

b) For the new large- and small-scale irrigation projects without detailed cost data, the project costs were estimated by applying unit costs per ha and indirect construction costs as calculated above. The unit construction costs were assumed at KSh900,000/ha for large-scale dam irrigation, KSh600,000/ha for small-scale dam irrigation, KSh400,000/ha for weir irrigation, and KSh900,000/ha for groundwater irrigation projects by applying actual costs for similar projects.

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

d) The annual O&M costs were estimated by applying the rate of 0.3% to the direct construction costs for the water source facilities (dams, weirs, boreholes) and 1% for the irrigation canal systems. The replacement costs such as mechanical works were assumed at 20% to the direct construction costs, which will be conducted every 20 years.

(4) Hydropower Development Projects

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

b) The annual O&M costs were estimated by applying the amount of 0.5% of the project costs including replacement costs.

(5) Water Resources Development Projects

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

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

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

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

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

Other basic conditions applied for the cost estimates are enumerated as follows:

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

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

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

5.1.2 Conditions and Methodologies of Cost Estimates for Management Plans

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

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

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

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

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

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

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

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

a) Project costs of dams with flood control allocation were excluded and were estimated separately in the water resources development plan;

b) Project costs for river improvement works were excluded because there were limited basic data necessary for planning and cost estimates of the works; and

c) Project costs for drought management plan were excluded because these were considered to be within the WRMA's regular tasks.

Other basic conditions applied in the cost estimates are as follows:

a) The cost estimate was based on the market price on November 1, 2012.

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

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

5.2 Cost Estimate for Proposed Plans

5.2.1 Cost Estimate for Proposed Development Plans

(1) General Scopes of Proposed Plans for Cost Estimate

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

1) Water Supply Development Plan

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

2) Sanitation Development Plan

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

3) Irrigation Development Plan

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

4) Hydropower Development Plan

Of the 14 hydropower schemes, 13 schemes are multi-purpose dam projects and one scheme is a single purpose project.

5) Water Resources Development Plan

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

(2) Estimated Costs

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

Estimated Costs for Proposed Projects in Development Plans (TCA)

(Unit: KSh million)

Development Plan	Proposed Project	Type	Project Cost	Annual O&M Cost
Water Supply*	Urban Water Supply (23 UCs)	Rehabilitation	6,887	-
		New construction	122,601	4,145
		Sub-total	129,488	4,145
	Rural Water Supply (16 Counties)	Rehabilitation	6,274	-
		New construction	4,450	217
		Sub-total	10,723	217
	Sub-total		140,211	4,362
Sanitation*	Sewerage System (18 UCs)	Rehabilitation	1,655	-
		New construction	62,497	3,422
	Sub-total		64,152	3,422
Irrigation**	Large-scale Irrigation (135,961 ha)	New construction	324,875	975
	Small-scale Irrigation (15,784 ha)	New construction	10,200	51
	Private Irrigation (10,054 ha)	New construction	19,491	195
	Sub-total		354,566	1,221
Hydropower	2 projects	New construction	152,886	765
Total			711,815	9,770

Note: UC = Urban Centre

* O&M cost of existing water supply and sewerage facilities to be rehabilitated was not estimated due to lack of data required for cost estimate.

** Rehabilitation cost of existing irrigation facilities was not estimated due to lack of data required for cost estimate though there are needs of rehabilitation of them.

Source: JICA Study Team (Ref. Tables 5.2.1 – 5.2.5)

The costs for the proposed water resources development were estimated to be KSh268,676 million for project cost, KSh1347 million for O&M cost, which include the costs of 11 dams and four water transfer systems. The costs had been allocated to the costs for water supply, irrigation, and hydropower subsectors.

5.2.2 Cost Estimate for the Proposed Management Plans

(1) General Scopes of Proposed Plans for Cost Estimate

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

1) Water Resources Management Plan

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

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

2) Flood and Drought Disaster Management Plan

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

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

3) Environmental Management Plan

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

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

(2) Estimated Costs

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

Estimated Costs for Proposed Management Plans (TCA)

(Unit: KSh million)

Management Plan	Proposed Plans	Development Costs	Annual Recurrent Costs*
Water Resources Management	Monitoring	125	137
	Evaluation	54	-
	Permitting	27	-
	Watershed Conservation (1,366,000 ha)	107,914	-
	Operation of Catchment Forum	-	1
	Sub-total	108,120	138
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	-
	Sub-total	701	2.6
Environmental Management	Setting of Environmental Flow Rate including Survey (4 locations)	62	-
	Environmental Monitoring (6 locations)	-	0
	Sub-total	62	0
Total		108,883	140.6

Note: *Recurrent cost includes operation and maintenance costs
CBRD = Community-based Disaster Management
Source: JICA Study Team (Ref. Tables 5.2.7 – 5.2.9)

CHAPTER 6 ECONOMIC EVALUATION

6.1 Basic Conditions and Methodology for Economic Evaluation

The overall economic evaluation was performed for four sectors; 1) urban water supply (for 22 UCs, excluding rehabilitation works), 2) sewerage (for 18 UCs, excluding rehabilitation works), 3) large-scale irrigation (with 132,360 ha), and 4) hydropower (with two dams) in TCA at a master plan level. The following assumptions were made for economic analysis:

a) Price Level

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

b) Social Discount Rate

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

c) Economic Life of Facilities

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

d) Cost Allocation for Multipurpose Dams

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

e) Economic Cost

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

f) Economic Benefits

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

Estimated Economic Benefits (TCA)

Subsector	Items of Economic Benefits	Benefit at Net Present Value
a) Water Supply	- Cost saving for water users - Increase of water supply amount	KSh127.4 billion (30 years)
b) Sewerage	- Cost saving for users - Affordability to pay - Improvement of public health	KSh82.2 billion (30 years)
c) Irrigation	- Crop production increase	KSh181.7 billion (50 years)
d) Hydropower	- Capacity increase - Energy increase	KSh137.6 billion (50 years)

Source: JICA Study Team

The details of the calculations are described in the sectoral reports.

6.2 Economic Evaluation for the Proposed Plan

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

Summary of Economic Evaluation Results (TCA)

(Unit: KSh billion)

Subector	Scope	Estimated Financial Cost	Estimated Economic Cost	Net Present Value		B/C	EIRR
				Cost	Benefit		
Water Supply	22 UCs	120.9	114.4	125.4	127.4	1.02	10.20%
Sewerage	18 UCs	62.5	58.7	72.0	82.2	1.14	11.90%
Irrigation	132,300 ha	275.5	254.0	220.1	181.7	0.83	8.30%
Hydropower	Two projects	152.9	142.0	121.0	137.6	1.14	11.80%

Source: JICA Study Team

The total economic costs for water resources development is estimated at KSh569.1 billion, of which large-scale irrigation projects are the largest (KSh254.0 billion), followed by hydropower projects (KSh142.0 billion). These large amounts of economic costs in irrigation schemes result from the High Grand Falls Project, which has an estimated initial investment costs of US$2,946 million. In terms of economic viability, the water supply, sewerage, and hydropower subsectors were found to be economically feasible with more than 10% of EIRR, while the irrigation subsectors had a low efficiency from economic point of view. The results of the economic analysis for the four subsectors are summarised as below;

a) Water supply projects in TCA do not require high cost structures for water transmission system to the Lamu area, which resulted in high economic viability. EIRR is lowered by the Lamu Water Supply with high cost of transmission system; however, it will be promoted under the national priority program of LAPSET.

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

c) The irrigation subsector has the potential of creating some KSh181.7 billion in the national economy, but the lower EIRR in this subsector indicates that the project costs and design need to be reviewed carefully before the implementation.

d) The hydropower projects in TCA were found to be efficient, due to topographic condition that could gain sufficient advantage for power generation, which resulted in positive economic viability.

CHAPTER 7 IMPLEMENTATION PROGRAMMES

7.1 General

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

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

The programmes of the proposed projects and plans were prepared with an implementation term of 18 years from the fiscal year 2013/14 to 2030/31 by dividing the term into three terms, 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 the three terms.

7.2 Criteria for Prioritisation for Implementation

7.2.1 Criteria for Prioritisation of Development Plans

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

(1) Prioritisation by Project Status

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

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

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

(2) Prioritisation by Subsector

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

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

c) Small-scale rural water supply projects will be implemented progressively by individuals or communities.

2) Sanitation:
a) Rehabilitation of the existing facilities will be made prior to their expansion.
b) Sewerage projects in the urban areas with more severe impacts on the environment have higher priority.
c) On-site sanitation facilities will be installed progressively by individuals and communities.

3) Irrigation:
a) Rehabilitation of existing facilities will be made prior to their expansion.
b) Projects with higher economic viability including large- and small-scale projects proposed by the government organisations have higher priority.
c) Other small-scale projects and private projects will be implemented progressively under counties and by private companies, respectively.

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

5) Water resources:
a) Water resources development such as dams, water transfers, small dams, water pans, and boreholes will be implemented according to requirements of the water supply and irrigation development.

7.2.2 Criteria for Prioritisation of Management Plans

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

(1) Criteria for Water Resources Management Plan

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

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

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

(2) Criteria for Flood and Drought Disaster Management Plan

1) Flood Disaster Management Plan

a) Non-structural measures are scheduled mostly in the short term because they serve as immediate measures to mitigate flood damage before the completion of structural measures.
b) The construction schedule of multipurpose dams is certainly in accordance with the water resources development subsector.

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

2) Drought Disaster Management Plan

a) Drought disaster management plans such as preparation of water use restriction for reservoirs and establishment of a Basin Drought Conciliation Council should be implemented, as early as possible, wherever applicable.

(3) Environmental Management Plan

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

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

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

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

7.3 Implementation Programmes of the Proposed Plans

The implementation programmes were prepared under the following conditions as well as the criteria for prioritisation as described in the preceding section:

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

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

Tables

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

(m^3/s)

Sub-basin	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Des	Annual (MCM/year)
4AA	0.1	3.2	4.6	2.0	0.8	1.4	0.1	0.1	1.9	3.5	1.8	2.3	57
4AB	0.2	3.5	5.1	2.2	0.8	1.6	0.2	0.2	2.1	3.9	2.0	2.5	63
4AC	1.1	3.5	4.5	2.3	1.1	2.0	1.1	1.1	2.4	3.7	2.4	2.7	73
4AD	0.3	2.7	3.8	1.5	0.3	1.1	0.3	0.3	1.6	2.9	1.6	1.9	47
4BA	0.2	2.4	3.4	1.3	0.2	1.0	0.2	0.2	1.4	2.6	1.4	1.7	42
4BB	0.1	4.3	6.3	2.3	0.1	1.6	0.1	0.1	2.4	4.8	2.4	3.0	71
4BC	0.2	9.4	14.0	5.8	5.8	5.0	0.2	0.2	5.4	9.1	4.5	7.7	176
4BD	0.4	2.9	4.1	1.7	0.4	1.3	0.4	0.4	1.8	3.2	1.8	2.1	54
4BE	0.5	5.6	7.2	1.7	4.0	2.6	0.5	0.5	2.8	4.7	2.7	4.0	96
4BF	0.5	2.5	3.2	1.1	2.0	1.4	0.5	0.5	1.5	2.3	1.5	2.0	51
4BG	0.1	2.3	3.1	0.8	1.7	1.1	0.1	0.1	1.2	2.1	1.2	1.8	41
4CA	0.2	4.7	6.2	1.3	3.3	2.1	0.2	0.2	2.3	4.0	2.2	3.3	79
4CB	0.1	3.2	4.1	0.9	2.2	1.4	0.1	0.1	1.6	2.7	1.5	2.2	53
4CC	0.6	6.9	9.0	2.3	5.2	3.4	0.6	0.6	3.7	6.2	3.6	5.2	124
4DA	0.6	29.4	43.7	18.0	18.0	15.6	0.6	0.6	16.8	28.4	14.1	24.0	549
4DB	0.2	19.0	28.3	11.5	11.6	10.0	0.2	0.2	10.7	18.3	9.0	15.5	352
4DC	0.5	3.5	4.9	2.3	2.3	2.1	0.5	0.5	2.2	3.3	1.9	2.9	71
4DD	0.1	2.2	3.3	1.3	2.6	1.2	0.1	0.1	1.4	2.2	0.9	1.5	44
4DE	0.1	1.2	1.8	0.8	1.5	0.7	0.1	0.1	0.8	1.3	0.6	0.9	26
4EA	0.2	5.1	9.6	8.1	8.7	4.2	0.2	0.2	3.3	6.0	4.2	4.4	142
4EB	0.8	6.3	11.4	9.8	10.6	5.3	0.8	0.8	4.2	7.4	5.4	5.5	179
4EC	0.3	3.5	6.3	5.6	6.2	2.9	0.3	0.3	2.3	4.2	3.0	3.2	100
4ED	0.4	5.8	10.7	9.5	10.6	4.9	0.4	0.4	3.7	7.1	5.0	5.4	167
4FA	0.8	13.8	25.8	21.9	23.7	11.5	0.8	0.8	8.9	16.3	11.5	11.9	387
4FB	0.6	16.8	31.8	26.9	29.1	14.0	0.6	0.6	10.7	19.9	13.9	14.4	471
4GA	0.1	4.9	9.4	8.1	8.8	4.1	0.1	0.1	3.1	5.9	4.2	4.3	140
4GB	0.1	8.6	16.6	15.4	16.6	7.3	0.1	0.1	5.3	10.6	7.9	8.2	254
4GC	0.3	3.7	6.9	6.4	6.9	3.1	0.3	0.3	2.3	4.4	3.4	3.5	108
4GD	0.1	11.9	23.1	21.4	23.1	10.1	0.1	0.1	7.3	14.7	11.0	11.4	352
4GE	0.4	13.5	23.7	22.0	22.8	10.7	0.4	0.4	8.1	14.6	11.9	13.6	372
4GF	0.4	21.5	37.9	35.1	36.4	16.9	0.4	0.4	12.8	23.2	18.9	21.6	591
4GG	0.2	8.5	15.1	13.8	14.3	6.6	0.2	0.2	5.1	9.2	7.5	8.6	234
4HA	1.0	3.0	4.6	4.2	4.4	2.6	1.0	1.0	2.2	3.2	2.7	3.0	87
4HB	0.1	12.4	22.0	20.2	20.9	9.6	0.1	0.1	7.3	13.4	10.9	12.5	340
4HC	0.1	9.4	16.7	15.3	15.8	7.3	0.1	0.1	5.6	10.2	8.2	9.5	257
4JA	0.1	20.7	38.8	33.1	44.9	20.3	0.1	0.1	13.4	24.6	17.6	19.1	611
4JB	0.1	7.9	14.8	12.6	17.0	7.7	0.1	0.1	5.1	9.4	6.7	7.3	232
4KA	0.1	17.4	32.5	27.8	37.7	17.1	0.1	0.1	11.2	20.6	14.7	16.0	513
4KB	2.8	21.5	37.8	32.6	43.1	21.0	2.8	2.8	14.8	25.0	18.7	20.1	638
Total	15.0	328.4	556.2	411.2	465.4	243.7	15.0	15.0	200.4	359.3	243.9	290.6	8,241

Source: JICA Study Team

Table 4.2.1 Water Service Providers (WSPs) (TCA)

WSPs	Service Towns/Areas	Service Population in 2010	Capacity (m^3/day)	NRW
[Urban]				
Nyeri WSC	Nyeri	89,582	27,000	31%
Embu WSC	Embu	83,865	12,000	55%
Kirinyaga WSC	Kerugoya, Kutus, Wang'uru, Sagana, Kagumo,	186,478	19,452	82%
Mathira WSC	Mathira	29,760	17,000	66%
Meru WSC	Meru	56,914	4,509	23%
Murang'a WSC	Murang'a	32,034	4,848	47%
Kitui WSC	Kitui	174,231	7,756	56%
Kiambere Mwingi WSC	Mwingi	57,240	1,417	35%
Yatta WC	Matuu	6,828	704	28%
Lamu WSC	Lamu, Mukowe	12,802	3,600	50%
Tana WSC	Garsen, Hola		3,100	N.A
Garissa WSC	Garissa, Madogo	124,715	12,640	58%
Sub-total of Urban		854,449	114,026	
[Rural]				
Gatanga Community Water Project	Gatanga	36,354	5418	38%
Othaya Mukurweini	Othaya, Mukurweini	85,782	16,616	58%
Kahuti	Kangema	52,578	9,000	69%
Murang'a South	Kigumo, Kandara, Maragwa, Saba Saba	119,346	9,220	53%
Gichugu	Gichugu	29,928	17,717	74%
Nithi	Chogoria, Chuka, Kiriani	35,799	3,300	79%
Ngandori – Nginda	Manyatta, Mutunduri	49,977	15,000	26%
Gathamati	Njumbi, Kiriaini	38,930	8,391	72%
Kyeni	Kathageri, Karurumo &Kigumo	8,916	527	38%
Imetha	Nkubu, Timau, Kanyakine, Tigania, Maua, Mitunguu, Mwimbi, Ruiri	52,698	4,100	74%
Muthambi 4K	Muthambi	11,259	0	42%
Kathita Kiirua (CEFA)	Kiirua	16,788	1,253	60%
Ngagaka	Kianjokoma	27,504	24,780	70%
Tetu Aberdaire	Tetu, Kinaini, Titie	72,403	7,037	58%
Rukanga	Rukanga	N.A	800	N.A
Murugi Mukumango	Mukumango	15,612	0	67%
Ruiri Thau Water Association	Ruiri	13,892	1,080	85%
Embe	Ishiara, Ena, Siakago	7,871	6,733	86%
Sub-total of Rural		675,637	130,972	
Total		1,530,086	244,998	

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

Table 4.2.2 Proposed Water Supply Development Plan for UWSS (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 was 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 was counted as service population.

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

Table 4.2.3 Proposed Water Supply Development Plan for LSRWSS (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 4.2.4 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 4.3.1 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 4.3.2 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 4.4.1 Large Scale Irrigation Projects Selected for Implementation by 2030 (TCA)

No	Name of Project	County	Sub-basin Code	Irrigation Area (ha)	Project Type*1	Water Source Facilities*2		Present Status*3	Estimated Cost*4 (KSh mil.)	Executing Agency
						Type	Name of Dam			
1.	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 Extention	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

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

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

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

Sub-basin	Surface Water (m^3/s) Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average	Groundwater (MCM/year)
4AA	3.2	2.0	1.9	5.6	9.8	2.7	1.4	1.2	1.2	1.9	4.9	5.1	3.4	0.6
4AB	3.9	2.7	2.4	6.2	11.1	3.9	2.1	1.5	1.4	2.3	5.4	5.2	4.0	0.6
4AC	2.3	1.1	1.0	4.7	8.8	2.6	0.8	0.3	0.3	1.1	3.9	3.5	2.5	0.4
4AD	3.8	2.2	2.1	8.0	13.2	4.2	1.9	1.2	1.1	2.6	6.9	6.1	4.4	0.5
4BA	1.8	1.1	1.1	3.7	6.6	1.8	0.8	0.7	0.6	0.9	2.7	2.8	2.0	0.3
4BB	4.2	3.3	3.3	9.0	12.0	4.3	2.8	2.4	2.3	3.8	7.6	6.5	5.1	0.3
4BC	0.0	0.0	0.0	0.2	0.4	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.2
4BD	6.8	5.2	5.2	14.6	19.9	7.0	4.3	3.7	3.5	5.9	12.3	10.5	8.2	0.5
4BE	5.6	3.7	3.4	12.6	17.4	5.8	2.9	2.2	1.9	3.5	9.5	9.0	6.5	0.7
4BF	1.3	0.6	0.5	4.0	4.3	0.5	0.0	0.0	0.0	0.1	1.8	2.1	1.3	0.2
4BG	1.8	0.6	0.3	2.3	4.2	0.9	0.0	0.0	0.0	0.0	1.0	2.3	1.1	0.2
4CA	3.9	2.7	2.5	9.6	12.7	4.6	2.2	1.4	1.2	2.8	7.5	6.6	4.8	0.8
4CB	2.1	1.3	1.2	6.1	7.9	2.2	0.6	0.2	0.1	1.0	4.0	3.9	2.5	0.5
4CC	0.7	0.4	0.4	2.0	2.6	0.7	0.2	0.1	0.0	0.3	1.3	1.2	0.8	0.5
4DA	1.0	0.1	0.2	1.8	3.7	0.0	0.0	0.0	0.0	0.0	0.5	0.9	0.7	0.7
4DB	8.2	5.3	5.1	18.4	21.9	6.1	4.0	3.7	3.6	5.1	15.1	13.2	9.1	0.5
4DC	3.5	2.3	2.1	8.1	9.5	2.7	1.6	1.4	1.4	2.5	7.6	6.1	4.1	0.5
4DD	1.3	0.6	0.2	1.3	2.1	0.5	0.2	0.1	0.1	0.1	0.7	1.8	0.7	0.3
4DE	2.5	1.0	0.2	1.6	3.8	1.2	0.1	0.0	0.0	0.0	0.7	2.9	1.2	0.3
4EA	15.9	9.1	7.9	25.0	26.1	8.8	6.2	5.6	5.5	9.5	32.3	28.3	15.0	1.3
4EB	16.9	9.2	8.5	34.3	35.9	8.2	5.3	5.0	4.9	11.3	38.1	29.6	17.3	2.3
4EC	3.6	1.4	0.5	8.2	9.0	0.8	0.0	0.0	0.0	0.7	7.5	7.6	3.3	0.8
4ED	25.0	9.4	2.4	23.0	24.6	1.9	0.0	0.0	0.0	0.0	19.8	43.7	12.5	1.0
4FA	32.0	16.9	13.5	40.2	49.1	13.9	10.3	9.7	9.5	15.2	60.0	60.8	27.6	25.4
4FB	12.4	3.8	1.1	13.7	22.7	3.7	0.6	0.1	0.0	1.5	31.8	34.4	10.5	117.2
4GA	16.0	6.7	4.2	7.5	17.1	5.9	3.9	3.6	3.5	2.7	29.5	34.2	11.2	32.6
4GB	11.8	2.6	0.5	0.7	6.8	2.3	0.4	0.1	0.1	0.0	18.3	25.7	5.8	37.6
4GC	3.7	1.2	0.2	0.0	3.8	1.8	0.3	0.0	0.0	0.0	0.0	4.0	1.2	10.3
4GD	11.4	2.8	0.5	0.2	7.4	3.6	0.7	0.3	0.1	0.1	0.3	12.1	3.3	34.5
4GE	11.8	1.8	0.2	0.0	4.1	2.3	0.4	0.1	0.0	0.0	0.0	8.0	2.4	58.7
4GF	56.9	11.6	1.9	4.7	12.1	7.0	1.6	0.5	0.2	0.1	2.8	51.3	12.6	70.1
4GG	12.7	4.6	1.0	0.0	8.6	10.5	2.0	0.2	0.0	0.0	0.8	12.0	4.4	63.5
4HA	26.1	6.9	2.5	8.3	6.7	2.1	1.0	0.6	0.4	0.4	9.4	28.5	7.7	28.0
4HB	22.1	6.7	1.7	0.8	0.7	0.3	0.2	0.1	0.1	0.1	0.3	6.8	3.3	38.1
4HC	1.5	1.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.3	12.1
4JA	8.5	2.1	0.0	0.0	8.0	2.7	0.0	0.0	0.0	0.0	0.2	12.9	2.9	6.6
4JB	3.3	0.8	0.0	0.0	3.1	1.1	0.0	0.0	0.0	0.0	0.1	5.1	1.1	4.9
4KA	5.4	1.3	0.0	0.0	5.1	1.7	0.0	0.0	0.0	0.0	0.1	8.2	1.8	5.7
4KB	9.1	2.2	0.0	0.0	8.6	2.9	0.0	0.0	0.0	0.0	0.2	13.8	3.1	7.5

Source: JICA Study Team

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

(m³/s)

Sub-basin	Domestic		Industrial		Irrigation		Livestock		Wildlife		Fisheries	
	2010	2030	2010	2030	2010	2030	2010	2030	2010	2030	2010	2030
4AA	0.06	0.05	0.00	0.00	0.25	0.27	0.01	0.03	0.00	0.00	0.01	0.03
4AB	0.10	0.09	0.01	0.01	0.26	0.28	0.02	0.04	0.00	0.00	0.01	0.03
4AC	0.14	0.95	0.01	0.13	0.17	0.19	0.01	0.04	0.00	0.00	0.01	0.02
4AD	0.17	0.19	0.02	0.02	0.39	0.40	0.02	0.04	0.00	0.00	0.01	0.02
4BA	0.09	0.14	0.01	0.01	0.18	0.20	0.01	0.03	0.00	0.00	0.01	0.02
4BB	0.04	0.04	0.00	0.00	0.42	0.43	0.01	0.02	0.00	0.00	0.00	0.01
4BC	0.07	0.14	0.00	0.00	1.34	1.35	0.01	0.02	0.00	0.00	0.01	0.01
4BD	0.17	0.32	0.00	0.01	0.42	0.44	0.03	0.06	0.00	0.00	0.01	0.02
4BE	0.22	0.37	0.00	0.01	0.58	0.60	0.03	0.06	0.00	0.00	0.01	0.02
4BF	0.16	0.47	0.00	0.02	0.16	0.18	0.02	0.04	0.00	0.00	0.01	0.01
4BG	0.07	0.07	0.00	0.00	0.20	0.22	0.01	0.03	0.00	0.00	0.00	0.01
4CA	0.16	0.14	0.01	0.00	0.39	0.42	0.02	0.05	0.00	0.00	0.00	0.01
4CB	0.10	0.10	0.00	0.00	0.26	0.28	0.01	0.03	0.00	0.00	0.01	0.01
4CC	0.22	0.54	0.01	0.02	1.24	1.29	0.03	0.06	0.00	0.00	0.01	0.02
4DA	0.23	0.52	0.00	0.02	4.17	4.21	0.03	0.07	0.00	0.00	0.01	0.03
4DB	0.15	0.14	0.00	0.00	2.73	2.75	0.02	0.04	0.00	0.00	0.01	0.01
4DC	0.13	0.49	0.00	0.02	0.77	0.79	0.01	0.03	0.00	0.00	0.00	0.00
4DD	0.04	0.04	0.00	0.00	0.29	0.32	0.01	0.02	0.00	0.00	0.00	0.01
4DE	0.07	0.04	0.00	0.00	0.15	0.18	0.01	0.03	0.00	0.00	0.00	0.01
4EA	0.14	0.16	0.00	0.00	1.60	1.63	0.02	0.06	0.00	0.00	0.01	0.01
4EB	0.25	0.64	0.01	0.03	1.26	1.31	0.03	0.08	0.00	0.00	0.01	0.01
4EC	0.13	0.21	0.00	0.01	0.76	0.79	0.02	0.04	0.00	0.00	0.01	0.02
4ED	0.14	0.25	0.00	0.01	1.98	2.11	0.04	0.10	0.00	0.00	0.01	0.01
4FA	0.20	0.63	0.00	0.02	3.22	117.34	0.05	0.13	0.00	0.00	0.01	0.02
4FB	0.14	0.41	0.00	0.01	3.96	5.00	0.05	0.13	0.00	0.00	0.02	0.04
4GA	0.04	0.07	0.00	0.00	0.96	1.30	0.02	0.04	0.00	0.00	0.00	0.00
4GB	0.11	0.04	0.00	0.00	0.40	0.78	0.05	0.07	0.00	0.00	0.00	0.00
4GC	0.05	0.23	0.00	0.00	0.16	0.69	0.02	0.03	0.00	0.00	0.00	0.00
4GD	0.05	0.04	0.00	0.00	0.70	2.20	0.03	0.04	0.00	0.00	0.00	0.01
4GE	0.24	0.19	0.01	0.00	0.69	1.96	0.06	0.14	0.00	0.00	0.01	0.01
4GF	0.22	0.21	0.01	0.00	1.09	3.77	0.06	0.12	0.00	0.00	0.01	0.03
4GG	0.13	0.08	0.01	0.00	1.27	2.00	0.03	0.05	0.00	0.00	0.00	0.01
4HA	0.17	0.88	0.01	0.04	0.15	0.49	0.03	0.08	0.00	0.00	0.01	0.03
4HB	0.02	0.05	0.00	0.00	0.67	0.98	0.03	0.04	0.00	0.00	0.00	0.01
4HC	0.03	0.04	0.00	0.00	0.51	0.63	0.02	0.03	0.00	0.00	0.00	0.00
4JA	0.06	0.05	0.00	0.00	0.39	0.43	0.05	0.06	0.00	0.00	0.00	0.00
4JB	0.02	0.02	0.00	0.00	0.15	0.19	0.03	0.04	0.00	0.00	0.00	0.00
4KA	0.04	0.03	0.00	0.00	0.34	0.44	0.04	0.05	0.00	0.00	0.00	0.00
4KB	0.08	1.78	0.00	0.93	0.38	0.50	0.07	0.10	0.00	0.00	0.00	0.01

Source: JICA Study Team

Table 4.6.3 Reserve Quantity by Sub-basin for Water Balance Study

Sub-basin	Catchment Area (km^2)	Accumulated Catchment Area (km^2)	River Name	Reserve *1 (m^3/s)	Node *2
4AA	497		Tana River	1.0	2
4AB	672			1.5	4
4AC	417	1,586		4.8	9
4AD	457			2.2	11
4BA	299	2,343		7.4	16
4BB	256			0.8	18
4BC	209	2,808		9.9	23
4BD	539			1.6	26
4BE	611	3,959		13.5	35
4BF	382			1.8	37
4BG	450	4,791		16.4	42
4CB	326			2.7	48
4CA	530			4.1	60
4CC	1,010	1,866		9.4	69
4DE	731	7,388		26.3	81
4DC	345			0.5	86
4DB	435			0.4	88
4DA	778	1,559		3.2	96
4DD	456	2,015		3.5	100
4EC	653			3.7	122
4ED	3,208	13,265		39.7	125
4EB	1,169			4.5	127
4EA	765	1,934		8.3	130
4FA	2,187	17,386		52.1	143
4FB	3,999	21,385		53.5	147
4GA	3,903	25,288		56.3	152
4GB	5,530	30,818		55.0	157
4GC	1,931	32,749		53.5	161
4GD	7,499	40,249		51.0	165
4GE	11,752	52,001		49.1	170
4GF	15,582	67,583		43.8	175
4HA	5,477			3.3	189
4HB	8,579	14,057		0.0	193
4HC	7,010			0.0	198
4GG	7,235	95,884		35.2	201
4KA	6,011			0.0	203
4KB	10,174			0.0	206
4JA	9,553			0.0	208
4JB	3,728			0.0	210

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

Table 4.6.4 Dam Candidates (TCA)

(1) Priority Dams proposed in NWMP (1992)

		NWMP (1992)				Current Status			
Catchment Area		Proposed Dams	Sub-basin	Stage	Purpose	Related Agency/ Owner	Status/ Construction Year	Source of Information	Remarks
5.	Tana	23. Chania-B	4CA	M/P	W, I	TWSB	No further study is done.	WRMA	
		24. Thiba	4DA	F/S	I	NIB	D/D review completed (2012)	NWCPC	2008-12 Flagship Projects under Vision 2030
		25. Mutonga	4FA	Pre-F/S	P	KenGen	F/S done (1998)	MORDA	
		26. Low Grand Falls	4FB	Pre-F/S	P	KenGen	F/S done (1998)	MORDA	F/S and D/D done for High Grand Falls Scheme

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

		NWMP (1992)				Current Status			
Catchment Area		Future Development Potential Dams		Sub-basin	Purpose	Related Agency/ Owner	Status/ Construction Year	Source of Information	Remarks
5.	Tana	30	Maragua 8	4BE	W				No information is found.
		31	Ndiara	4CA	W				No information is found.
		32	High Grand Falls	4FB	P, W, I	TARDA/ MORDA	F/S, D/D completed (2012)	MORDA	2008-12 Flagship Projects under Vision 2030, MORDA 18 Projects, Construction will start soon.
		33	Adamson Falls	4GA	P, W, I				No information is found.
		34	Kora	4GB	P, W, I	NWCPC	No further study is done.	NWCPC	2008-12 Flagship Projects under Vision 2030
		35	Umaa	4HA	W	NWCPC	U/C (to be completed in 2013)	NWCPC	2008-12 Flagship Projects under Vision 2030
		36	Mutuni	4HA	W				No information is found.
		37	Kitimui	4HA	W				No information is found.

(3) Dam Schemes Studied by Government

		Identified Dams				Current Status			
Catchment Area		Dams not in NWMP (1992)		Sub-basin	Purpose	Related Agency/ Owner	Status/ Construction Year	Source of Information	Remarks
5.	Tana	17	Maragua 4	4BE	W	AWSB	F/S, M/P ongoing (to be completed in 2012)	AWSB	F/S and M/P for Developing New Water Sources for Nairobi and Satellite Towns
		18	Karimenu 2	4CA	W	AWSB	F/S, M/P ongoing (to be completed in 2012)	AWSB	F/S and M/P for Developing New Water Sources for Nairobi and Satellite Towns
		19	Thika 3A	4CC	W	AWSB	F/S, M/P ongoing (to be completed in 2012)	AWSB	F/S and M/P for Developing New Water Sources for Nairobi and Satellite Towns
		20	Yatta	4CC	W	NWCPC	D/D completed (2009)	NWCPC	
		21	Thua	-	-	NWCPC	Pre-F/S will start soon.	NWCPC	NWCPC Strategic Plan 2010-15

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

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

Table 4.6.5 Water Transfer Candidates (TCA)

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

a) Intra-basin Bulk Water Transfer Schemes
None

b) Inter-basin Bulk Water Transfer Schemes

Catchment Area			NWMP (1992) Inter- basin Water Transfer					Current Status			
		No.	Sub-basin	Water Source		Sub-basin	Notes	Related Agency / Owner	Status/ Construction Year	Source of Information	Remarks
5.	Tana	E10	4CA	Chania B Dam		3BA		AWSB	Some study is done.	AWSB	
		E11	4CA	Komu Transfer	without dam	3CB		AWSB	Studies ongoing.	AWSB	
		E12	4CA	Komu Transfer	without dam	3DA	Alternative for Ndarugu Dam	AWSB	Studies ongoing.	AWSB	
		E13	4CB	Thika Dam System		3AA		AWSB	Operational	AWSB	Study for additional pipeline is ongoing.
		E14	4DE	Masinga Dam	existing dam	4HA		TARDA/ KenGen	Operational	Tanathi WSB	
		E15	4GF	Tana River	without dam	4KB		MWI/ NWCPC	No further study is done.	CWSB	

(2) Water Transfer Schemes Studied by Government

a) Intra-basin Bulk Water Transfer Schemes

Catchment Area		No.	Sub-basin	Water Source		Sub-basin	Related Agency / Owner	Status/ Construction Year	Source of Information	Remarks
5.	Tana		4ED	Kiambere to Mwingi		4ED/ 4GE		Operational	Tanathi WSB	

b) Inter-basin Bulk Water Transfer Schemes

Catchment Area		No.	Sub-basin	Water Source		Sub-basin	Related Agency / Owner	Status/ Construction Year	Source of Information	Remarks
5.	Tana		4CA	Sasumua Dam		3BA	AWSB	Operational	AWSB	
			4HA	Umaa Dam*		4HA	NWCPC	Under construction	NWCPC	

Note:
Project Stage: M/P=master plan, Pre-F/S=prefeasibility study, F/S=feasibility study, D/D=detailed design, T/D=tender documents, U/C=under construction
* = Listed by NWCPC as "Inter-basin Transfer Schemes."

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

Table 4.6.6 Proposed Dams and Water Transfer (TCA) (1/2)

(1) Proposed Dams

No.	Name of Dam	Sub-basin	Relevant County	Purpose 1)	Effective Storage Volume (MCM)	Storage Volume Allocation (MCM)			
						Domestic and Industrial	Irrigation	Hydro-power	Flood Control
44	Maragua 4	4BE	Muranga	W (Nairobi in ACA)	2) *33.0*	33.0	0.0		
45	Ndiara	4CA	Kiambu	W (Nairobi in ACA)	12.0	12.0	0.0		
46	Chania-B	4CA	Kiambu	W (Nairobi in ACA)	49.0	49.0	0.0		
47	Karimenu 2	4CA	Kiambu	W (Nairobi in ACA)	*14.0*	14.0	0.0		
48	Thika 3A	4CC	Kiambu	W (Nairobi in ACA)	*13.0*	13.0	0.0		
49	Yatta	4CC	Kiambu, Machakos	W (Matuu)	*35.0*	*35.0*	*0.0*		
50	Thiba	4DA	Kirinyaga, Embu	I (9,485 ha)	*11.2*	*0.0*	*11.2*		
51	High Grand Falls	4FB	Kitui, Tharaka	W (Garissa, Madogo, Hola, Masalani, Lamu), I (106,000 ha), P (700 MW), F	3) *5,000.0*	4), 5) (291.0)	(3,251.0)	3,542.0	1,458.0
52	Kora	4GA	Tana River, Isiolo	I (25,000 ha)	*537.0*	0.0	537.0		
53	Mutuni	4HA	Kitui	W (Kitui)	17.0	17.0	0.0		
54	Kitimui	4HA	Kitui, Machakos	W (Kitui)	8.0	8.0	0.0		
	Total				5,729.2	181.0	548.2	3,542.0	1,458.0

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

Table 4.6.6 Proposed Dams and Water Transfer (TCA) (2/2)

(2) Proposed Water Transfer

Water Transfer Scheme		Relevant County	Purpose	Capacity, Dimensions
7	Tana River (High Grand Falls Dam) to Lamu Port	Muranga, Kiambu, Nairobi	W	Capacity of 69 MCM/year, Pipeline
8	Masinga Dam to Kitui (Expansion)	Garissa, Lamu	W	Capacity of 23 MCM/year, Pipeline of 300 mm dia, 70 km long
9	Kiambere Dam to Mwingi (Expansion)	Machakos, Kitui	W	Capacity of 2 MCM/year, Pipeline of 300 mm dia, 30 km long
10	TCA to Nairobi in ACA (Expansion)	Kitui	W	Capacity of 168 MCM/year, Tunnels and pipelines

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

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

(Unit: MCM/year)

No.	Sub basin	CA (km^2)	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	0.1	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	0.1	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	0.1	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	0.2	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	0.1	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	0.1	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	0.1	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	0.1	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	0.1	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	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	0.1	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	0.1	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 4.6.8 Naturalised River Flow, Reserve, Water Demands, and Yields and Supply Reliability at Reference Points (TCA)

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			
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

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

Source: JICA Study Team

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

	Urban Centre	Service Population in 2030	Water Demand in 2030 (m^3/day)	Rehabilitation Works (m^3/day)	Development Capacity (m^3/day)	Project Cost (KSh million)					O&M Cost (KSh million/year)
						Total	Rehabilitation Works	Major Dam/ Major Transmission	Intake/ Minor Transmission	Distribution	
Upstream of Tana Catchment											
1	Nyeri	600,803	71,496	27,000	36,048	9,423	2,510		1,152	5,761	336
14	Karatina	42,783	5,091	0							
15	Othaya	25,859	3,077	16,616							
2	Embu	305,362	36,338	12,000	36,048	7,604	690		1,152	5,761	336
11	Runyenjes	98,401	11,710	0							
3	Meru	269,949	32,124	4,500	37,943	7,536	259		1,213	6,064	354
6	Maua	86,713	10,319	0							
4	Chuka	218,821	26,040	2,700	39,761	7,816	190		1,271	6,355	371
5	Chogoria	143,036	17,021	600							
8	Muranga	144,849	17,237	14,848	44,549	9,398	854		1,424	7,120	416
9	Maragua	132,762	15,799	0							
7	Makuyu	221,524	26,361	0							
12	Kerugoya/Kutus	97,767	11,634	11,834	18,129	4,294	817		579	2,897	169
10	Wanguru	120,726	14,366	0							
13	Sagana	53,112	6,320	2,358							
	Sub-total	2,562,468	304,934	92,456	212,478	46,071	5,320	0	6,792	33,959	1,983
Arid Area											
1	Garissa	143,348	17,058	12,640	4,418	1,575	727		141	706	41
2	Madogo	19,308	2,298	0	2,298	441	0		73	367	21
3	Msalani	18,371	2,186	0	2,186	419	0		70	349	20
4	Hola	17,553	2,089	1,400	689	213	81		22	110	6
	Sub-total	198,580	23,631	14,040	9,591	2,647	808	0	307	1,533	90
Other Area											
1	Lamu	1,250,000	108,750	3,400	105,350	22,787	196		5,754	16,838	983
	High Grand Falls Dam							0			0
	Transmission (from Tana to Lamu)					26,936		26,936			135
2	Kitui	551,547	65,634	7,750	57,884	11,548	446		1,850	9,251	540
	Mutuni Dam					3,273		3,273			16
	Kitimui Dam					4,910		4,910			25
	Transmission (to Kitis)					1,705		1,705			9
3	Matuu	255,467	30,401	702	29,699	5,736	40		949	4,747	277
	Yatta Dam					1,381		1,381			7
4	Mwingi	80,390	9,566	1,417	8,149	1,645	82		260	1,302	76
	Transmission (to Muwangi)					852		852			4
	Sub-total	2,137,404	214,351	13,269	201,082	80,772	763	39,057	8,814	32,138	2,072
	Total	4,898,453	542,916	119,765	423,151	129,488	6,887	39,057	15,912	67,632	4,145

Source: JICA Study Team

Table 5.2.2 Cost Estimate for Proposed Urban Water Supply Development (TCA)

	Item	Service Population in 2030	Water Demand in 2030 (m^3/day)	Rehabilitation Works (m^3/day)	Development Capacity (m^3/day)	Project Cost (KSh million)					O&M Cost (KSh million/year)
						Total	Rehabilitation Works	Major Dam/ Major Transmission	Intake/ Minor Transmission	Distribution	
1	Other Urban Pop.	932,041	110,913	108,972	1,941	6,646	6,274		62	310	18
2	Rural Pop.	810,576	61,604	40,320	21,284	4,077	0		680	3,397	199
	Total	1,742,617	172,517	149,292	23,225	10,723	6,274		742	3,707	217

Source: JICA Study Team

Table 5.2.3 Cost Estimate for Proposed Sewerage Development (TCA)

Major Urban Area		Service Population in 2030	Required Capacity in 2030 (m^3/day)	Current Capacity in 2010 (m^3/day)	Capacity to be developed (m^3/day)	Project Cost (KSh million)			O&M Cost (KSh million/year)
						Total	Rehabilitation Works	Expansion/ New Construct.	
1	Lamu	1,250,000	95,250	0	95,250	16,240	0	16,240	889
2	Nyeri	600,803	45,781	8,100	37,681	6,838	414	6,424	352
3	Kitui	551,547	42,028	0	42,028	7,165	0	7,165	392
4	Thika	513,806	39,152	20,000	19,152	4,289	1,024	3,265	179
5	Embu	305,362	23,269	682	22,587	3,885	35	3,851	211
6	Meru	269,949	20,570	1,000	19,570	3,387	51	3,336	183
7	Matuu	255,467	19,467	0	19,467	3,319	0	3,319	182
8	Makuyu	221,524	16,880	0	16,880	2,878	0	2,878	158
9	Chuka	218,821	16,674	0	16,674	2,843	0	2,843	156
10	Muranga	144,849	11,037	1,561	9,476	1,695	80	1,616	88
11	Garissa	143,348	10,923	1,000	9,923	1,743	51	1,692	93
12	Chogoria	143,036	10,899	0	10,899	1,858	0	1,858	102
13	Maragua	132,762	10,116	0	10,116	1,725	0	1,725	94
14	Wanguru	120,726	9,199	0	9,199	1,568	0	1,568	86
15	Runyenjes	98,401	7,498	0	7,498	1,278	0	1,278	70
16	Kerugoya/Kutus	97,767	7,450	0	7,450	1,270	0	1,270	70
17	Maua	86,713	6,608	0	6,608	1,126	0	1,126	62
18	Mwingi	80,390	6,126	0	6,126	1,044	0	1,044	57
Total		5,235,273	398,928	32,343	366,585	64,152	1,655	62,497	3,422

Source: JICA Study Team

Table 5.2.4 Cost Estimate for Proposed Irrigation Development (TCA)

Category	Irrigation Area in 2030 (ha)	Project Cost* (KSh million)			Annual O&M Cost (KSh million)
		Irrigation System	Multipurpose Dam Cost Allocation**	Total Project Cost	
Large Scale Irrigation	135,961	311,620	13,255	324,875	975
Small Scale Irrigation	15,784	10,200	-	10,200	51
Private Irrigation	10,054	19,491	-	19,491	195
Total	161,799	341,311	13,255	354,566	1,221

Note: *: Project cost includes direct construction cost, physical contingency, engineering services and indirect costs.
**: Refer to Sectoral Report (G)
Source: JICA Study Team, based on data from relevant government authorities

Table 5.2.5 Cost Estimate for Proposed Hydropower Projects (TCA)

Catchment Area	No.	Name of Plan	Installed Capacity	Estimated Cost: Dam Allocation Cost (KSh million)	Estimated Cost: Hydropower Component cost (KSh million)	Estimated Cost: Total Project Cost (KSh million)	Estimated Cost: Annual O&M Cost (KSh million)	Purpose
TCA	13	High Grand Falls Multipurpose Dam Development Plan	Stage 1: 500 MW (Stage 2: + 200 MW)	99,611	24,890	124,501	623	Water Supply, Irrigation, Hydropower
	14	Karura Hydropower Development Project	90 MW		28,385	28,385	142	Hydropower
		Total	790 MW	99,611	53,275	152,886	765	

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

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

Dams

Name of Dam		Sub-basin	Purpose 1)	Effective Storage (MCM)	Study Stage 2)	Cost (KSh million)
44	Maragua 4	4BE	W	33.0	F/S and M/P ongoing	6,990
45	Ndiara	4CA	W	12.0	NWMP 2030	6,990
46	Chania-B	4CA	W	49.0	NWMP 2030	14,065
47	Karimenu 2	4CA	W	14.0	F/S and M/P ongoing	3,665
48	Thika 3A	4CC	W	13.0	F/S and M/P ongoing	3,239
49	Yatta	4CC	W	35.0	D/D completed	1,364
50	Thiba	4DA	I	11.2	D/D completed	7,416
51	High Grand Falls	4FB	W, I, P, F	5,000.0	D/D completed	89,161
52	Kora	4GA	I	537.0	NWMP 2030	13,127
53	Mutuni	4HA	W	17.0	NWMP 2030	3,239
54	Kitimui	4HA	W	8.0	NWMP 2030	4,859
Total				5,729.2		154,115

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

Water Transfer

Wter Transfer Scheme		Purpose	Capacity, Dimensions	Cost (KSh million)
7	Tana River (High Grand Falls Dam) to Lamu Port	W	Capacity of 69 MCM/year, Pipeline	26,936
8	Masinga Dam to Kitui (Expansion)	W	Capacity of 23 MCM/year, Pipeline of 300 mm dia, 70 km long	1,790
9	Kiambere Dam to Mwingi (Expansion)	W	Capacity of 2 MCM/year, Pipeline of 300 mm dia, 30 km long	767
10	TCA to Nairobi in ACA (Expansion)	W	Capacity of 168 MCM/year, Tunnels and pipelines	74,244
Total				103,737

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

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

Development Cost (Unit: KSh thousand)

No.	Item	TCA			
		Unit cost	Q'ty	Unit of Q'ty	Cost
1) Monitoring					**124,500**
	Installation/Rehabilitation of River Gauging Stations	240	10	nos.	2,400
	Installation/Rehabilitation of Rainfall Gauging Stations	100	19	nos.	1,900
	Installation of Dedicated Boreholes for Groundwater Monitoring	2,000	18	nos.	36,000
	Replacement of iron post for river gauge to concrete post	100	26	nos.	2,600
	Upgrade manual gauge to automatic (surface water level)	1,000	26	nos.	26,000
	Upgrade manual gauge to automatic (groundwater level)	200	18	nos.	3,600
	Upgrade manual gauge to automatic (rainfall)	1,000	47	nos.	47,000
	Flood Discharge Measurement Equipment (each sub-region)	1,000	5	nos.	5,000
2) Evaluation					**53,855**
	Hydromet DB Upgrade (Software + Hardware) including training	2,500	18	nos.	45,000
	Establishment of additional Water Quality Test Laboratory (Lodwar, Kapenguria, Mombasa, Garissa, Marsabit, Wajir) - Building and Utility	6,750	1	nos.	6,750
	Laboratory Equipment and Reagents	2,105	1	nos.	2,105
3) Permitting					
	PDB Upgrade (Software + Hardware) including training	1,500	18	nos.	27,000
4) Watershed Conservation					
	Forestation to achieve 10% of Forest Cover	79	1,366,000	ha	107,914,000
	Total				**108,119,355**

Recurrent Cost (Annual) (Unit: KSh thousand)

No.	Item	TCA			
		Unit cost	Q'ty	Unit of Q'ty	Cost*
1) Monintoring and Analysis					**137,064**
	Surface Water Monitoring (Daily)	12	312	nos.	3,744
	River Discharge Measurement (Monthly)	80	312	nos.	24,960
	Groundwater Monitoring (Monthly)	12	216	nos.	2,592
	Rainfall Monitoring (Daily)	12	564	nos.	6,768
	Flood Discharge Measurement (Three times a year)	100	936	nos.	93,600
	Surface Water Quality Monitoring (Monthly)	30	60	nos.	1,800
	Surface Water Quality Monitoring (Quarterly)	30	84	nos.	2,520
	Gruondwater Quality Monitoring (Twice a year)	30	36	nos.	1,080
2) Others					
	Catchment Forum Operation (Venue and Allowances to WRUAs)	500	2	times	1,000
	Total				**138,064**

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

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

CA	No.		Description	Project Cost for Structure (KSh million)	Project Cost for Non-Structure (KSh million)	Recurrent Cost* (KSh million /year)	Source	Remarks
Tana	T1	**Garissa**		**153.83**	**60.00**	**0.30**		
	A	T1.1	Construction of Multipurpose Dam	-		-		High Grand Falls Dam
	B	T1.2	River Training Works	153.83		-		
	D	T1.3	Preparation of Hazard Map		30.00	0.15		10M/M
	E	T1.4	Formulation of Evacuation Plan		30.00	0.15		10M/M
	T2	**Tana River lower than Garissa**		**310.52**	**176.07**	**2.43**		
	F	T2.1	Establishment of Community-based Flood Management System	310.52	146.07	2.28	Nyando MP	
	J	T2.2	Improvement of Warning System for Hydropower Dam		30.00	0.15		10M/M

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

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

Table 5.2.9 Cost Estimate for Proposed Environmental Management Plan (TCA)

Description		Development Cost: River and Lake Environment Survey (KSh million)	Development Cost: Setting of Environmental Flow Rate (KSh million)	Recurrent Cost* (KSh million /year)
1.Environmental River Flow				
1.1	Tana River	51.5	3.3	-
1.2	Chania River	6.1	1.1	-
2.Environmental Monitoring				
2.1	Tana River	-	-	0.0
2.2	Chania River	-	-	0.0

Note: Basic conditions for cost estimate are supposed as follows;

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

*Recurrent cost includes operation and maintenance costs

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

Figures

JAPAN INTERNATIONAL COOPERATION AGENCY

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

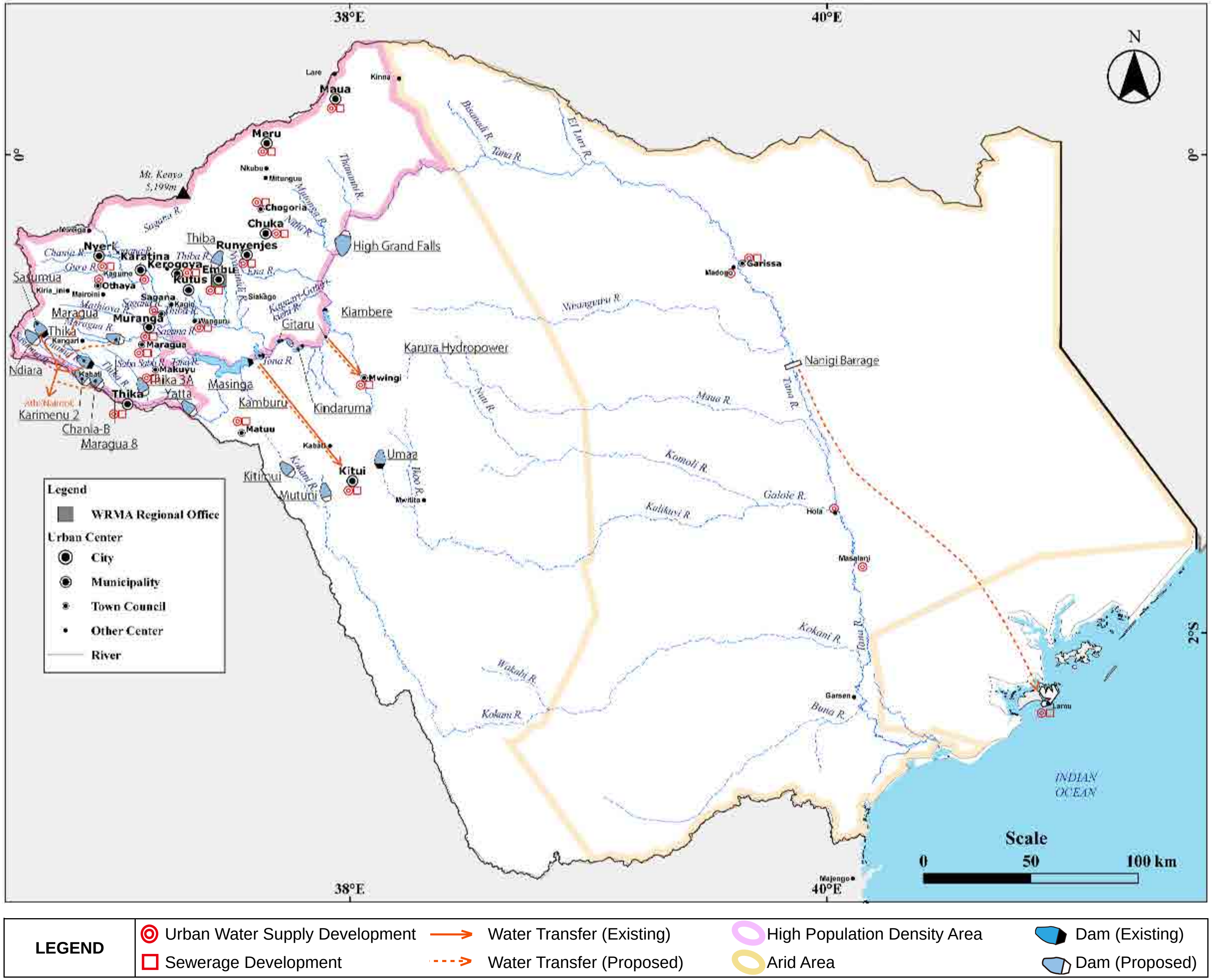
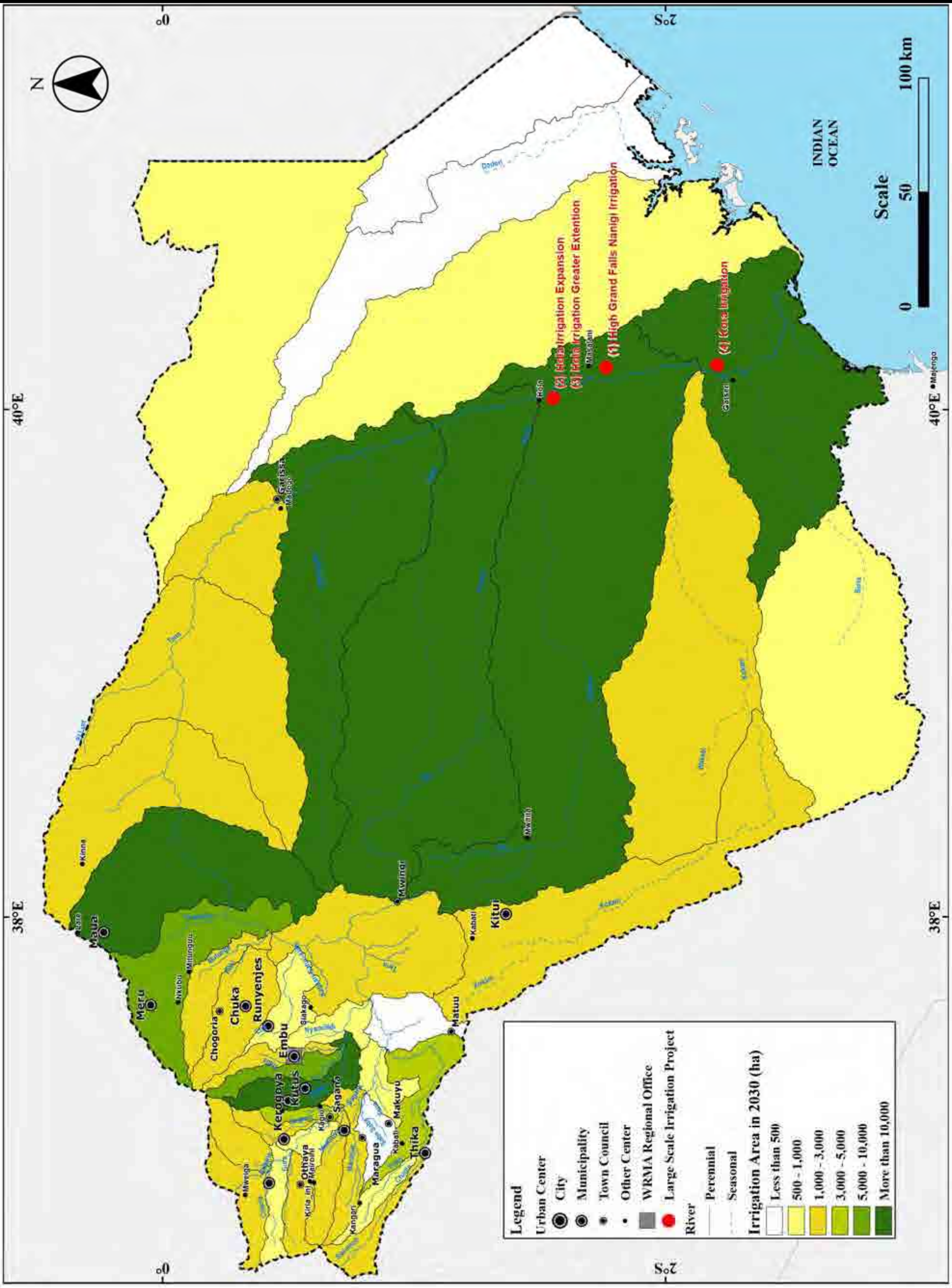


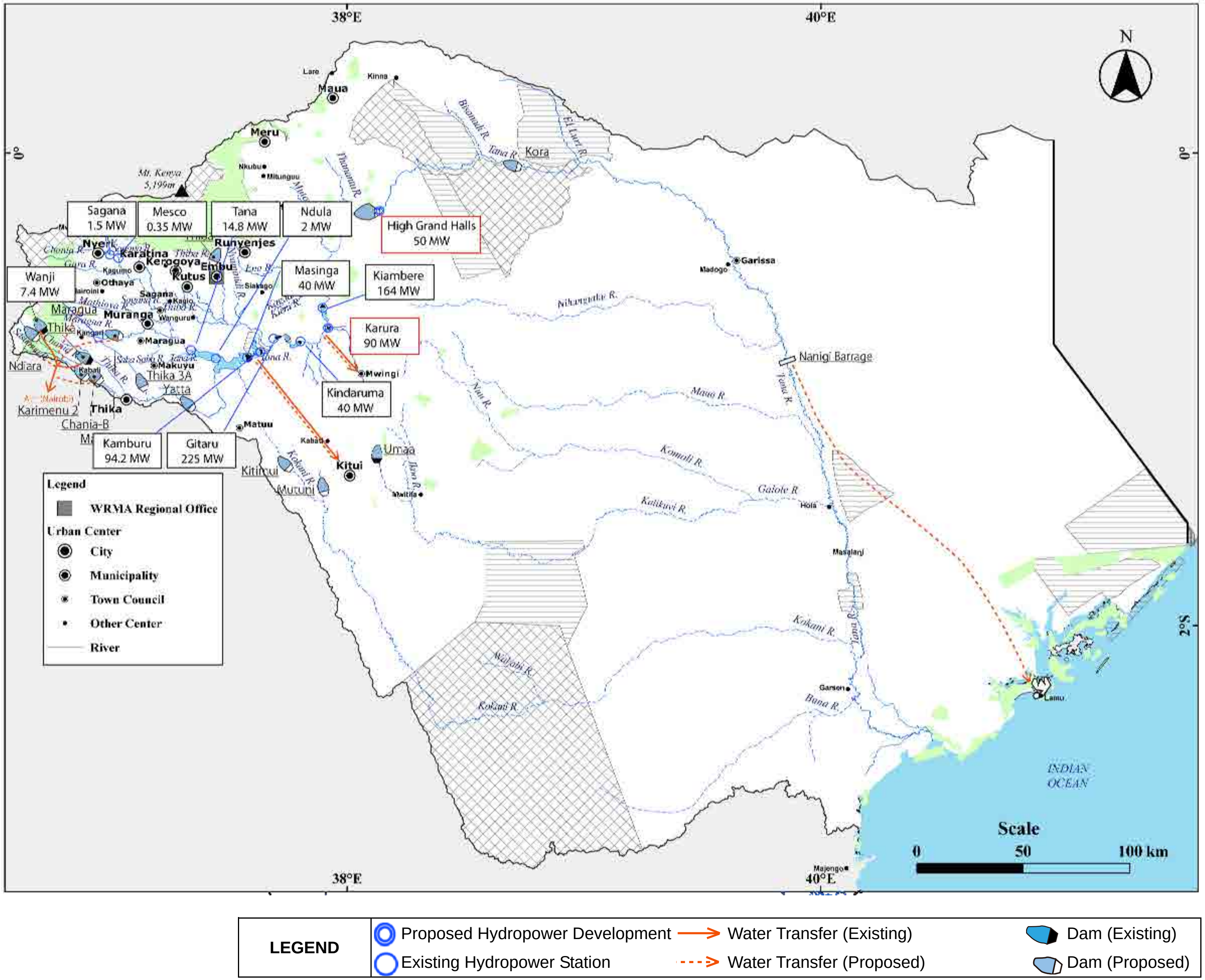
Figure 4.2.1
Proposed Urban Water Supply and
Sewerage Development Plans (TCA)

Source: JICA Study Team



Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	Figure 4.4.1 Proposed Irrigation Development Plan (TCA)
JAPAN INTERNATIONAL COOPERATION AGENCY	



Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030

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Figure 4.5.1 Existing Hydropower Station and Proposed Hydropower Development Plan (TCA)

THE DEVELOPMENT OF
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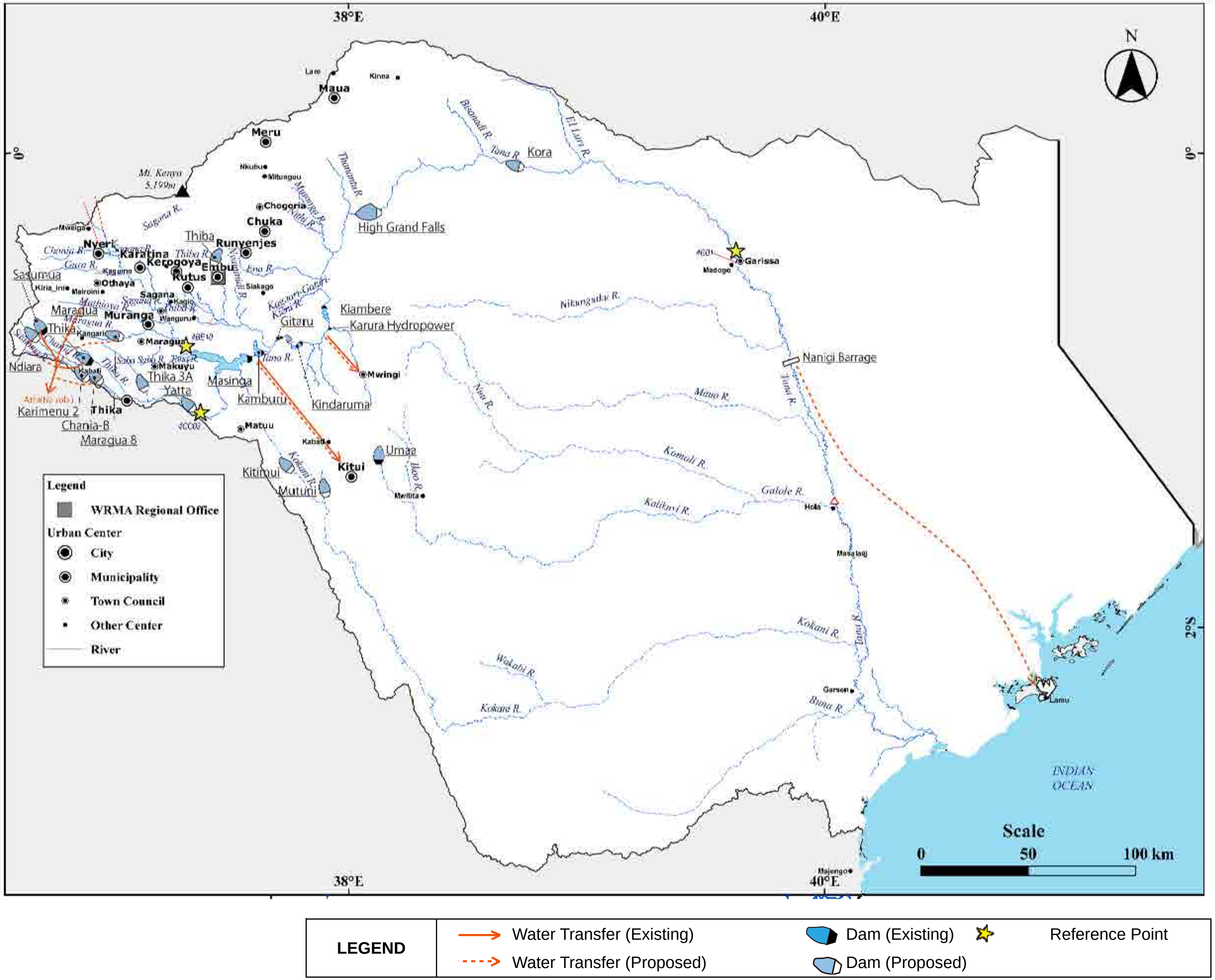
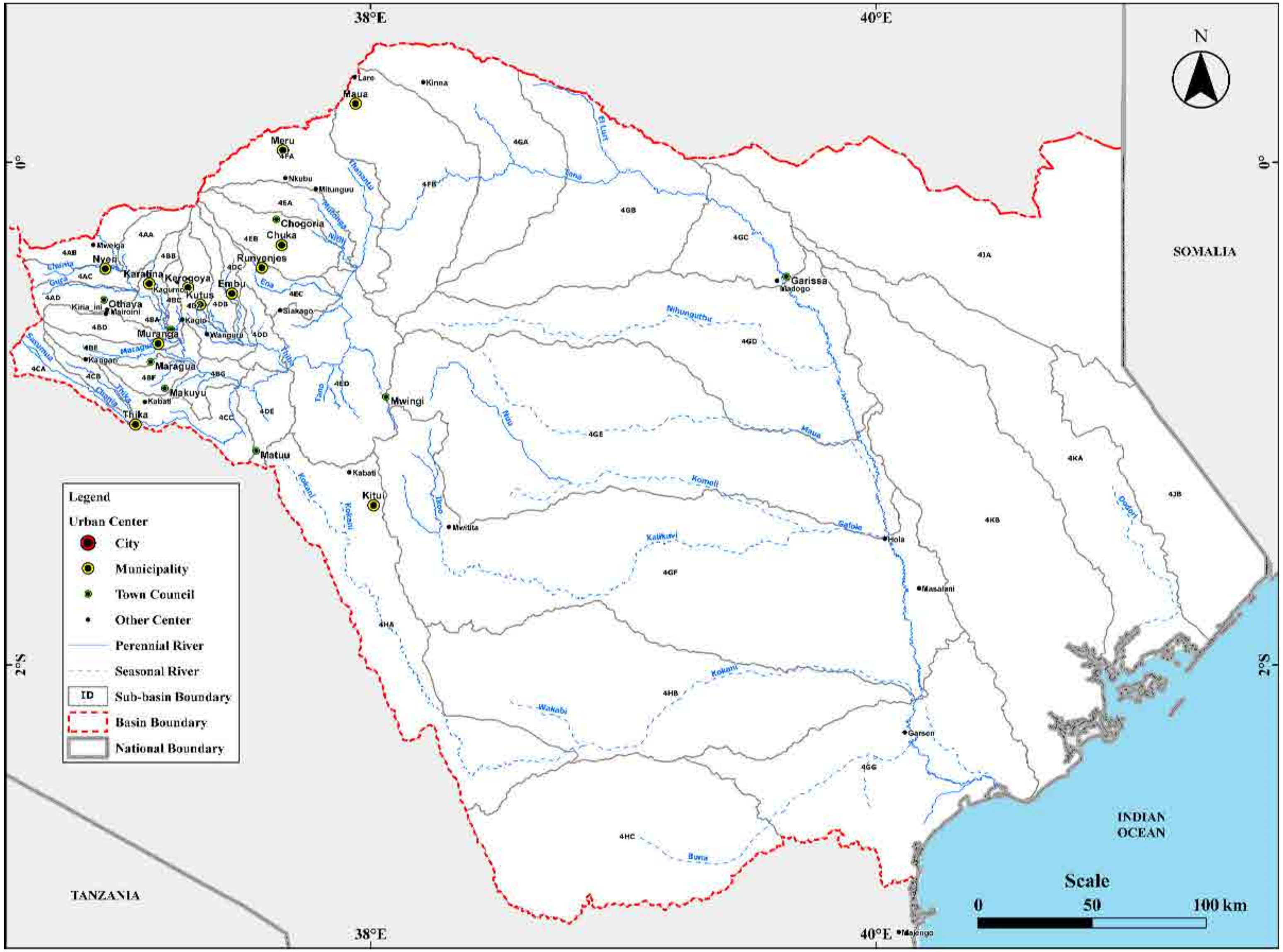
Figure 4.6.1
Existing and Proposed Dams and Water Transfer Facilities (TCA)

Source: JICA Study Team





Source: JICA Study Team

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030
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Figure 4.6.2
Sub-basin Division Map (TCA)

THE DEVELOPMENT OF
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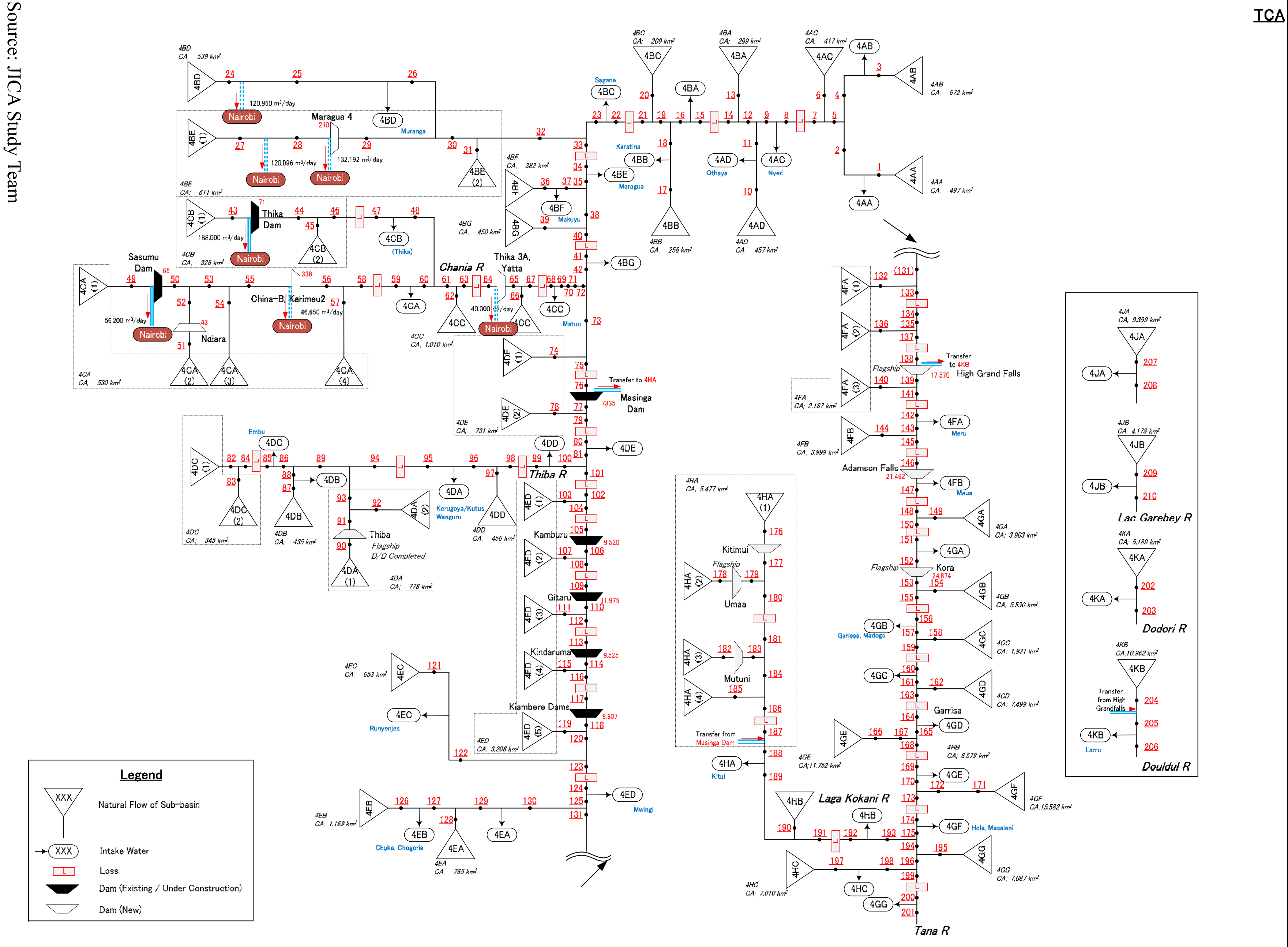
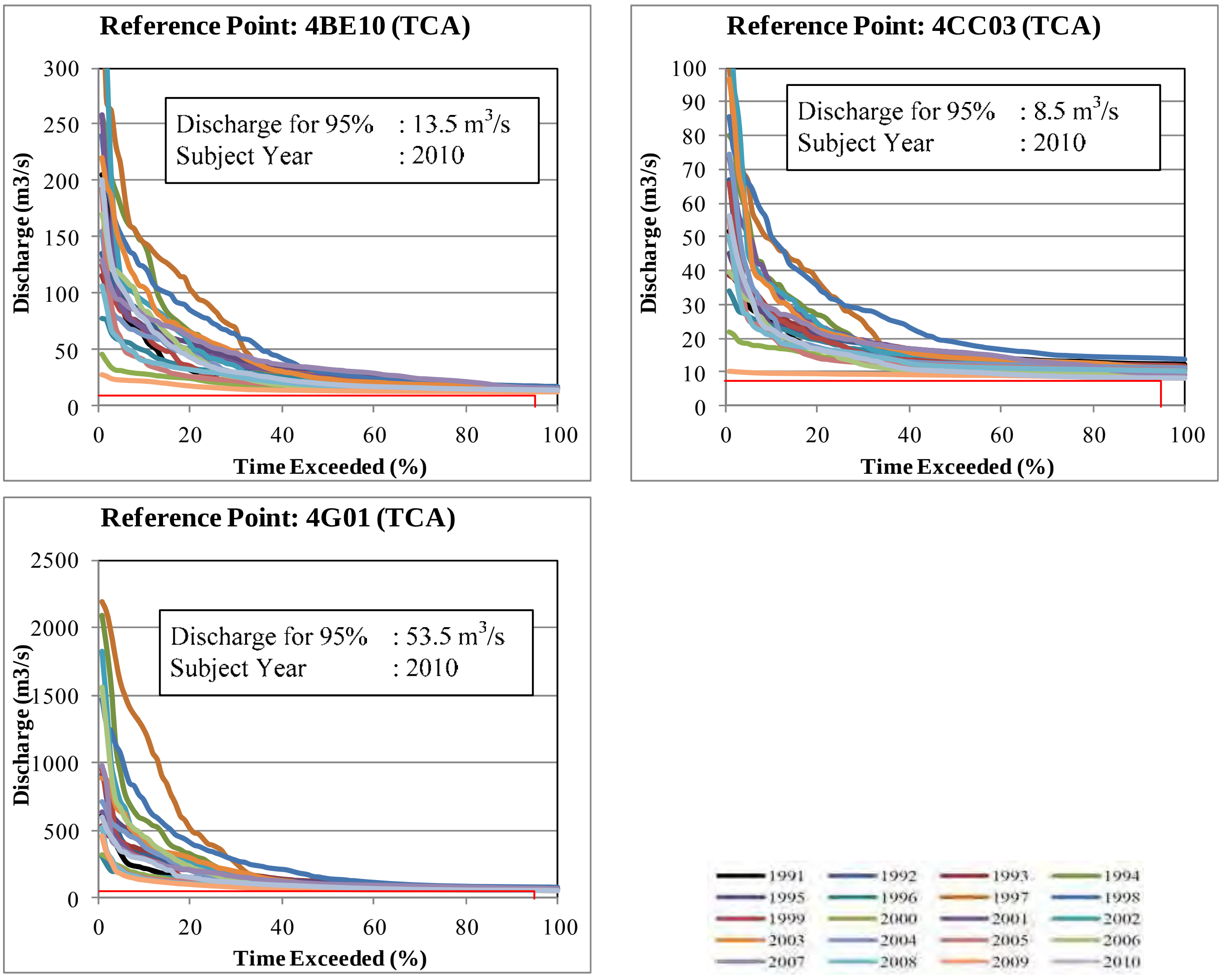
Figure 4.6.3
Surface Water Balance Calculation Model (TCA)

Source: JICA Study Team

TCA





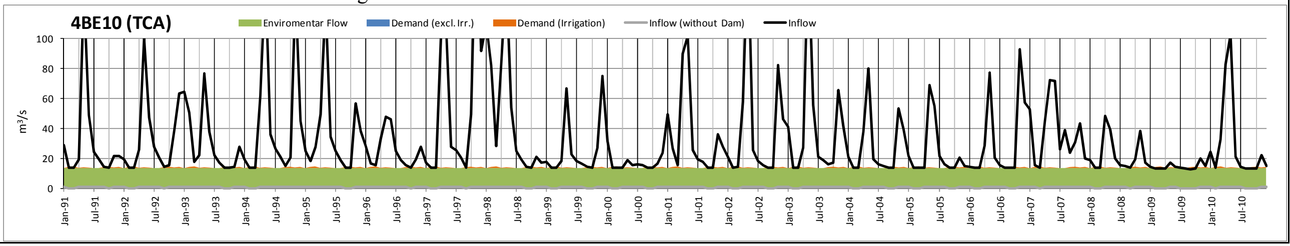
Source: JICA Study Team

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

River Name: Tana River (upper) (TCA)
Reference Point: 4BE10

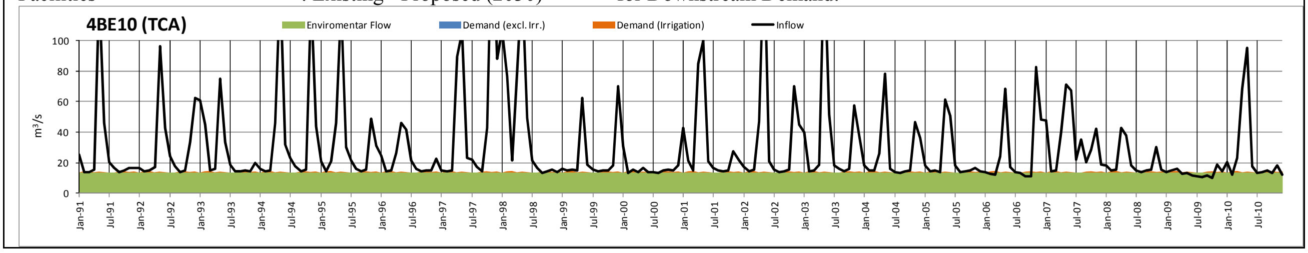
River Flow : Present (1991-2010)
Water Demand : 2010
Facilities : Existing

Reserve: 13.5 (m³/s)
Required Discharge to be maintained for Downstream Demand: 0.7 (m³/s)



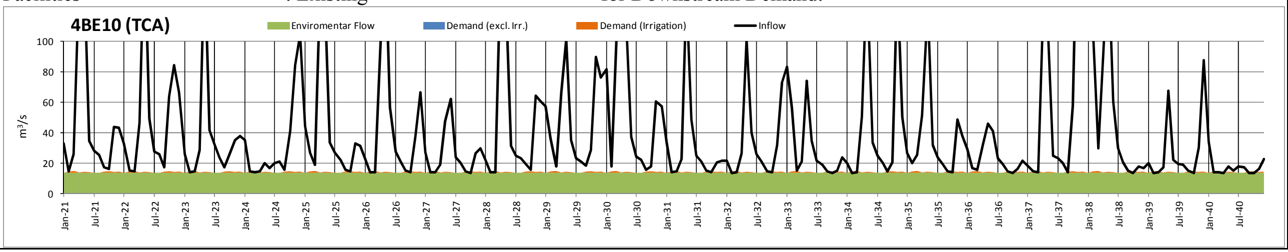
River Flow : Present (1991-2010)
Water Demand : 2030
Facilities : Existing +Proposed (2030)

Reserve: 13.5 (m³/s)
Required Discharge to be maintained for Downstream Demand: 0.9 (m³/s)



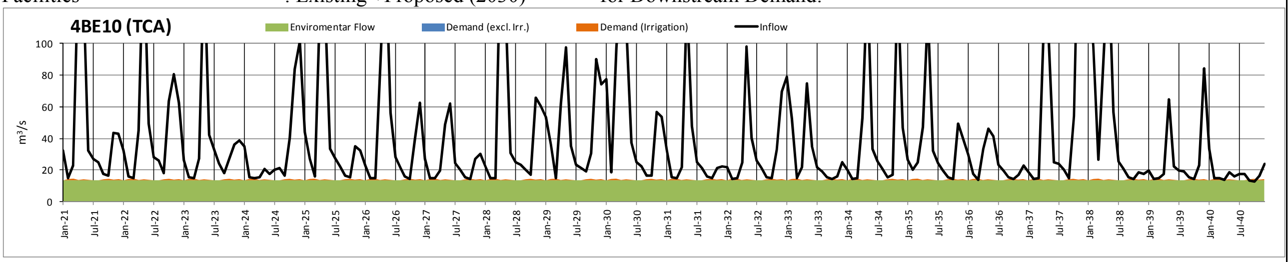
River Flow : Future (2021-2040)
Water Demand : 2010
Facilities : Existing

Reserve: 13.5 (m³/s)
Required Discharge to be maintained for Downstream Demand: 0.7 (m³/s)



River Flow : Future (2021-2040)
Water Demand : 2030
Facilities : Existing +Proposed (2030)

Reserve: 13.5 (m³/s)
Required Discharge to be maintained for Downstream Demand: 0.9 (m³/s)



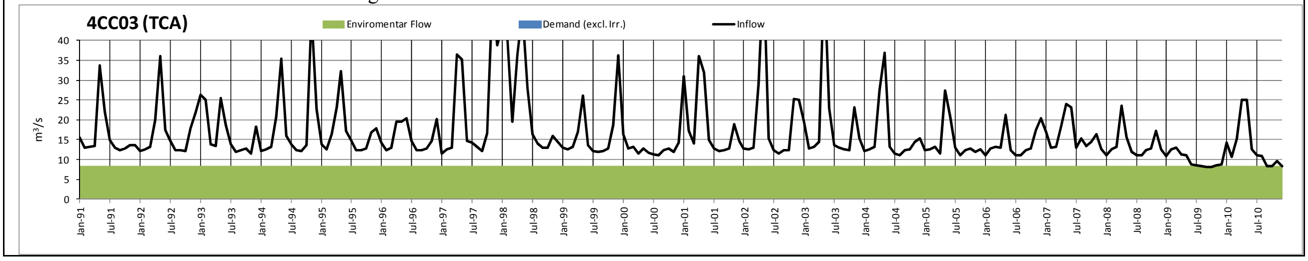
Note: * Irrigation water demand is the average irrigation water demand during March, April, and May.

Source: JICA Study Team

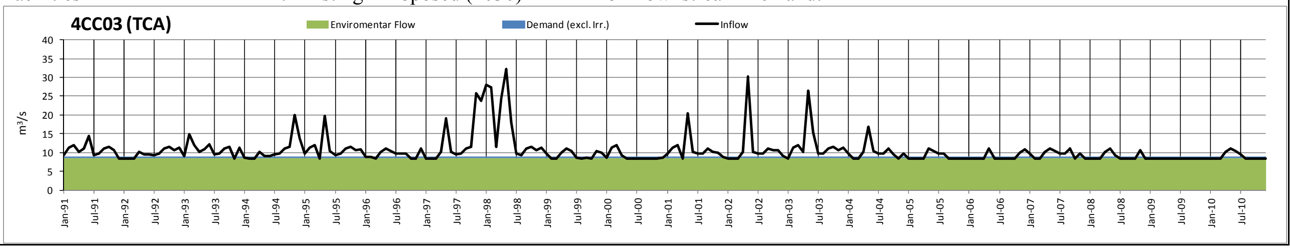
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 4.6.5**
JAPAN INTERNATIONAL COOPERATION AGENCY	**River Flow at Reference Point 4BE10 under Present and Future Water Demands and Facilities Conditions (TCA) (1/3)**

River Name: Thika River (TCA)
Reference Point: 4CC03

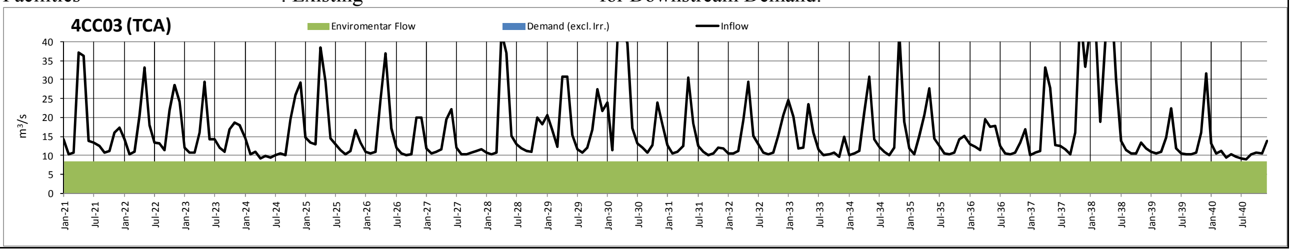
River Flow	: Present (1991-2010)	Reserve:	8.4	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained for Downstream Demand:	1.4	(m^3/s)
Facilities	: Existing			



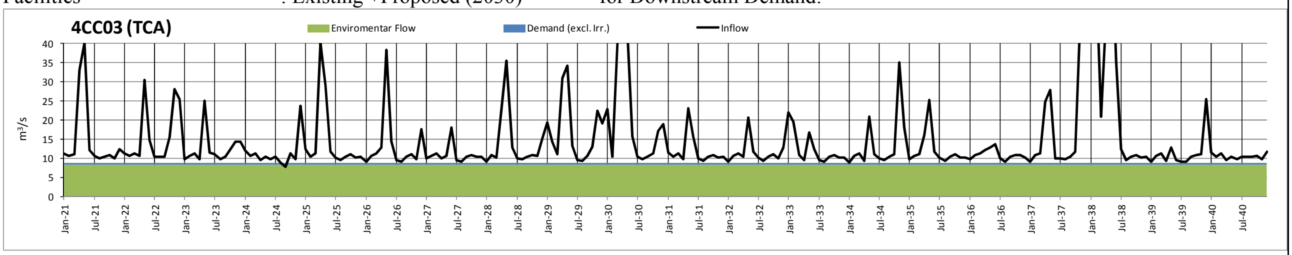
River Flow	: Present (1991-2010)	Reserve:	8.4	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained for Downstream Demand:	1.7	(m^3/s)
Facilities	: Existing +Proposed (2030)			



River Flow	: 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 Flow	: 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)			



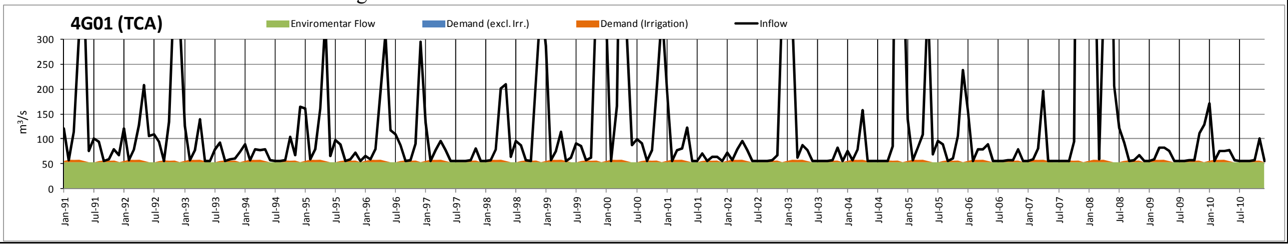
Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030 JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure 4.6.5** **River Flow at Reference Point 4CC03 under Present and Future Water Demands and Facilities Conditions (TCA) (2/3)**

River Name: Tana River (lower) (TCA)
Reference Point: 4G01

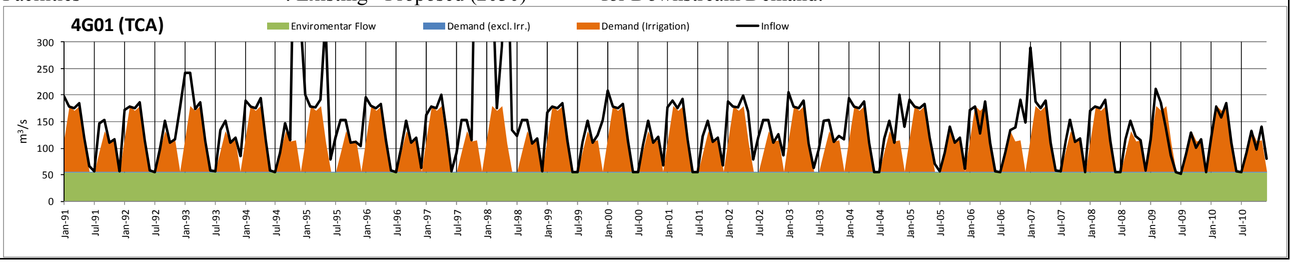
River Flow : Present (1991-2010)
Water Demand : 2010
Facilities : Existing

Reserve: 53.5 (m^3/s)
Required Discharge to be maintained for Downstream Demand: 3.5 (m^3/s)



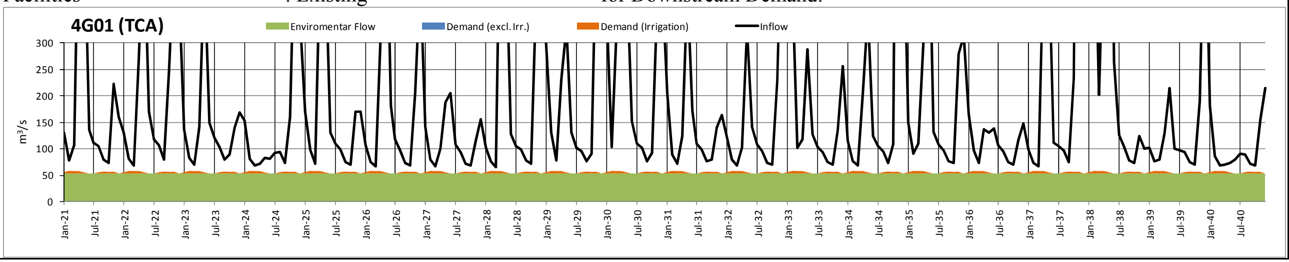
River Flow : Present (1991-2010)
Water Demand : 2030
Facilities : Existing +Proposed (2030)

Reserve: 53.5 (m^3/s)
Required Discharge to be maintained for Downstream Demand: 99.7 (m^3/s)



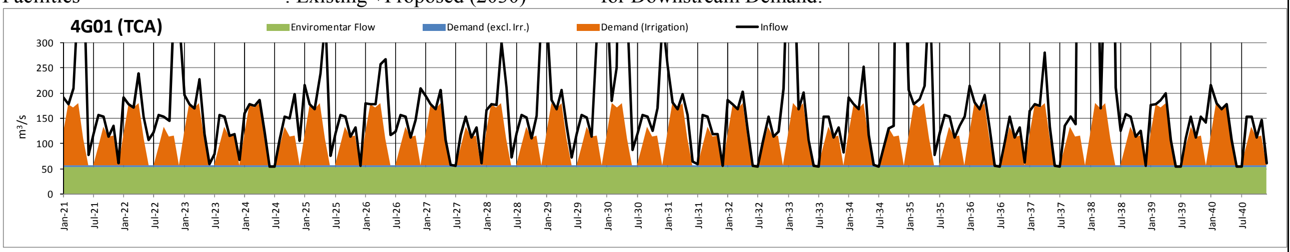
River Flow : Future (2021-2040)
Water Demand : 2010
Facilities : Existing

Reserve: 53.5 (m^3/s)
Required Discharge to be maintained for Downstream Demand: 3.5 (m^3/s)



River Flow : Future (2021-2040)
Water Demand : 2030
Facilities : Existing +Proposed (2030)

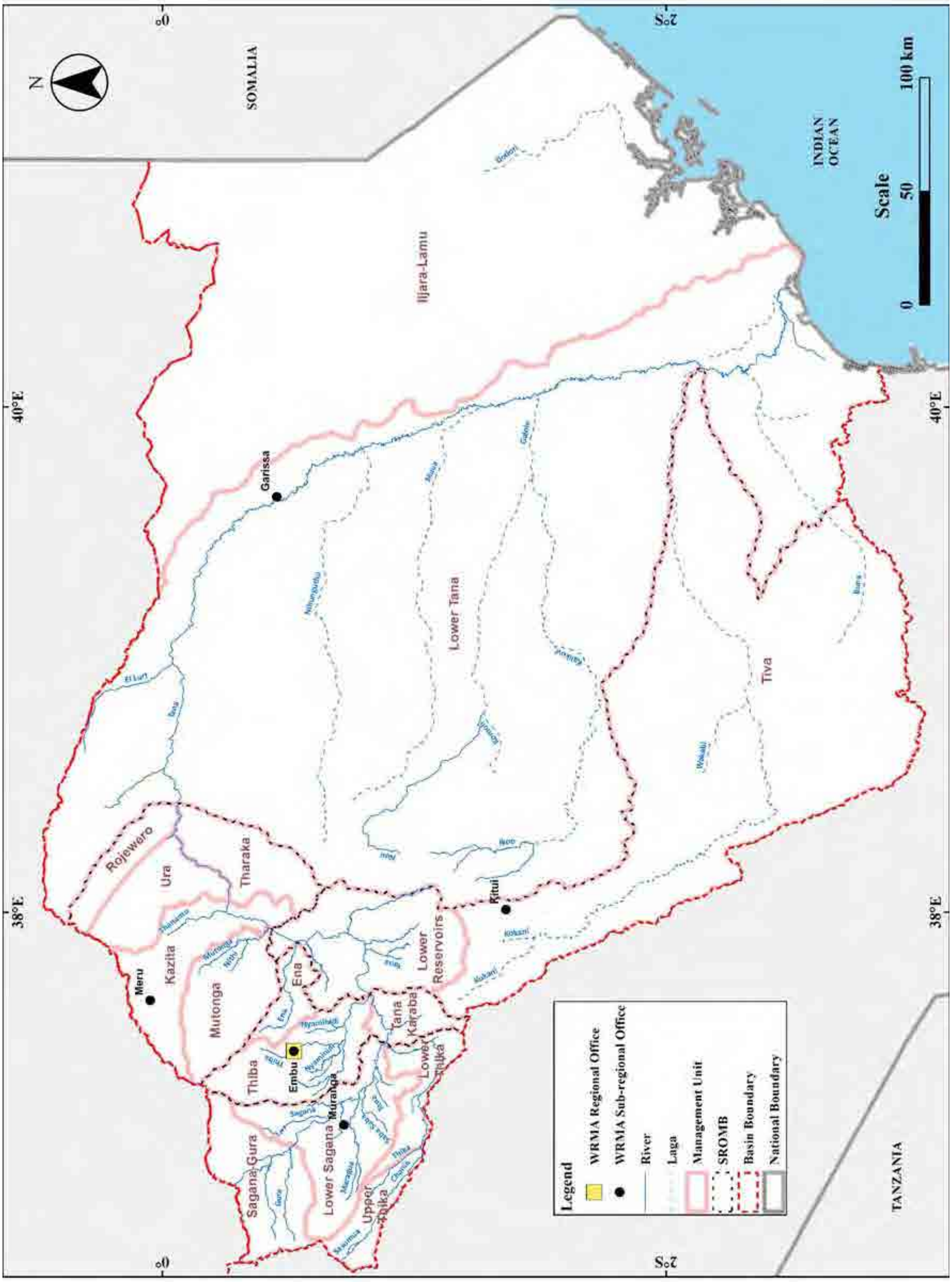
Reserve: 53.5 (m^3/s)
Required Discharge to be maintained for Downstream Demand: 99.7 (m^3/s)



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 4.6.5** **River Flow at Reference Point 4G01 under Present and Future Water Demands and Facilities Conditions (TCA) (3/3)**
JAPAN INTERNATIONAL COOPERATION AGENCY	



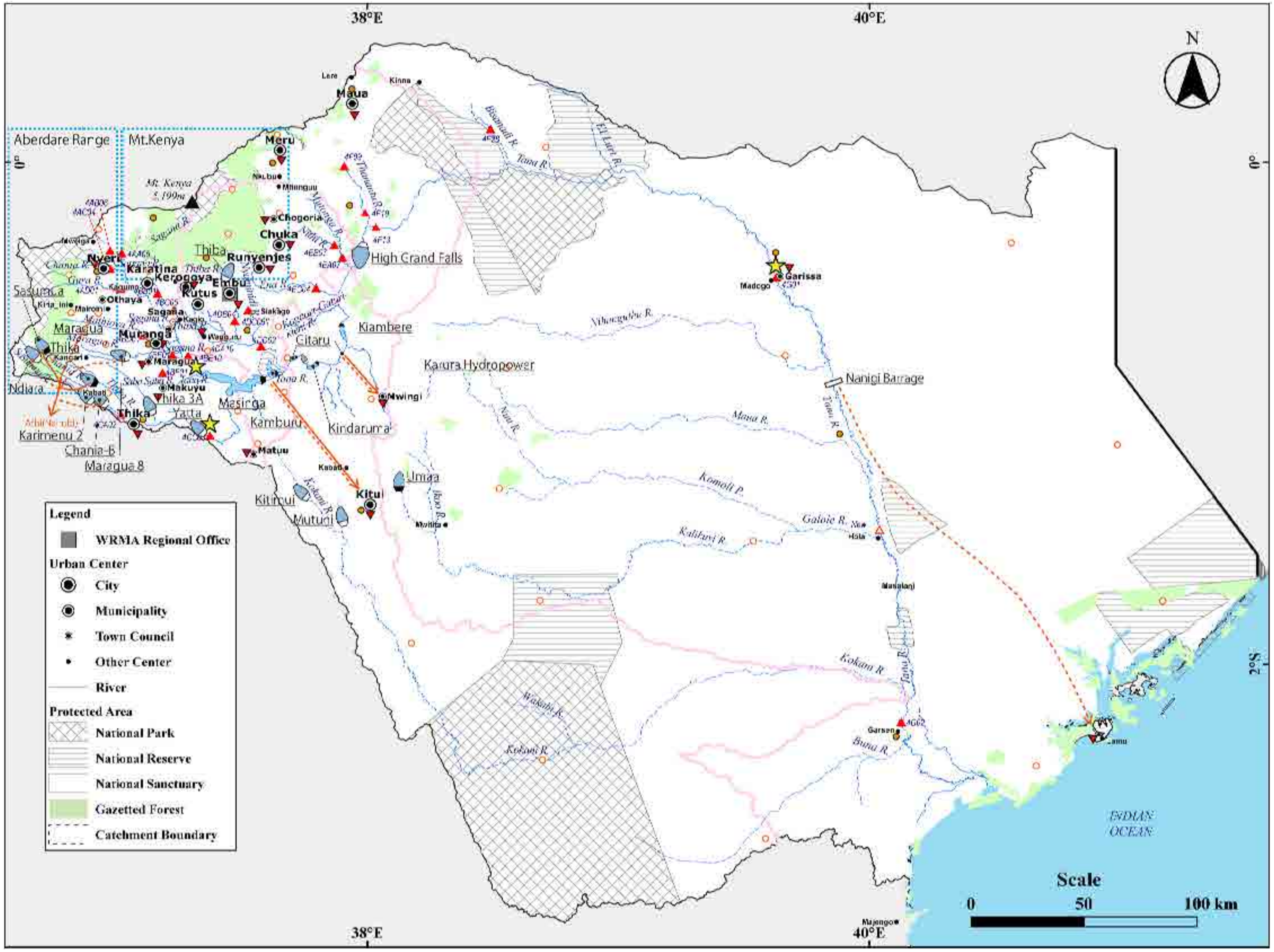
Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 4.7.1** **Rivers and Boundaries for Administration (TCA)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

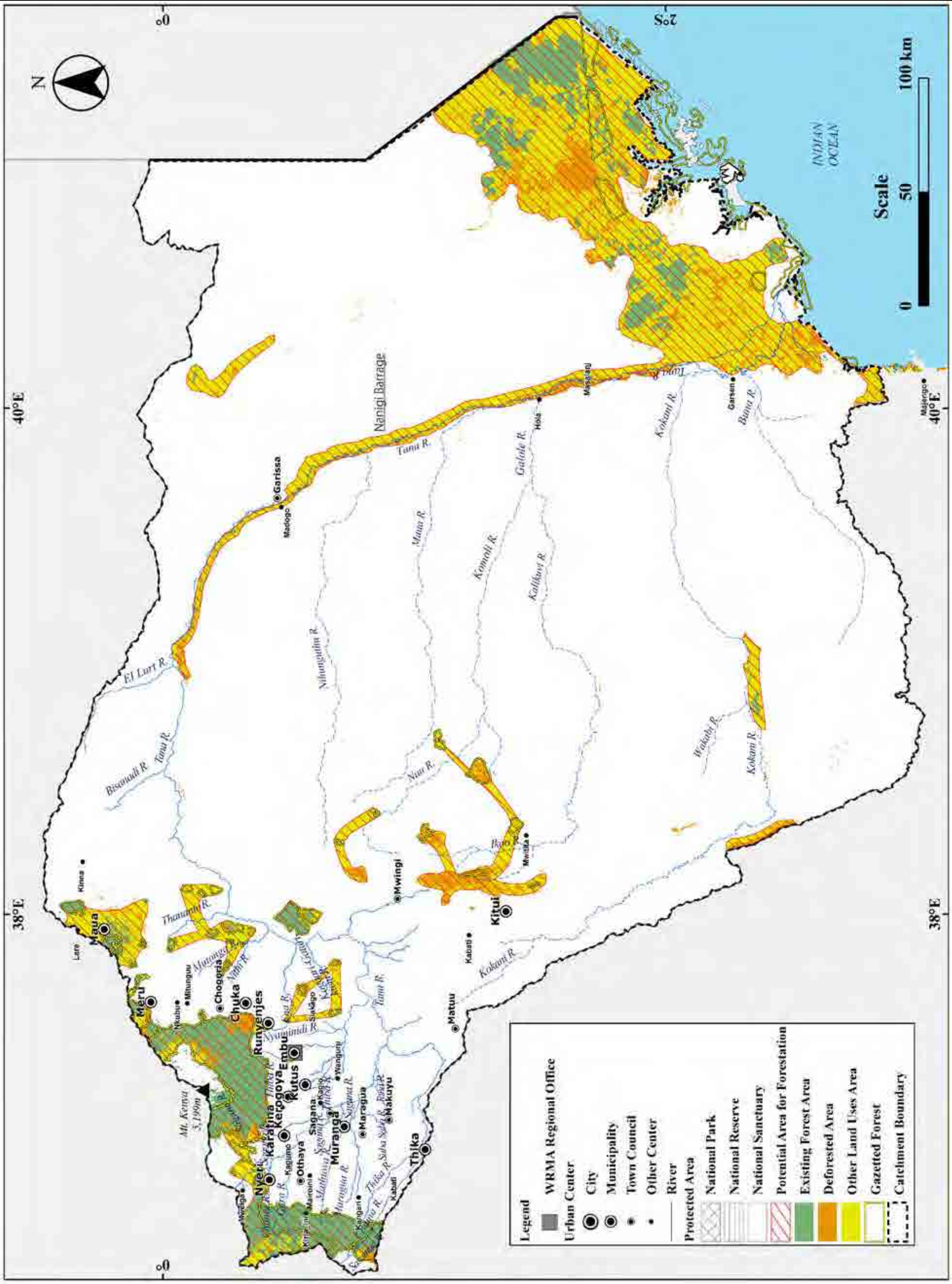
JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 4.7.2
Proposed Monitoring Stations for Water Resources Management (TCA)



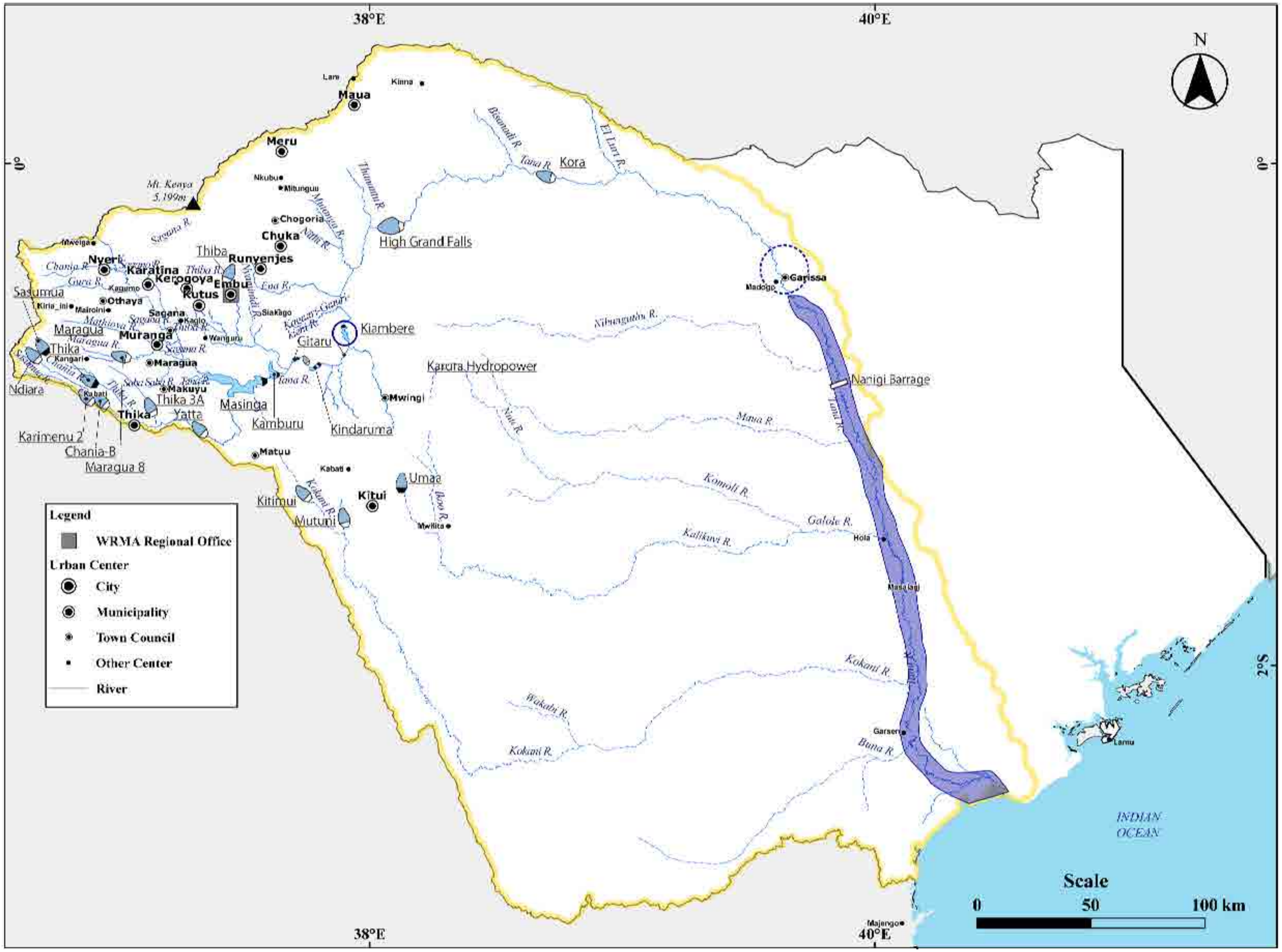
LEGEND				
	Surface Water Monitoring Station	26 locations	Groundwater Monitoring Station	18 locations
	Existing / Newly Proposed		Proposed Monitoring Station	
	Rainfall Monitoring Station	47 locations	Reference Point	3 locations
	Existing / Newly Proposed		Proposed Reference Point	

Source: JICA Study Team



Source: JICA Study Team based on satellite images

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



LEGEND	Community-based Disaster Management	Flood Control	Improvement of Discharge Warning System	Dam (Existing)
	Catchment of Boundary			Dam (Proposed)

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

Source: JICA Study Team

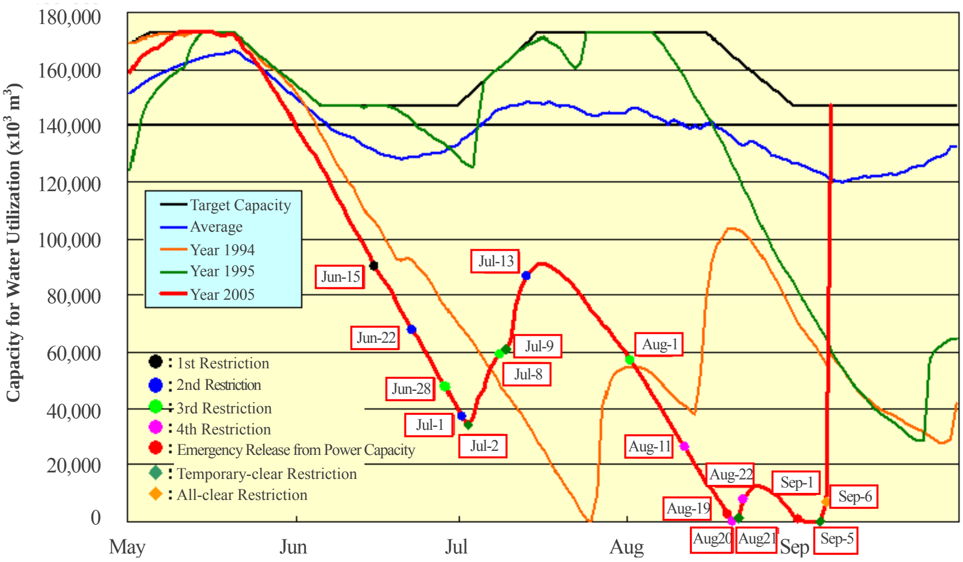
THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 4.8.1
Proposed Flood and Drought Disaster Management Plan (TCA)

Flow of Water Use Restriction of the Sameura Dam in 2005 Drought

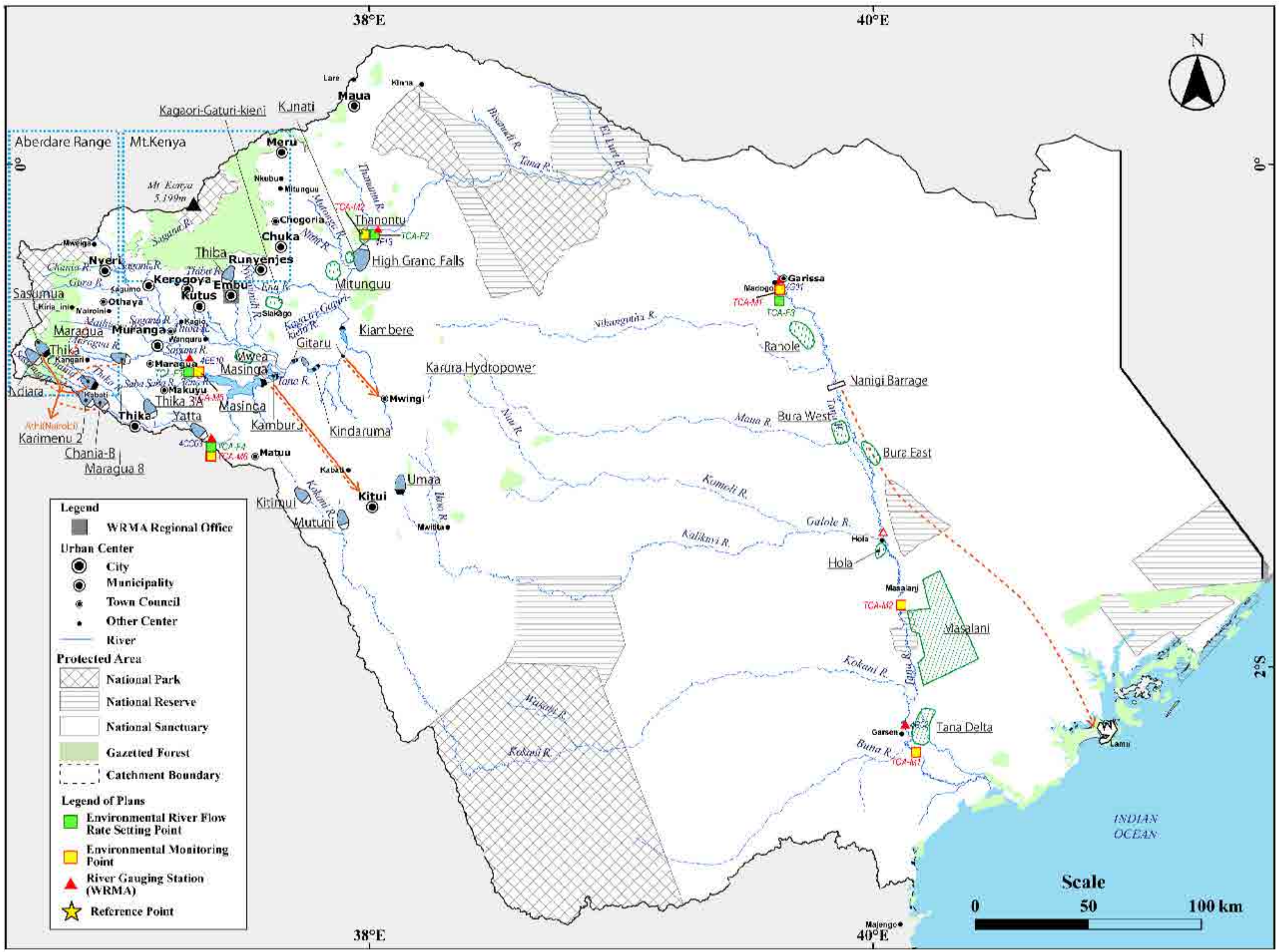
Date	Reserve	Water Use Restriction	Organizational Arrangement
May 26	96.40%		15:00 Setting up a head office of special task force for water restriction in Shikoku Regional Development Bureau (a) 15:00 Setting up a branch office of special task force for water restriction in Integrated Management Office of Dams in Yoshino River (b)
Jun 13	66.60%	0:00 Voluntary water-saving [Tokushima 5.9%]	
Jun 15	61.20%	9:00 The first water restriction [Tokushima 14.1% (new 20%), Kagawa 20%]	9:00 Setting up a branch office of special task force for water restriction in Tokushima River and National Highway Office (c)
Jun 22	46.00%	9:00 The second water restriction [Tokushima 15.9% (new 35%), Kagawa 35%]	
Jun 28	32.40%	9:00 The third water restriction [Tokushima 17.6% (new 50%), Kagawa 50%]	
Jul 1	25.10%	22:00 Ease the second water restriction [Tokushima 17.2% (new 35%), Kagawa 35%]	
Jul 2	22.80%	6:00 Temporary-clear water restriction	
Jul 8	36.80%	0:00 The third water restriction [Tokushima 19.0% (new 50%), Kagawa 50%]	
Jul 9	37.50%	15:00 Temporary-clear water restriction	
Jul 13	51.20%	18:00 The second water restriction [Tokushima 17.2% (new 35%), Kagawa 35%]	
Aug 1	32.90%	9:00 The third water restriction [Tokushima 19.0% (new 50%), Kagawa 50%]	
Aug 11	15.10%	9:00 The forth water restriction [Tokushima 22.0% (new 75%), Kagawa 75%]	9:00 Setting up a head office of emergency task force for extraordinary drought in Shikoku Region (d)
Aug 19 (20:00)	1.5% (0.0%)	20:00 Start emergency release from power generation capacity [Tokushima 1.85 m^3/s, Kagawa 1.81 m^3/s]	
Aug 20	0.00%	22:00 Temporary ease the forth water restriction [Tokushima 22.0% (new 75%), Kagawa 75%] Stop emergency release from power generation capacity	
Aug 21	1.10%	11:00 Temporary-clear water restriction	
Aug 22	4.90%	22:00 Restart the forth water restriction [Tokushima 22.4% (new 75%), Kagawa 75%]	
Sep 1 (8:00)	0.5% (0.0%)	8:00 Start emergency release from power generation capacity [Tokushima 1.85m^3/s, Kagawa 1.81m^3/s]	
Sep 5	0.00%	5:00 Stop emergency release from power generation capacity 9:00 Temporary-clear water restriction	
Sep 6 (20:00)	4.6% (100%)	18:00 All-clear water restriction	18:00 Breaking up the office (a) 18:00 Breaking up the office (d) 18:00 Breaking up the office (c) 20:00 Breaking up the office (b)



Time Series Graph of Water Use Capacity of the Sameura Dam and Restriction Actions in 2005 Drought

Source: Shikoku Regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism, Japan

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 4.8.2** **Example for Water Use Restriction of Sameura Dam in 2005 Drought**
JAPAN INTERNATIONAL COOPERATION AGENCY	



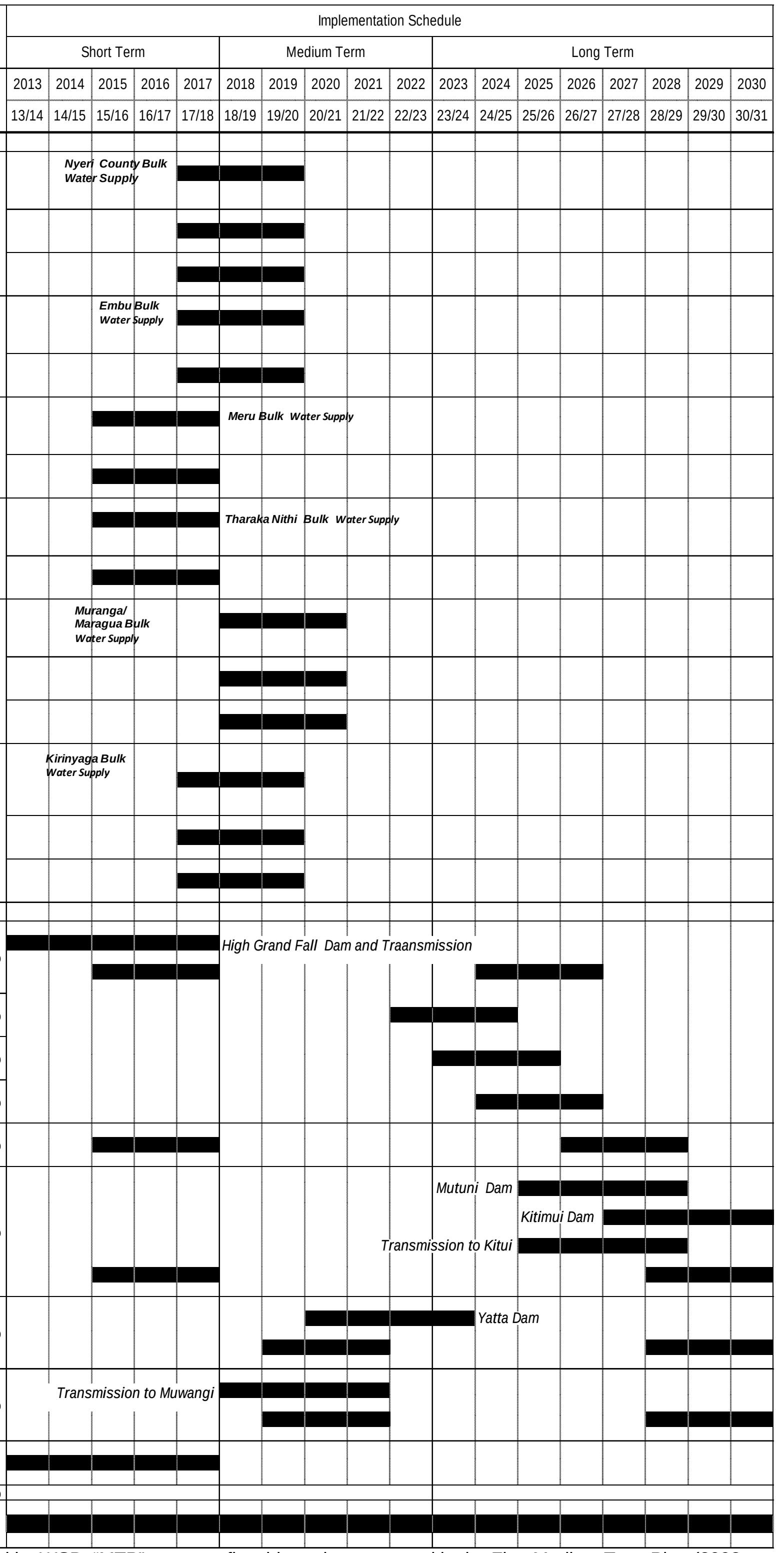
Source: JICA Study Team

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 4.9.1
Proposed Environmental Management Plan (TCA)

WRMA Catchment	No.	Name of Project	Project Status	Capacity to be developed (m^3/day) Total	Initial Develop.	Ratio
Tana		Upstream of Tana Catchment				
	1	Nyeri	WSB, F/S	49,587	49,587	
	2	Karatina				
	3	Othaya				
	4	Embu	WSB, F/S	36,048	36,048	
	5	Runyenjes				
	6	Muranga	WSB, F/S*, MTP	37,943	37,943	
	7	Maua				
	8	Chuka	WSB, F/S*, MTP	39,761	39,761	
	9	Chogoria				
	10	Muranga	WSB, F/S	44,549	44,549	
	11	Maragua				
	12	Makuyu				
	13	Kerugoya/Kutus	WSB, F/S	18,129	18,129	
	14	Wanguru				
	15	Sagana				
		Other Area				
	16	Lamu	MTP	105,350	31,605	30%
	17	Garissa	-	4,418	4,418	100%
	18	Madogo	-	2,298	2,298	100%
	19	Msalani	-	2,186	2,186	100%
	20	Hola	WSB, F/S	689	207	30%
	21	Kitui	WSB, F/S	57,884	9,000	16%
	22	Matuu	MTP	29,699	8,910	30%
	23	Garissa	WSB, F/S	8,149	2,000	25%
		Rehabilitation for 16 Urban Centres				
		Total Urban Water Supply Projects		436,690	286,640	66%
		Rural Water Supply Projects				



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

Source: JICA Study Team

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 7.3.1
Implementation Schedule of Proposed Water Supply System Development Plan (TCA)

WRMA Catchment	No.	Urban Centre	F/S Status	Capacity to be developed (m³/day) Total	Initial Develop.	Ratio	Implementation Schedule: Short Term 2013 (13/14)	2014 (14/15)	2015 (15/16)	2016 (16/17)	2017 (17/18)	Medium Term 2018 (18/19)	2019 (19/20)	2020 (20/21)	2021 (21/22)	2022 (22/23)	Long Term 2023 (23/24)	2024 (24/25)	2025 (25/26)	2026 (26/27)	2027 (27/28)	2028 (28/29)	2029 (29/30)	2030 (30/31)
Tana	1	Embu	WS, D/D	22,587	6,387	27%	■	■	■									■	■	■				
	2	Maua	WSB, MTP, D/D	6,608	1,982	30%		■	■	■								■	■	■				
	3	Kitui	WSB, MTP, F/S	42,028	5,000	23%					■	■	■						■	■	■			
	4	Meru	WSB, F/S	19,570	10,000	50%			■	■	■								■	■	■			
	5	Lamu	MTP	95,250	26,145	30%					■	■	■						■	■	■			
	7	Thlka	WSB, F/S	19,152	40,000	153%			■	■	■													
	6	Chuka	WSB, MTP, F/S*	16,674	3,000	18%			■	■	■									■	■	■		
	7	Garissa	WSB, F/S	9,923	1,561	17%						■	■	■						■	■	■		
	8	Chogoria	F/S*	10,899	3,270	30%			■	■	■									■	■	■		
	9	Runyenjes	WSB, F/S*	7,498	2,249	30%				■	■	■										■	■	■
	10	Kerugoya/Kutus	WSB, F/S*	7,450	2,235	30%								■	■	■						■	■	■
	11	Nyeri	WSB	37,681	5,000	11%								■	■	■						■	■	■
	12	Matuu	MTP	19,467	19,467	100%													■	■	■			
	13	Makuyu	WSB	16,880	16,880	100%													■	■	■			
	14	Muranga	_	9,476	11,037	100%																■	■	■
	15	Maragua	_	10,116	10,116	100%																■	■	■
	16	Wanguru	_	9,199	9,199	100%																■	■	■
	17	Mwingi	_	6,126	6,126	100%																■	■	■
	Rehabilitation Works for 6 Urban Centres						■	■	■	■	■													
	Total			366,585	179,655	49%																		

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

Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	Figure 7.3.2 Implementation Schedule of Proposed Sewerage System Development Plan (TCA)
JAPAN INTERNATIONAL COOPERATION AGENCY	

No	Name of Project	County	Irrigation Area (ha)	Multi-purpose Dam	Short Term (2013–2017; 13/14–17/18)	Medium Term (2018–2022; 18/19–22/23)	Long Term (2023–2030; 23/24–30/31)
A. Large Scale Irrigation Project (New)							
1	Hola Irrigation	Tana River	800	-	P		
2	Hola Irrigation Extension	Tana River	4,161	-	P		
3	High Grand Falls Irrigation	Garissa/ Tana R.	106,000	High Grand Falls	P	Dam	
4	Kora Irrigation	Tana River	25,000	Kora		P	Dam
	Total		135,961			40,294	95,667
B. Small Scale Irrigation Project (New)							
1	Weir Irrigation		0		0	0	0
2	Dam Irrigation		0		0	0	0
3	Small Dam/Pond/Water Pan Irrigation		5,730		1,146	1,719	2,865
4	Groundwater Irrigation		10,054		2,011	3,016	5,027
	Total for B		15,784		3,157	4,735	7,892
C. Private Irrigation Project (New)							
1	Weir Irrigation		0		0	0	0
2	Groundwater Irrigation		10,054		2,011	3,016	5,027
	Total for C		10,054		2,011	3,016	5,027
	Total for TCA		161,799		5,168	48,045	108,586

Note:
- F/S and/or D/D
- P Procurement
- Construction of Irrigation System
- Construction of Multipurpose Dam

Note: * = incorporate into the High Grand Falls irrigation area by 2030 (Bula, Hola and Tana delta schemes, 20,600 ha in total)
Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 7.3.3 Implementation Schedule of Proposed Irrigation Development Plan (TCA)

WRMA Catchment	No	Name of Project	Purpose	Installed Capacity (MW)	Project Status	Implementation Schedule																	
						Short Term					Medium Term					Long Term							
						2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
						13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29	29/30	30/31
Tana	13	High Grand Falls	W, I, P, F	Stage 1: 500 Stage 2: +200	Flagship D/D done			Stage 1										Stage 2					
	14	Karura	P	90			P																

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

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

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

Source: JICA Study Team

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 7.3.4
Implementation Schedule of Proposed Hydropower Development Plan (TCA)

WRMA Catchment	No.	Name of Project	Purpose	Effective Storage Volume (MCM)	Project Status	Implementation Schedule																	
						Short Term					Medium Term					Long Term							
						2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
						13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29	29/30	30/31
Tana	1	High Grand Falls Dam	W, I, P, F	5,000	Flagship D/D done																		
	2	Thiba Dam	I	11	Flagship D/D done	P																	
	3	Karimenu 2	W	14	F/S ongoing			P															
	4	Maragua 4 Dam	W	33	F/S ongoing			P															
	5	Chania-B Dam	W	49						P													
	6	Yatta Dam	W	35	D/D done							P											
	7	Thika 3A	W	13	F/S ongoing							P											
	8	Ndiara Dam	W	12										P									
	9	Kora Dam	I	537	Flagship										P								
	10	Mutuni Dam	W	17													P						
	11	Kitimui Dam	W	8															P				

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

Source: JICA Study Team

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 7.3.5
Implementation Schedule of Proposed Water Resources Development Plan (TCA)

No.	Description	Implementation Schedule																	
		Short Term					Medium Term					Long Term							
		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
		13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29	29/30	30/31
Development Activities																			
(1)	Monitoring																		
M1	Replacement of iron post for river gauge to concrete post	■	■	■															
M2	Upgrade manual gauge to automatic (surface water level)			■	■	■	■	■											
M3	Upgrade manual gauge to automatic (groundwater level)			■	■	■	■	■											
M4	Upgrade manual gauge to automatic (rainfall)			■	■	■	■	■											
M5	Installation of Dedicated Boreholes for Groundwater Monitoring	■	■	■															
M6	Installation/Rehabilitation of River Gauging Stations	■	■				■	■				■	■						
M7	Installation/Rehabilitation of Rainfall Gauging Stations	■	■				■	■				■	■						
M8	Flood Discharge Measurement Equipment (Each SRO)		■	■	■								■	■	■				
(2)	Evaluation																		
E1	Hydromet DB Upgrade (Software + Hardware)			■	■				■	■				■	■				
E2	Establishment of additional Water Quality Test Laboratory in Garissa	■	■																
(3)	Permitting																		
P1	PDB Upgrade (Software + Hardware)			■	■				■	■				■	■				
(4)	Watershed Conservation						■	■	■	■									
W1	Forestation (Gazetted Forest Area)	■	■	■	■	■													
W2	Forestation (Non-gazetted Forest Area)						■	■	■	■	■	■	■	■	■	■	■	■	■
Recurrent Activities																			
(1)	Monitoring																		
M1	Surface Water Level Monitoring	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
M2	River Discharge Measurement	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
M3	Groundwaer Level Monitoring	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
M4	Rainfall Monitoring	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
M5	Flood Discharge Measurement			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
M6	Surface Water Quality Monitoring	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
M7	Groundwater Quality Monitoring	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
(2)	Others																		
O1	Catchment Forum Operation (Venue and Allownce to WURAs)	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 7.3.6** **Implementation Schedule of Proposed Water Resources Management Plan (TCA)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

Flood Disaster Management Plan

WRMA Catchment	No.	Description	Implementation Schedule																		Remarks
			Short Term					Medium Term					Long Term								
			2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	
			13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29	29/30	30/31	
Tana	T1	Garissa																			
		T1.1 Construction of Multipurpose Dam																			High Grand Falls Dam
		T1.2 River Training Works	F/S																		
		T1.3 Preparation of Hazard Map																			
		T1.4 Formulation of Evacuation Plan																			
	T2	Tana River lower than Garissa																			
		T2.1 Establishment of Community-based Flood Management System																			
		T2.2 Improvement of Warning System for Hydropower Dam																			

Note: Construction Schedule for River Training Works (to be determined in the Feasibility Study)

Drought Disaster Management Plan

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

Legend: Establishment Update / Expansion

Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	Figure 7.3.7 Implementation Schedule of Proposed Flood and Drought Disaster Management Plan (TCA)
JAPAN INTERNATIONAL COOPERATION AGENCY	

WRMA Catchment	No.	Name of Project	Target	Related Project (Dams and Irrigation)	Implementation Schedule																	
					Short Term					Medium Term					Long Term							
					2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
					13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29	29/30	30/31
Tana	1	Setting of Environmental Flow	Tana River	High Grand Falls, Thiba, Marauga, Yatta, Ndiara, and Kitimui Dams				Set														
			Chania River	Chania-B					Set													
	2	Environmental Monitoring	Tana River	High Grand Falls, Thiba, Marauga, Yatta, Ndiara, and Kitimui Dams																		
			Chania River	Chania-B																		

Environmental Survey for Setting Environmental Flow

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

Environmental Monitoring (including Planning)

Source: JICA Study Team

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 7.3.8
Implementation Schedule of Proposed Environmental Management Plan (TCA)

Part G
Ewaso Ng'iro North Catchment Area

Location Map (ENNCA)

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

FINAL REPORT
VOLUME - III MAIN REPORT (2/2)

PART G: EWASO NG'IRO NORTH CATCHMENT AREA

Location Map
Abbreviation

Table of Contents

List of Tables

Page

List of Figures

List of Abbreviations and Acronyms

ALRMP	:	Arid Land Resources Management Project
B/C	:	Benefit and Cost
CBDM	:	Community-based disaster management
EIRR	:	Economic Internal Rate of Return
ENN	:	Ewaso Ng'iro North
ENNCA	:	Ewaso Ng'iro North Catchment Area
F/S	:	Feasibility Study
FFWS	:	Flood Forecasting and Warning System
JICA	:	Japan International Cooperation Agency
KMD	:	Kenya Meteorological Department
KWS	:	Kenya Wildlife Service
LCPDP	:	Least Cost Power Development Plan
LSRWSS	:	Large Scale Rural Water Supply System
LVNCA	:	Lake Victoria North Catchment Area
MWI	:	Ministry of Water and Irrigation
NWCPC	:	National Water Conservation and Pipeline Corporation
NWMP	:	National Water Master Plan
O&M	:	Operation and Maintenance
RV	:	Rift Valley
SSRWSS	:	Small Scale Rural Water Supply System
TCA	:	Tana Catchment Area
UC	:	Urban Centre
WASREB	:	Water Services Regulatory Board
WRMA	:	Water Resource Management Authority
WRMA	:	Water Resource Management Authority
WRUA	:	Water Resources Users Association
WSB	:	Water Service Board
WWTP	:	Waste Water Treatment Plant

Abbreviations of Measures

Length

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

Area

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

Volume

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

Weight

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

Time

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

Money

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

Energy

kcal	=	Kilocalorie
kW	=	kilowatt
MW	=	megawatt
kWh	=	kilowatt-hour
GWh	=	gigawatt-hour

Others

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

NOTE

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

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

3. Information to be updated

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

   (1) Information on the proposed development projects

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

   (2) Information on the water demand

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

4. Exchange rate for cost estimate

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

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

CHAPTER 1 INTRODUCTION

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

This volume, Main Report Part G, presents the water master plan for the Ewaso Ng'iro North Catchment Area (ENNCA). The water master plan for ENNCA consists of the following eight component plans as mentioned in the Chapter 7 of the Main Report Part A.

Development plans

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

Management plans

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

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

CHAPTER 2 CATCHMENT CHARACTERISTICS

ENNCA is located in the northeastern part of the country. ENNCA borders with Ethiopia in the north, Somalia in the east, Rift Valley Catchment Area (RVCA) in the west, and Tana Catchment Area (TCA) in the south.

Total area of ENNCA is 210,226 km^2 corresponding to 36.8% of the country's area. According to the Census 2009, the population of ENNCA is 3.87 million, or 10.1% of the total population of Kenya. Its population density is as low as 18 persons/km^2.

The topography of ENNCA varies from the highest altitude of Mt. Kenya peak (El. 5,199 m) to the Lorian Swamp of 150 m above mean sea level (amsl). Most of the area lies below 1000 m amsl.

The Ewaso Ng'iro North River is the largest river in ENNCA, originating from Mt. Kenya (El. 5,199 m). It flows in the central part of the country eastward and 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 of the area to 1,000 mm in the upstream area of the Ewaso Ng'iro North River. The catchment area average mean annual rainfall comes to 510 mm. The renewable water resources which are defined by precipitation minus evapotranspiration is estimated at 7.4 BCM/year in 2010 for ENNCA and the per capita renewable water resources is calculated at 1,933 m^3/year/capita.

Major cities and towns in ENNCA are Nanyhuki, Nyahululu, Isiolo, Marsabit, Moyale, Mandera, and Wajir. The catchment area includes the whole area of Mandera and Wajir counties, most part of Marsabit, Samburu, Isiolo, and Laikipia counties, and parts of Nyandarua, Nyeri, Meru, and Garissa counties.

There is no major industry other than the textile industry in Nanyuki located in the upper reaches of the Ewaso Ng'iro North River.

CHAPTER 3 WATER RESOURCES, WATER DEMANDS AND WATER ALLOCATION

3.1 General

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

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

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

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

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

3.2 Available Water Resources

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

Annual Available Water Resources (ENNCA)

(Unit: MCM/year)

Year	Surface Water	Groundwater	Total
2010	1,725	526	2,251
2030	2,536	475	3,011
Percentage of 2010 values	147%	90%	134%

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

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

The above table shows that the 2030 surface water runoff will increase to 147% of 2010 runoff, while the 2030 sustainable yield of groundwater will decrease to 90% of 2010 yield, both due to climate change impacts, resulting in an increase of 2030 available water resources to 134% of 2010 resources.

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

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

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

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

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 A, Section 6.10 and Setoral Report (G), Sub-section 3.3.1 (3))

The total projected water demands of 2,857 MCM/year in 2030 is approximately 13.5 times of the present water demand of 212 MCM/year mainly due to the increase in population from 3.82 million to 4.40 million and irrigation areas from 7,896 ha to 150,561 ha mentioned in Chapter 6 of the Main Report Part A. Monthly water demands in 2030 by sub-basin are shown in Table 3.3.1.

3.4 Proposed Water Allocation Plan

(1) Water Balance Study

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

Available Water Resources and Water Demands (ENNCA)

(Unit: MCM/year)

2010		2030	
Water Resources	Water Demands	Water Resources	Water Demands
2,251	212	3,011	2,857
Percentage of Resources	9%	Percentage of Resources	95%

Source: JICA Study Team (Ref. Setoral Report (G), Sub-section 4.4.1)

Although the present water demands in 2010 are estimated to be 9% of the available water resources, the water demands for 2030 are expected to increase drastically up to 95% of the available water resources in 2030. The percentage of 95% of water demand to water resources, which is called a water stress ratio, indicates a severely tight situation in the water balance compared with the ratio of 40% regarded to indicate severe water stress.

In order to examine a more detailed situation of future water balance from the spatial and temporal perspectives, a surface water balance study for 2030 was carried out. Since the surface water demands occupy more than 80% of the total demands nationwide, it was judged that the surface water balance would give general situation of water deficits. This study divided the catchment area into 27 sub-basins and applied a study model with the existing dam only as discussed in Section 6.11 of the Main Report Part A. Conditions of the water balance study are described in Subsection 4.6.3 of this report and detailed in Chapter 4 of the Sectoral Report (G).

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

Water Demands and Water Deficits (ENNCA)

(Unit: MCM/year)

2010		2030	
Water Demands	Water Deficits	Water Demands	Water Deficits
212	68	2,857	2,442
Percentage of Demands	32%	Percentage of Demands	85%

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

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

(2) Modified Future Water Demands

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

The modified water demands projections are as summarised below.

Modified Water Demand Projections for 2030 (ENNCA)

Year	Water Demands (MCM/year)						
	Domestic	Industrial	Irrigation	Livestock	Wildlife	Fisheries	Total
2030	125	2	539	79	0	7	752

Source: JICA Study Team

The projected demand following Kenya Vision 2030 in Section 3.3 was reduced to 752 MCM/year by reducing the irrigation water demand corresponding to the irrigation area reduction to 49,379 ha.

(3) Proposed Water Allocation Plan

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

Water Resources Allocation Plan (ENNCA)

(Unit: MCM/year)

Subsector	Water Demand (2030)	Water Resources Allocation (2030)	
		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

The total amount of allocated surface water is 561 MCM/year, which is about 75% of the total water demand and about 22% of the available surface water resources. The total amount of allocated groundwater is 191 MCM/year, which is about 25% of the total water demand and about 40% of the available groundwater resources. The above percentages in terms of water resources imply that the water balance situation in 2030 is expected to be almost severe or severe judging from the water stress ratio.

The allocation plan should be considered as a guide in the water resources management in ENNCA.

CHAPTER 4 DEVELOPMENT AND MANAGEMENT PLANS

4.1 General

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

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

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

4.2 Water Supply Development Plan

4.2.1 Current Situation of Water Supply

As shown in Section 3.2 of Main Report Part A, the current population of ENNCA as of 2010 is estimated to be 3.82 million which is composed of 0.74 million of urban population and 3.07 million of rural population. Based on the data of Census 2009, the current situation of water connection in ENNCA is estimated 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 sources. Around 34% of the population get drinking water from such unimproved drinking water sources. Also, around 40% of the population get water from springs, wells, and boreholes. Unprotected wells and springs are also categorised as an unimproved drinking water sources, but the utilisation ratio of unprotected sources is unknown.

It is projected that the urban population will increase by 1.02 million while the rural population will decrease by 0.44 million in 2030 as shown in Section 3.2 of Main Report Part A. Hence, the total population is expected to reach 4.40 million in 2030 as shown below.

Projected Population (ENNCA)

(Unit: million persons)

Year	Urban population	Rural Population	Total
2010	0.74	3.08	3.82
2030	1.76	2.64	4.40

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

The 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 than other catchment areas.

According to the "Performance Report of Kenya's Water Services, No. 4, 2011", the water supply system managed by registered WSPs covers 0.49 million service population, nine urban water service providers (WSPs), and three rural WSPs having a total water supply capacity of 40,500 m^3/day as shown in the table below. The average water supply volume per person is estimated at 82 L/p/day including non-revenue water (NRW). It is almost the same level as the national average of urban water supply volume of 65 L/p/day including NRW (36 L/p/day excluding NRW). NRW ratio is relatively high. Out of the nine urban WSPs, four WSPs have records of more than 50% of NRW. The current situations of the WSPs in ENNCA are shown in Table 4.2.1.

4.2.2 Development Strategy

ENNCA is divided into two areas, namely, northern arid area and southern non-arid area, for water supply systems planning considering the characteristics of these two areas.

Characteristics of the Areas (ENNCA)

Catchment Area	Features
Arid Area	There are eight urban centres in the arid area. Both urban and rural water supply systems depend on groundwater.
Other Area	This is outside of the arid area. There are four urban centres, which are planned to use surface water on a priority basis. As for the rural water supply, it is planned to use groundwater on a priority basis.

Source: JICA Study Team

Based on the overall concept mentioned in Section 7.3.2 of the Main Report Part A, the urban water supply systems (UWSS) are planned for 12 urban centres (UCs) in ENNCA. The water supply capacity required for UWSS in the LNVCA for 2030 is 124,000 m^3/day against the current water supply capacity (including those under construction) which is 32,000 m^3/day. This results to an additional capacity of 92,000 m^3/day to be developed by 2030 through the following projects:

a) Rehabilitation of the existing UWSS

In order to achieve 20% of the NRW ratio, water meters will be installed for all households and existing old pipes of UWSS for six UCs, which have a water supply capacity of 32,000 m^3/day will be replaced. In addition, the rehabilitation includes replacement and repair of mechanical and electrical equipment in water treatment plants and pumping stations.

b) Expansion of UWSS

The expansion of UWSS is planned for six UCs to meet the water demand in 2030. The total expansion will provide an additional 61,000 m^3/day.

c) Construction of new UWSS

New UWSSs are planned to be constructed for six UCs, which have no existing UWSS. The new construction will provide an additional 31,000 m^3/day.

d) Incorporation of existing plans

According to data from WSBs, there are six plans of water supply development projects to cover two UCs and surrounding areas in ENNCA, 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 7.3.2 of the Main Report Part A, the rural water supply systems are planned to be developed by large-scale rural water supply system (LSRWSS) and small-scale rural water supply system (SSRWSS).

a) Development of LSRWSS

LSRWSS is proposed mainly in areas with high population density or areas with difficulties extracting groundwater for personal or community use. LSRWSS will be developed for 1.16 million residents in 14 counties under ENNCA.

b) Development of SSRWSS

SSRWSS is proposed for 2.20 million residents in 14 counties under ENNCA, and includes the construction and improvement of boreholes, wells, and springs for personal and community use, which will be implemented by individuals or communities.

4.2.3 Proposed Water Supply Development Plan

The proposed UWSS is presented in Table 4.2.2, while the proposed LSRWSS and SSRWSS are shown in Tables 4.2.3 and 4.2.4, respectively. The proposed water supply development plan for ENNCA is outlined below.

Proposed Water Supply Development Plan (ENNCA)

Type of Project		Target Area	Target Capacity (m^3/day)	Target Population (million persons)
Urban Water Supply	Rehabilitation	6 UCs	32,000	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 based on Tables 4.2.2 to 4.2.4

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

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 referred to Sectoral Report (C), Section 2.3. Figures for 2030 were based on Tables 4.2.2 to 4.2.4.)

In order to ensure water sources required for the water supply systems mentioned above, it is proposed to construct four new dams in ENNCA, as the result of the water balance study. (Ref. Sectoral Report (G), Chapter 4.9).

4.3 Sanitation Development Plan

4.3.1 Current Situation of Sanitation Development

Based on Census 2009, the current situation of access to sanitation facilities in ENNCA is estimated below:

Current Situation of Access 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 the current sewerage coverage ratio is only 2%. There is a small-scale waste water treatment plant in Nyahururu with a total treatment capacity of about 4600 m^3/day. Around 62% of the population use on-site sanitation facilities such as septic tanks. These on-site sanitation facilities include unimproved ones, and the ratio of the unimproved facilities is unknown. Around 36% of the population do not have any treatment facilities, and resort to unsanitary waste disposal.

4.3.2 Development Strategy

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

a) Rehabilitation of existing sewerage system

The rehabilitation includes repair and replacement of the mechanical and electrical equipment of wastewater treatment plants (WWTPs) and pumping stations and replacement of damaged sewer pipes in two UCs, which have sewerage systems with a total capacity of 5000 m^3/day.

b) Expansion of sewerage system

In order to cover the demand in 2030, the capacities of existing sewerage systems of two UCs will be expanded. These include expansion and new construction of sewerage pipes, pumping stations, and WWTPs. The expansion will be carried out for existing sewerage systems with the capacity of 27,000 m^3/day.

c) Construction of New Sewerage System

There are no sewerage systems in three UCs. New sewerage systems will be constructed in these UCs that will provide an additional capacity of 30,000 m^3/day to meet the demand in 2030.

d) Incorporation of existing plans

According to data from WSBs, there are two plans of sewerage development projects to cover two UCs in ENNCA, which have 7,000 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.

For those outside the sewerage service area, the improved on-site treatment facilities will be provided for the remaining 3.58 million residents in 2030. Currently, 2.40 million residents (or 62% of the entire population) are using the existing on-site treatment facilities, while unimproved ones will be improved with new housing. Development of on-site sanitation facilities is planned for 14 counties in ENNCA.

4.3.3 Proposed Sanitation Development Plan

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

Proposed Sanitation Development Plan (ENNCA)

Type of Project		Target Area	Target Capacity (m^3/day)	Target Population (million persons)
Sewerage System (Off-site Treatment)	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 based on Tables 4.3.1 and 4.3.2.

About 47% of the 1.76 million of the urban population in ENNCA are 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 few large-scale UCs prioritised in the sewerage development in ENNCA. Currently 36% of the population has no sanitation facilities, therefore, development of on-site treatment facilities is of higher priority than sewerage development. With the above sanitation development plans, the sanitation situation of ENNCA in 2030 will be as follows:

Sanitation Situation in 2030 (ENNCA)

Items		Sewerage System (Off-site Facilities)	Septic Tank, etc (On-site 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 reference to Sectoral Report (D), Section 2.3. Figures for 2030 were based on Tables 4.3.1 and 4.3.2.)

4.4 Irrigation Development

4.4.1 Current Situation of Irrigation Development

ENNCA is the driest catchment area in Kenya. Except for highlands at the southwest corner of ENNCA, most of the areas have an arid climate with an annual rainfall of 200 mm to 400 mm. The largest river is the Ewaso Ng'iro North River originating at the highland but becomes a dry river in the downstream section. The cropping area in ENNCA in 2011 was 194,123 ha in total. The productivity of rainfed culture is quite low. The irrigation area is 7896 ha in 2010, consisting of 6233 ha (79%) of small-scale schemes, and 1663 ha (21%) of private schemes. The share of irrigation area against cropping area is 4.1% only.

4.4.2 Development Strategy

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

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

b) In order 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 available for irrigation in ENNCA, priority should be given to large dam irrigation in arid and semi-arid lands to maximise irrigation areas. Furthermore, small-scale dam irrigation and groundwater irrigation should be developed where water resources are available.

4.4.3 Proposed Irrigation Development Plan

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

Proposed Irrigation Areas in 2030 (ENNCA)

(Unit: ha)

Category	Existing Irrigation Area in 2010	New Irrigation Area in 2030						Total Irrigation Area in 2030
		Surface Water Irrigation			Ground-water Irrigation (Borehole)	Water Harvesting Irrigation (Small Dam/ Water Pan)	Total New Irrigation Area	
		Weir	Dam	Total				
Large-scale	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. Sectoral Report (E), Section 3.4)

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 7.5 of the Main Report Part A, 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 4.6 due to limitation of available water resources.

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

a) Kieni Irrigation Project (4202 ha, Weir);
b) Wajir Irrigation Project (4000 ha, Archers Post multipurpose dam); and
c) Kihoto Irrigation Project (18,000 ha, Kihoto multipurpose dam).

The irrigation water demands necessary for the abovementioned new irrigation projects were estimated at 432 MCM/year for surface irrigation area and 107 MCM/year for groundwater irrigation area as shown in Table 6.5.7 in the Main Report Part A.

4.5 Hydropower Development Plan

4.5.1 Current Situation of Hydropower

(1) Existing Hydropower Station

There is no existing hydropower station in the catchment area.

(2) Multipurpose Dam Development Project

There is no development plan in the catchment area.

4.5.2 Development Strategy

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

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

The abovementioned strategy will be applied to ENNCA as follows:

c) LCPDP projects: There are no plans proposed for LCPDP.
d) Multipurpose dam development schemes: There is no multipurpose dam scheme which have hydropower component.

Considering the abovementioned strategies and situation in the catchment area, there is no hydropower development plan proposed for ENNCA.

4.5.3 Proposed Hydropower Development Plan

There is no hydropower development plan proposed for ENNCA.

4.6 Water Resources Development Plan

4.6.1 Current Situation of Water Resources Development

ENNCA has a total catchment area of 210,226 km^2 and an annual average rainfall of 510 mm which is similar to that of the 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 Mt. Kenya of the Five Water Towers. The main rivers in ENNCA are Ewaso Ng'iro North, Bogal, and Bor rivers. The available water resources estimated in ENNCA for 2010 (present) are 1,725 MCM/year for surface water and 526 MCM/year for groundwater.

The present water demands in ENNCA were estimated to be 212 MCM/year based on the population of 3.82 million and irrigation area of 7,896 ha as presented in Chapter 3. The existing water resources structures and facilities except for direct intake facilities from rivers that satisfy the present water demands are listed below.

Existing Water Resources Structures and Facilities (ENNCA)

Existing Structures/ Facilities	Name of Structures/ Facilities	Purposes	Notes
Dam	-	-	-
Small Dam/ Water Pan	Total No.= 615	Domestic and livestock water supply	Total storage volume of 10.3 MCM, average volume per facility of 17,000 m^3
Borehole	Total No.= 1,147	Domestic water supply mainly	Total abstraction volume of 35 MCM/year

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

The total storage volume of existing water resources structures and facilities in ENNCA is approximately 10 MCM summing the volumes of dams and small dams/ water pans listed in the above table. There is no existing dam. The Badasa Dam is under construction and will be for domestic water supply purposes (storage volume of 4 MCM). The feasibility study for the Isiolo Dam is in progress (domestic water supply).

There are 615 small dams/water pans with total storage volume of 10.3 MCM. There are a total of 1,147 boreholes in ENNCA, which comprise approximately 9% of the national total of 12,444 boreholes (MWI). These boreholes supply around 60% of the domestic water demands in ENNCA.

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. The water supply reliability of 1/1 means that the present water demands are satisfied with the available water resources with existing water resources structures under drought condition with probability of once in a year.

4.6.2 Development Strategy

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

Present and Future Water Demands (ENNCA)

(Unit: MCM/year)

Subsector	Present Water Demand (2010)	Future Water Demand (2030)
Domestic	58	125
Industrial	1	2
Irrigation	92	539
Livestock	57	79
Wildlife	0	0
Fisheries	4	7
Total	212	752

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

The water demand projections for 2030 show a great increase by about 3.5 times as compared with the present demand due to considerable expected increase in population to 4.40 million and irrigation areas to 49,379 ha as mentioned in Chapter 6 of the Main Report Part A.

Judging from the estimated 2030 water deficits discussed in Section 3.4 (1), it is certain that the existing water resources structures and facilities will not be able to satisfy the great increase in water demand in 2030, therefore, new structures and facilities are required to be developed. Although the estimated 2030 surface water of 2,536 MCM/year and the groundwater of 475 MCM/year are available in the catchment area, the majority of the surface water is distributed at the foot of Mt. Kenya on the southwest of the catchment area. The rest of the area needs to rely on the groundwater.

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

a) Dam development is essential and will be promoted in the southwest part of the catchment area where a sharp increase in future large water demands such as domestic, industrial and irrigation water demands are expected in 2030. Candidate dam development projects for maximising surface water abstraction include in principle i) dams proposed by the NWMP

(1992), and ii) dams being designed and planned by the government including the Kenya Vision 2030 flagship projects.

b) Small dams and/or water pans will be developed in small rivers over the entire catchment area except in the northwestern and eastern part, where there is less rainfall, 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 expected for large dams but surface water is available.

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

4.6.3 Proposed Water Resources Development Plan

(1) Water Balance Study

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

The water balance study followed the policies of the water allocation as stated in Section 7.2 of the Main Report Part A. A summary of which are tabulated as follows:

Prioritisation of Water Allocation

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

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

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

Conditions of the surface water balance study are discussed in Section 4.3 of the Sectoral Report (G) and summarised as follows: i) the model consists of 27 sub-basins, water demand points, existing water resource infrastructures, and candidates for future development such as dams and water transfer facilities; ii) monthly mean values of the naturalised water resources and demands are applied; iii) the amount of the reserve is determined as 95% value of the naturalised present daily flow duration curve in Figure 4.6.4 with the probability of once in 10 years as shown in Table 4.6.3; and iv) return flow rates of 25%, 5%, and 100% for urban domestic water supply, paddy irrigation, and hydropower generation are applied.

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

(2) Proposed Water Resources Development Plan

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

1) Dams

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

Proposed Dams (ENNCA)

(Unit: MCM)

Name of Dams	Storage Volume for Domestic/ Industrial	Storage Volume for Irrigation	Total Storage Volume	Remarks
Nyahururu Dam	11.0	0.0	11.0	Flagship Project
Rumuruti Dam	1.0	0.0	1.0	Flagship Project
Kihoto Dam	0.0	389.0	389.0	
Isiolo Dam	21.0	0.0	21.0 *	F/S ongoing (NWCPC)
Archers' Post Dam	7.0	93.0	100.0	Flagship Project
Total	40.0	482.0	522.0	

Note: * = The total storage volumes with * are those planned or designed by the government.
F/S=Feasibility study
Source: JICA Study Team, based on information from relevant government agencies

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

The total storage volume of Isiolo Dam followed the ongoing feasibility study as shown in the above table.

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

2) Small Dams/Water Pans

The storage volumes for irrigation use were estimated considering the conditions of the irrigation subsector.

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

Proposed Small Dams/Water Pans (ENNCA)

(Unit: MCM)

Structures	Volume for Domestic	Volume for Irrigation	Volume for Livestock	Volume for Wildlife/ Fishery	Total Storage Volume	Remarks
Small Dam/Water Pan	0	5	79	7	91	Total No. of small dams/ water pans = 1,820

Note: Excluding the storage volume of the existing small dams and water pans of 10 MCM
Source: JICA Study Team

The total number of the small dams / water pans of 1,820 was estimated by applying the volume per dam/ pan of 50,000 m^3 as the minimum capacity following the volume applied in NWMP(1992) and assumed based on the existing volumes.

3) Boreholes

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

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

Proposed Boreholes (ENNCA)

(Unit: MCM/year)

Facilities	Volume for Domestic/ Industry	Volume for Irrigation	Total Abstraction Volume	Remarks
Borehole	48	108	156	Total No. of boreholes = 1,560

Note: Excluding the 35 MCM/year abstraction of existing boreholes .
Source: JICA Study Team

The total number of the boreholes of 1,560 was estimated by applying the capacity per borehole of 100,000 m^3/year assumed based on the existing data.

(3) Evaluation of Proposed Water Resources Development Plan

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

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

Water Supply Reliability at Reference Point (ENNCA)

Reference Point	Present (2010) Water Supply Reliability	Future (2030) Water Supply Reliability
Ewaso Ng'iro North River (5ED01), Archers' Post	1/1	1/5

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

The future water supply reliability at the reference point of Archers' Post in Ewaso Ng'iro North River is estimated at 1/5, since water demand downstream of the reference point is irrigation use only.

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

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

4.7 Water Resources Management Plan

4.7.1 Current Situation of Water Resources Management

ENNCA is located in arid and semi-arid areas in the northeastern part of Kenya with a total catchment area of 210,226 km^2 which is 36.8% of the total area of Kenya. It is the largest catchment area among the six catchment areas of WRMA. The average annual rainfall in the basin is 510 mm, which is almost the same as the one for the RVCA, the smallest among the six catchment areas.

Major rivers in the catchment area are the Ewaso Ng'iro North River which originates from Mt. Kenya (5,199 m) and flows in the central part of the country eastward, and the Daua River that flows along the border of Ethiopia. Usage of surface water is mainly limited in the upper most area of Ewaso Ng'iro North River. There are many locations in the northern part of the catchment area that rely their water sources on groundwater only.

The Water Resources Management Authority (WRMA) has its ENNCA Regional Office in Nanyuki. Under the regional office, there are five subregional offices as follows:

(i) Mandera that covers areas between Ewaso Ng'iro North and Daua rivers;
(ii) Isiolo that covers the middle reach of the Ewaso Ng'iro North River;

(iii) Rumuruti that covers the upper reach of the Ewaso Ng'iro North River at its southwestern edge of ENNCA;

(iv) Marsabit that covers the northwestern part of ENNCA that includes Moyale, Marsabit, and Laisamis; and

(v) Nanyuki that covers the upper reach of the Ewaso Ng'iro North River in the northern outskirts of Mt. Kenya.

Figure 4.7.1 shows the Management Unit Boundary and Subregional Office Management Boundary.

The following table shows the current monitoring targets of WRMA, numbers of operational stations and their achievement ratio for surface water, groundwater, water quality, and rainfall. The achievement ratio of groundwater level, surface water quality, and groundwater quality monitoring stations are very low.

Current Monitoring Situations of Water Resource (ENNCA)

Item	Surface Water Level	Groundwater Level	Surface Water Quality	Groundwater Quality	Rainfall
Target	40	10	40	10	26
Operational	25	5	24	3	8
Achievement (%)	63	50	60	30	31

Source: WRMA Performance Report 1 (July 2010)

The current situations on water permit issuance and management by WRMA are as shown below. The ratio of valid permits against issued permits is the lowest among the six catchment areas of WRMA, especially for surface water permits as shown below:

Current Situations of Water Permits (ENNCA)

Item	Application	Authorised	Issued Permits	Valid Permits	Ratio of Validity (%)
Surface Water	1,566	1,031	201	38	19
Groundwater	1,421	871	31	28	90
Total	2,987	1,902	232	66	28

Source: WRMA Performance Report 1 (July 2010)

As for the watershed conservation in ENNCA, it is important to conserve Mt. Kenya and the gazetted forests located in the western part of the catchment area which are major water sources within ENNCA. Deforestation and forest degradation are rampant in the water source forests like in the northern skirts of Mt. Kenya. According to the results of the satellite image analysis in this study[1] the forest area in ENNCA in 2010 was about 184,000 ha, which corresponded to 0.9% of forest cover in ENNCA. The deforested areas during the last two decades were about 36,000 ha, which meant the decrease of about 16% of the forest areas in 20 years since 1990.

According to interviews with stakeholders of watershed conservation including WRMA and KFS in ENNCA, there were deteriorations on small water sources in 12 springs in the catchment area. Such issues have severe effects on the availability of water resources in the catchment area as most of the area in ENNCA belongs to arid and semi-arid lands (ASALs) that highly depend on small water sources. However, as detailed information on the deterioration of small water sources such as location, magnitude, water use, water quality, vegetation, and method of management are unknown, further study is required.

Further, WRMA pointed out that the deforestation and forest degradation caused soil erosion and its inflow into rivers, which was one of the causes of flooding. As detailed information on soil erosion areas such as location, magnitude, water use, water quality, vegetation and method of management are not known, further study is required.

4.7.2 Management Strategy

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

(1) Monitoring

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

1) Surface Water Level

The Ewaso Ng'iro North River and its major tributaries were selected as representative rivers to capture runoff characteristics of the basin. However, most of the surface water use is concentrated in the upper reach than the Archer's Post, and surface water level monitoring stations are concentrated in the area. The locations of these monitoring stations should be reviewed so that the monitoring points would be the representative for each tributary. (Please refer to Figure 4.7.1).

2) Surface Water Quality

Surface water quality monitoring points were also selected from the representative rivers.

For the Ewaso Ng'iro North River, monitoring points should be selected from those that are located at the downstream of pollution sources such as major cities and irrigation schemes. Such points should be monitored monthly.

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

3) Groundwater Level

Groundwater monitoring points were set at locations where significant groundwater use is expected in the future. Such points are in urban centres which have both water supply and sanitation plans. In

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

the selected monitoring points, groundwater levels with dedicated boreholes are monitored monthly. It is important to monitor and confirm that the groundwater levels are recoverable in an annual cycle for sustainable use.

4) Groundwater Quality

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

5) Rainfall

The rainfall station density should be considered by climatic regions for arid, semi-arid or other areas. In ENNCA, most of the catchment area belongs to arid area. For this area, the criterion of one station in 8,000 to 10,000 km^2 was applied in reviewing existing stations. Upper reach of the Ewaso Ng'iro North River belongs to semi-arid or other areas. For this area, the criterion of one station in 3,000 to 5,000 km^2 for semi-arid and one station in 500 to 1,000 km^2 for humid areas are applied.

(2) Evaluation

1) Water Resources Quantity Evaluation

The water resources quantity evaluation is conducted annually based on i) monitoring data of surface water, groundwater, and rainfall and ii) records of water permit issuance. Water abstraction survey data will be used as necessary to grasp actual water use status. For surface water resources evaluation, the major rivers of Tana and its tributaries should be the focus as they are the representative rivers in ENNCA.

2) Water Resources Quality Evaluation

The water resources quality evaluation is conducted annually based on the monitoring data of surface water and groundwater quality. Currently, there is only one water quality test laboratory in Nyeri for the analysis of water quality in the catchment area. For the timely analysis of monitored water quality especially in the northeastern part of the catchment area, additional water quality test laboratories should be established.

(3) Water Permit Issuance and Control

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

(4) Watershed Conservation

All of the three major items of: a) recovery of forest areas; b) conservation of small water sources and c) control of soil erosion are to be considered in ENNCA.

1) Recovery of Forest Areas

Forest recovery will be implemented through reforestation focusing on the northern skirts of Mt. Kenya of the Five Water Towers and gazetted forests located in the western part of the catchment area.

2) Conservation of Small Water Sources

Conservation of small water sources in the catchment area will be considered.

3) Control of Soil Outflow caused by Deforestation

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

4.7.3 Proposed Water Resources Management Plan

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

(1) Monitoring

The monitoring plan is described in five monitoring items which are i) surface water level, ii) surface water quality, iii) groundwater level, iv) groundwater quality, and v) rainfall. Locations of the proposed monitoring stations are shown in Figure 4.7.2.

1) Surface Water Level

Surface water level is observed twice a day by an honorarium gauge reader. Observed water levels are submitted to WRMA regional offices once a month. In addition, WRMA staff conducts discharge measurement by current meter once a month. Based on the overall concept, the current monitoring network was reviewed mainly for the Ewaso Ng'iro North River and its tributaries, ten monitoring points were selected in the upper reach of the Ewaso Ng'iro North River and its tributaries and three more in the other areas of the catchment. In total, 13 monitoring points were selected for daily basis monitoring. For the Ewaso Ng'iro North River, the following reference point was selected as follows:

a) 5ED01 (Archers' Post) located in the upper reach of the Ewaso Ng'iro North River. This reference point was set to confirm available discharge for the irrigation demand located downstream after satisfying demands in the upstream. This point is an appropriate reference point to grasp river water discharge because the river water does not dry up throughout the year. Monitoring started in 1949.

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

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. Sectral Report (G), Sub-section 4.4.3 (3) and Table 4.4.4)

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

2) Surface Water Quality

Stations monitoring on monthly basis

Based on the management strategy, water quality of the following point is monitored on a monthly basis. This monitoring is for watching and detecting possible pollutant sources that may affect water usage in the relevant rivers.

a) 5ED01 (Archers' Post) located in the upper reach of the Ewaso Ng'iro North River: To monitor the impact of urban and irrigation effluent in the upper reach on river water quality.

Stations monitoring on a quarterly basis

Apart from the above three monitoring stations, water quality of the other surface water monitoring stations (13 points) should be monitored on a quarterly basis (January, April, July, and October every year). Such data are used as reference when WRMA issues water permits. The 13 stations to be monitored are: 5AB04, 5AC10, 5AC15, 5AD04, 5BC04, 5BE02, 5DA02, 5DA07, 5DC02 (5D), 5EC01 , 5EC02 , 5ED01, and 5HA01.

3) Groundwater Level

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

4) Groundwater Quality

Groundwater quality is monitored at the same locations where groundwater level monitoring stations are located. As groundwater quality does not change so frequently compared with surface water, monitoring is conducted twice a year (once in the rainy season and once in the dry season).

5) Rainfall

Based on the management strategy, distribution of the current rainfall monitoring stations was reviewed. As a result of the review, 34 rainfall monitoring stations were selected for daily basis monitoring.

(2) Evaluation

1) Water Resources Quantity Evaluation

Based on the management strategy, water resources quantity evaluation is conducted annually based on i) monitoring data for surface water, groundwater, and rainfall and ii) water permit issuance data. For this, a water resources evaluation team is formed and composed of: i) one chief hydrologist from Nanyuki Regional Office and ii) one assistant hydrologist each from Nanyuki, Rumuruti, Isiolo, Marsabit, and Mandera subregional offices. Water resources evaluation works are done for the whole of ENNCA on both surface water and groundwater.

2) Water Resources Quality Evaluation

Based on the management strategy, water resources quality evaluation is also conducted annually based on the monitoring data for surface water and groundwater quality.

Additional water quality test laboratories should be established in Marsabit and Wajir for the timely analysis of water quality samples especially in the northeastern part of the catchment. For the management of laboratories and evaluation of water quality, a chief water quality expert with appropriate staff should be assigned in the water quality test laboratories in Nyeri, Marsabit, and Wajir.

(3) Water Permit Issuance and Control

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

a) Control over the latest version of issued water permits
    - Periodical update of water permit database; and
    - Establishment and enhancement of the notification system on permit expiry.
b) Revision of Guidelines for Water Allocation
    - Formulation of water allocation plans considering future water demand
c) Increase of the number of water rights officers shown as below for smooth implementation of water permit issuance and control.

Number of Required Water Rights Officers (ENNCA)

Offices	Number of Water Rights Officers		
	Current	Required	Future
ENN RO	2	No change	2
Nanyuki SRO	1	+1	2
Rumuruti SRO	2	No change	2
Isiolo SRO	2	No change	2
Marsabit SRO	0	+2	2
Mandera SRO	1	+1	2
Total	8	+4	12

Note: RO=Regional Office, SRO=Subregional Office

Source: JICA Study Team, based on interview with WRMA Regional Office

(4) Watershed Conservation

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

1) Recovery of Forest Areas

As for the forest recovery for watershed conservation, about 590,000 ha of forestation is proposed in ENNCA to achieve the targets of Kenya Vision 2030. Current situations of the forest areas in ENNCA and potential areas for forestation are shown in Figure 4.7.3.

The followings steps were applied in the preparation of Figure 4.7.3.

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

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

2) Conservation of Small Water Sources

As for the conservation of small water sources, it is proposed to carry out a survey on small water sources, which includes location, scale, water use, water quality, vegetation condition, management method, major issues, etc.

c) Control of Soil Erosion

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

4.8 Flood and Drought Disaster Management Plan

4.8.1 Current Situation of Flood Disaster Management

(1) Flood Situation

Although most of ENNCA is defined as arid district, severe flood disasters have been reported in various parts of the catchment area.

In 2005, the banks of Daua River, which flows along the Kenya-Ethiopia border, were damaged and destroyed many farms in the Ramu area of the Mandera District. During the short rainy season of 2006, the Daua River overflowed rapidly and caused wide range inundation in several divisions of the Mandera District. The massive flooding that occurred in 2009 caused 16 deaths in the Mandera District. In the urban area of Isiolo town, flooding is frequently caused by the small channel flowing into the Isiolo River, the tributary of the Ewaso Ng'iro North River, due to the insufficient discharge capacity of the channel.

On the other hand, the Flood Mitigation Strategy (MWI, 2009) describes Wajir District, located in the middle to lower reach of the Ewaso Ng'iro River, as one of the areas that experience flooding almost annually. Moreover, it was confirmed through the damage survey that inundation depth in this area is relatively larger than others. In addition, according to the WRMA ENN Regional Office, in recent years, occurrences of flash floods are increasing in the particular type of arid lands.

(2) Flood Disaster Management

Flood control structural measures are underway gradually, while in recent years construction of dikes with a length of 0.5 km and revetment works with a length of 5.3 km along the Daua River have been implemented in Mandera county by the NWCPC. However, it could not be said that systematic flood management has been implemented in ENNCA because setting of water warning levels even at major river gauge stations have not been confirmed.

4.8.2 Current Situation of Drought Disaster Management

(1) Drought Situation

Most of ENNCA except for very limited parts in and around the Five Water Towers is categorised as arid land, and drought damages in the catchment area are the most severe in Kenya.

During the time of drought in January 2011, civil insecurity and conflicts over water resources and grazing resources occurred particularly in Marsabit area. In Wajir and Mandera districts, earlier than usual, the drying of water pans and dams have increased trekking distances for livestock to an average of 15 km to 20 km and up to 40 km compared to the normal of 5 km to 10 km. As a result, livestock productivity declined sharply. For instance, milk production dropped to less than 40% of normal, and consequently milk price increased threefold.

(2) Drought Disaster Management

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

On the other hand, as for water resources management during drought, the WRMA ENN Regional Office has determined three water level warnings and its discharge, namely Normal, Alert, and Alarm levels at five river gauge stations as a reference level. Once the river water level reaches the warning level, the WRMA ENN Regional Office will carry out water use restrictions by regulating water intake.

There is one existing dam for the domestic water supply purposes, namely, Badas Dam (under construction).

4.8.3 Flood Disaster Management Strategy

As explained in the concept and framework e) mentioned in Section 7.9 of the Main Report Part A, the proposed study 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 part of the Ewaso Ng'iro North River basin. Out of these, urban areas are limited to Mandera (population as of 2009: 88,000) and Isiolo (population as of 2009: 46,000).

Initially, the Middle/Lower Ewaso Ng'iro North including Wajir will be excluded from the NWMP 2030 because severe flood damage has been rarely reported while river-induced inundation was confirmed.

Isiolo has both river-induced flood and urban drainage issues. 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 that will mitigate damages to properties and loss of lives since structural measures alone have limited safety capacity against extraordinary floods exceeding the design level. Hazard maps and evacuation plans should be prepared. Regarding urban drainage issues in Isiolo, the drainage system should also be improved in consideration of the high population density.

In Mandera, there are two causes of flood. One is the overflow from the Daua River that is the national boundary of Ethiopia, and another is two tributaries flowing from Somalia into the Daua River through the built-up area of Mandera. Both floods arise from international rivers, therefore, it is considered difficult to construct a flood control dam. In this regard, the urban area of Mandera should be protected through river improvement works, retarding basin or a combination of them. In addition, it is also more effective to adopt a strategy that will mitigate damages to properties and loss of lives since structural measures alone have limited safety against extraordinary floods exceeding a design level. Hazard maps and evacuation plans should be prepared.

The followings basic policies are important to formulate the flood disaster management plan in ENNCA:

a) Implementation of flood control measures as well as the preparation of hazard maps and evacuation plan in Mandera.

b) Implementation of flood control measures as well as preparation of hazard maps and evacuation plan in Isiolo.

c) Implementation of urban drainage systems in Isiolo.

4.8.4 Drought Disaster Management Strategy

Based on the overall concepts mentioned in Section 6.9 of the Main Report Part A, drought management strategy for the LVNCA will be implemented through the i) preparation of water use restricted rules for existing and proposed reservoir, ii) establishment of the Basin Drought Conciliation Council and iii) establishment of drought early warning system.

4.8.5 Proposed Flood Disaster Management Plan

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

(1) Implementation of Flood Control Measures in Mandera

As to the flood control measures for Mandera, the following alternatives are proposed. The alternatives for Mandera are limited to the two cases discussed below because it is considered difficult to construct a dam due to the difficulty to control of international rivers.

(A) River improvement works alone:
Construction of a new dike, reinforcing or heightening of existing dike, widening of high water channel by realignment of existing dike, widening of low water channel by excavation, etc.

(B) Flood discharge control by retarding basin and river improvement works.

It should be noted that although it is not allowed to inundate landside-prone area as proposed in the NWMP 2030, it is necessary to consider the possibility of adopting a strategy for natural retarding effects such as pasture, paddy and dry fields for lands subject to frequent flooding at the time of detailed planning in the future.

In addition, flood hazard map covering all flood plain areas in Mandera shall be prepared and notified to the public. This map is assumed to be more accurate compared to the simplified hazard map prepared by communities and to show probable flood areas for several kinds of probable return periods and probable maximum flood. The WRMA ENN Regional Office should make a flood analysis by using hydrological and topographical data. Based on the hazard map, evacuation plan for Mandera should also be formulated with attention to classification of flood warnings and evacuation orders, dissemination method of warnings and orders, clear indication of evacuation place and route, confirmation method of evacuation activities, etc.

(2) Implementation of Flood Control Measures in Isiolo

As to the flood control measures for Isiolo, the following alternatives are proposed. The alternatives for Isiolo are limited to the two cases below because i) there is no plan to construct a multipurpose dam in the water resources development sector and ii) it is considered difficult to construct a retarding basin due to the relatively steep slope land around Isiolo. In Isiolo, it will be effective to take a measure to increase the discharge capacity of small channel flowing through the built-up area of Isiolo into the tributary of Ewaso Ng'iro North River.

(A) River improvement works alone:
Construction of a new dike, reinforcing or heightening of existing dike, widening of high water channel by realignment of existing dike, widening of low water channel by excavation, etc.

(B) Flood discharge control by several small-scale dams/pans and river improvement works.

As well as Mandera's case, it is necessary to consider the possibility to adopt natural retarding effects in the future. Also, flood hazard map and evacuation plan shall be prepared in the same manner as Mandera mentioned above.

(3) Implementation of Urban Drainage Measures in Isiolo

It is proposed to implement urban drainage measure works in Isiolo. The works would be the responsibility of local authorities, namely, Isiolo County and Isiolo Urban Centre. In the following section of cost estimates, it will show the preliminarily estimated cost of the drainage works composing of gravity drains based on the NWMP (1992). However, it should be noted that drainage work involves, in some cases, major associated works such as pumping station, retarding basin, improvement of receiving river channels, etc., which should be planned in detail in the future.

4.8.6 Proposed Drought Management Disaster Plan

(1) Preparation of the Water Use Restriction Rule for Reservoirs

1) Target Dam

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

Target Dams for Water Use Restriction Rules (ENNCA)

River System	No.	Dam Name	Status	
			Existing	Proposed
Ewaso Ng'iro North	1	Rumuruti		O
	2	Nyahururu		O
	3	Kihoto		O
	4	Isiolo		O
	5	Archers' Post		O
	6	Badasa	O	
Total			1	5

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

2) Setting of Reference Reservoir Water Level

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

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

3) Determination of Reduction Rate

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

a) Based on the current water level of reservoirs, subsequent water level shall be forecasted by considering future weather forecasts. Then, necessary reduction rate in water intake for all basins will be determined;
b) Based on item a), reduction rate shall be determined for the respective intended purposes such as domestic water supply, industry, and agriculture, considering the possibility to save water volume for each purpose. At this time, it is essential to consider priority order that has been conventionally stipulated in Kenya; and
c) While referring to the actual data on reduction rates during the past drought, the final reduction rate shall be determined.

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

(2) Establishment of a Basin Drought Conciliation Council

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

The previous table shows all the dams, which are incorporated into the water resources development plan of NWMP 2030, and their river systems. One council shall be established for each river system. The number of councils to be established in ENNCA will be one for Ewaso Ng'iro North River system as illustrated in Figure 4.8.1.

The council shall be composed of the WRMA Regional Office, relevant counties, representatives for water users (WRUAs), etc. The council shall be established legally to avoid water conflict during drought time.

(3) Drought Early Forecast

Water use restriction should be considered at the early stages taking into account the weather conditions, water storage in the reservoirs, social impacts in the worst case scenarios, etc.

Currently, the KMD issues long-term rainfall forecast of 4-day, 7-day, 1-month, and 3-month (seasonal), which are officially released on the website of the KMD or published in the newspaper. This information shall be utilised to commence timely water use restriction.

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

4.9 Environmental Management Plan

4.9.1 Current Situation of the Environmental Management

Most of ENNCA belongs to the ASAL area and ENNCA has the least water resources among the six catchment areas. The main river of ENNCA is the Ewaso Ng'iro North River originating from Mt. Kenya. The Shaba National Park, the Buffalo Springs, Nyambene, and Samburu national reserves are situated along the river. In addition, the river flows underground in the lower reaches. Wetlands named Lorian Swamp and vegetation zones are located along the groundwater vein of the Ewaso Ng'iro North River after underground flow. The Lorian Swamp is the largest wetlands of Kenya, important to many of the large mammals which live in the ASAL area. Therefore, setting of adequate environmental flow rate and environmental monitoring are required for the river.
The Losai and Shaba national parks and Mt. Kenya national parks/reserves are located in southwestern part of ENNCA. A large area of Mt. Kenya is designated as national parks/reserves. The designated area is strictly protected by KWS from illegal logging and encroachment. KWS activities are quite effective in protecting the area, but facing strong oppositions from local people who have lived near the area for a long time.

In addition, some relatively-large gazetted forests are located in the western area. It is required to set the appropriate environmental flow rate and to conduct environmental monitoring because the areas are significant conservation targets in ENNCA.

Summary of Natural Resources (ENNCA)

Protected Area		Total Area	Number of Wildlife Species	Location
National Park (N.P.)				
1	Marsabit N.P.	68 km^2	No information	Marsabit District, Eastern Province
2	Malka mari N.P.	876 km^2	No information	On the Kenya-Ethiopia border in the extreme northeast of Kenya on the Mandera plateau
3	Mt Kenya N.P.	715 km^2	200	East of the Rift Valley
National Reserve (N.R.)				
4	Buffalo Springs N.R.	131 km^2	85	Isiolo District, Eastern Province
5	Losai N.R	1,806 km^2	126	Losai Mountains, Northern Kenya
6	Samburu N.R.	165 km^2	145	The banks of the Ewaso Ng'iro River
7	Shaba N.R.	165 km^2	134	Ishiolo Distcict
8	Nyambene N.R.	640.6 km^2	No information	Meru North District
9	Marsabit N.R.	1,564 km^2	118	Marsabit District, Eastern Province
10	Laikipia N.R.	165 km^2	No information	Near Mt.Kenya
National Sanctuary (N.S.)				
11	Maralal N.S.	5 km^2	159	-

Protected Area		Total Area	Number of Wildlife Species	Location
Five Water Towers				
12	Mt.Kenya	220,000 ha	No information	180 km north of Nairobi
13	Aberdare Range	250,000 ha	No information	Central Kenya, on the eastern edge of the RVCA

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

4.9.2 Management Strategy

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

The water resources development projects in the NWMP 2030 are mostly proposed on the upper reaches of the Ewaso Ng'iro North River and its tributaries, namely, the Ewaso Narok and S.R.Uguoi rivers. Therefore, setting of the environmental flow rate and environmental monitoring are proposed for the main stem of the Ewaso Ng'iro North River.

4.9.3 Proposed Environmental Management Plan

Based on the abovementioned management strategy, and point selection criteria mentioned in the overall concept and framework, target points of environmental flow rate, and environmental monitoring of environmental management plan for ENNCA are shown in the following table. Locations of target points are shown in Figure 4.9.1.

Environmental Flow Rate Setting Points (ENNCA)

Target	Environmental Flow Setting Point		Proposed Major Development Projects	Vegetation	Reserve* (m^3/s)	Monitoring Point of WRM
Ewaso Ng'iro North River	ENN-F1	Reference point (Archer's Post Town)	Archer's Post, Isiolo, Kihoto, Rumuruti, and Nyahururu dams	Deciduous bushland and thicket	0.0	5ED01
	ENN-F2	Downstream of confluence point with the Ewaso Narok River		Evergreen bush land with wooded grassland	1.3	5DC02

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

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

In addition, the environmental survey for setting the environmental flow rate (current river flow rate, water quality, and river ecosystem) shall be conducted in the Ewaso Ng'iro North River.

Environmental Monitoring Points (ENNCA)

Target	Monitoring Point		Reserve* (m^3/s)	Monitoring Point of WRM	Selection Criteria
Ewaso Ng'iro North River	ENN-M1	Reference point (Archer's Post Town)	0.0	5ED01	a) Representative point to monitor the river ecosystem b) Points where rare or characteristic ecosystem exists (National parks and reserves) d) Points upstream from the protected area
	ENN-M2	Downstream of confluence point with the Ewaso Narok River	1.3	5DC02	a) Representative point to monitor the river ecosystem (including the Ewaso Narok River)

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

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

CHAPTER 5 COST ESTIMATES

5.1 Basic Conditions and Methodologies for Cost Estimates

5.1.1 Conditions and Methodologies of Cost Estimates for Development Plans

Costs of the projects proposed in the development plans formulated for ENNCA in this study including water supply, sanitation, irrigation, and water resources development plans were estimated to identify the total costs in general to evaluate the general economic viability, and to discuss the general idea of financing for the implementation of the proposed projects.

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

a) Water supply projects:

   i) For the urban water supply system, the project costs were estimated by applying the unit cost of US$250/$m^3$ for water supply capacity for rehabilitation, US$375/$m^3$ for expansion/new development of source works and water transmission system, and US$1875/$m^3$ for expansion/new development of treatment works and distribution pipe networks. The unit costs were derived from the data on the existing reports prepared by the WSBs and the Aftercare Study Report with adjustments. The used data includes direct construction costs and indirect construction costs (administration and engineering services). Land acquisition costs were not estimated because of the marginal amount of the water supply projects.

   ii) For the dams and bulk water transfer systems required for the urban water supply system, the project costs were estimated separately as described in the paragraph e) below.

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

   iv) Rural, boreholes

b) Sanitation projects:

   i) For the sewerage system, the project costs were estimated by applying the unit cost of US$600/$m^3$ for treatment capacity for rehabilitation, US$1250/$m^3$ for expansion/new development of wastewater collection system, and US$750/$m^3$ for expansion/new development of wastewater treatment works. The unit costs were derived from the data in the existing reports prepared by the WSBs and the Aftercare Study Report with adjustments. The used data included direct construction costs and indirect construction costs (administration and engineering services). Land acquisition costs were not estimated because of the marginal amount for the sewerage projects.

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

iii) Other sanitation projects

c) Irrigation projects:

i) For the large- and small-scale irrigation projects proposed by the government or local authorities, the project costs were estimated by summing the direct construction costs estimated by the government or authorities with adjustments and indirect construction costs as calculated below.

The indirect construction costs were calculated by summing administration, engineering services, and soft component costs assumed at 3%, 15%, and 3% of the direct construction costs, respectively. Land acquisition costs was calculated by applying the assumed unit cost of KSh100,000/ha based on the actual data.

ii) For the new large- and small-scale irrigation projects without existing cost data, the project costs were estimated by summing the direct construction costs calculated by applying unit costs per ha and indirect construction costs as calculated above. The unit costs were assumed to be between KSh150,000/ha and KSh900,000/ha depending on the type of water sources such as weir, dam, groundwater, and water harvesting.

iii) For private irrigation projects, the project costs were estimated by summing the direct construction costs calculated by applying the unit cost of KSh1.5 million/ha and indirect construction costs as calculated above. The unit cost was assumed by referring to the actual investment cost data for drip irrigation system invested by private sectors. Among components of the indirect cost, administration and soft component costs were not included for the private projects due to their nature.

iv) The annual O&M costs were estimated for the irrigation projects by applying the amount of 0.3% of the direct construction costs for the water source facilities and 1% for the irrigation systems. The replacement costs for electromechanical works were estimated by applying the amount of 20% of the direct construction costs. The replacement was assumed to be conducted every 20 years.

Small dams, boreholes

d) Hydropower projects:

There is no hydropower development plan proposed for ENNCA.

e) Water resources development projects:

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

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

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

iv) The annual O&M costs for dam projects and civil components of the water transfer projects were estimated by applying the amount of 0.5% of the project costs. The percentage was assumed based on the values in the NWMP (1992) and figures usually used in planning similar projects. O&M costs for the electromechanical component of the water transfer projects were estimated by applying the amount of 0.5% of the project costs. The replacement costs were not considered for the dams and water transfer facilities because of their nature.

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

Other basic conditions applied for the cost estimates are enumerated below.

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

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

5.1.2 Conditions and Methodologies of Cost Estimates for Management Plans

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

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

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

a) For water resources management plan, both development and recurrent costs were estimated by applying the unit costs for management activities based on interviews with WRMA staff in charge of related management activities.
b) For flood and drought disaster management plans, the development costs were estimated referring to the existing master plan studies such as the Nyando Flood Management Master Plan (2009) and the NWMP (1992) with adjustments. The annual recurrent costs were assumed to be 0.5% of the development costs.
c) For the environmental management plan, both development and recurrent costs were estimated by applying the unit costs for management activities in terms of required manpower, meetings, surveys, and monitoring.

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

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

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

Other basic conditions applied in the cost estimates are as follows:

a) Market price of November 1, 2012.
b) Exchange rate of KSh85.24 to US$1.00, ¥79.98 to US$1.00 and KSh110.48 to Euro1.00 as of November 1, 2012.

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

5.2 Cost Estimate for Proposed Plans

5.2.1 Cost Estimate for Proposed Development Plans

(1) General Scopes of Proposed Plans for Cost Estimate

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

(1) Water Supply

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

(2) Sanitation

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

(3) Irrigation

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

(4) Hydropower

There is no hydropower development plan proposed for ENNCA.

(5) Dam and Water Transfer

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

The project and annual O&M costs for the projects proposed in the development plans for ENNCA were estimated based on the conditions and methodologies stated in the preceding section. Results of the estimates are shown in Tables 5.2.1 to 5.2.5 and are summarised below.

Estimated Costs for Proposed Projects in Development Plans (ENNCA)

(Unit: KSh million)

Development Plan	Proposed Project	Type	Project Cost	Annual O&M Cost
Water Supply*	Urban Water Supply (12 UCs)	Rehabilitation	1,867	-
		New construction	21,114	870
		Sub-total	22,981	870
	Rural Water Supply (14 Counties)	Rehabilitation	401	-
		New construction	21,473	1,051
		Sub-total	21,874	1,051
	Sub-total		44,855	1,921
Sanitation*	Sewerage System (5 UCs)	Rehabilitation	236	-
		New construction	9,831	538
	Sub-total		10,067	538
Irrigation**	Large-scale Irrigation (26,202 ha)	New construction	46,305	139
	Small-scale Irrigation (8,116 ha)	New construction	5,245	26
	Private Irrigation (7,165 ha)	New construction	13,890	139
	Sub-total		65,440	304
Hydropower	No project	New construction	0	0
Total			120,362	2,763

Note: UC = Urban Centre

* O&M cost of existing water supply and sewerage facilities to be rehabilitated was not estimated due to lack of data required for cost estimate.

** Rehabilitation cost of existing irrigation facilities was not estimated due to lack of data required for cost estimate though there are needs of rehabilitation of them.

Source: JICA Study Team (Ref. Tables 5.2.1 – 5.2.5)

The costs for the proposed water resources development were estimated to be KSh36,653 million for project cost, KSh183 million/year for O&M cost, which include the costs of five dams. The costs had been allocated to the costs for water supply and irrigation subsectors.

5.2.2 Cost Estimate for the Proposed Management Plans

(1) General Scopes of Proposed Plans for Cost Estimate

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

(1) Water Resources Management Plan

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

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

(2) Flood and Drought Disaster Management Plan

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

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

(3) Environmental Management Plan

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

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

The development and recurrent costs for the proposed management plans of ENNCA were estimated based on the conditions and methodologies stated in the preceding section. Results of the estimates are shown in Tables 5.2.6 to 5.2.8 and summarised below.

Estimated Costs for Projects Proposed in the Management Plans (ENNCA)

(Unit: KSh million)

Management Plan	Proposed Plans	Development Costs	Annual Recurrent Costs
Water Resources Management	Monitoring	67	67
	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	69

Note:* Recurrent cost includes operation and maintenance costs

Source: JICA Study Team (Ref. Tables 5.2.7 – 5.2.9)

CHAPTER 6 ECONOMIC EVALUATION

6.1 Basic Conditions and Methodology for Economic Evaluation

The overall economic evaluation was performed for four sectors: 1) urban water supply (for 12 UCs, excluding rehabilitation works), 2) sewerage (for five UCs, excluding rehabilitation works), and 3) large-scale irrigation (with 20,646 ha) in ENNCA at a master plan level. There is no hydropower project proposed in ENNCA. The following assumptions were made for economic analysis:

a) Price Level

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

b) Social Discount Rate

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

c) Economic Life of Facilities

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

d) Cost Allocation for Multipurpose Dams

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

e) Economic Cost

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

f) Economic Benefits

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

Items of Economic Benefit (ENNCA)

Sector	Items of Economic Benefit	Benefit at Net Present Value (10%)
a) Water Supply	- Cost saving for water users - Increase of water supply amount	KSh 29.8 billion (30 years)
b) Sewerage	- Cost saving for users - Affordability to pay - Improvement of public health	KSh 12.0 billion (30 years)
c) Irrigation	- Crop production increase	KSh 28.4 billion (50 years)

Source: JICA Study Team

The details of the calculations are described in the sectoral reports.

6.2 Economic Evaluation for the Proposed Plan

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

Summary of Economic Evaluation Results (ENNCA)

(Unit: KSh billion)

Sector	Scope	Eestimated Financial Cost	Estimated Economic Cost	Net Present Value (10%)		B/C	EIRR
				Cost	Benefit		
Water Supply	12 UCs	20.6	19.5	22.4	29.8	1.33	14.10%
Sewerage	5 UCs	9.8	9.2	11.1	12.0	1.08	11.10%
Irrigation	20,646 ha	36.1	34.2	28.7	28.4	0.99	9.90%

Source: JICA Study Team

The total economic costs for water resources development is estimated at KSh62.9 billion, of which large-scale irrigation projects are the largest (KSh34.2 billion). This large amount of economic costs in irrigation schemes results from the high costs of dams (i.e., KSh19.3 billion in Archers' Post Dam). In terms of economic viability, the water supply and sewerage subsectors were found to be economically feasible with more than 10% of EIRR, while the irrigation subsector had a low efficiency from the economic point of view. The results of the economic analysis for the three subsectors are summarised below.

a) Water supply projects in ENNCA are generally small-scale, and do not require high cost structures for water sources, such as large scale dams or water transmission system, which led to a positive economic viability;

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

c) The irrigation subsector was not economically feasible due to the high cost of dams. However, the irrigation projects in ENNCA should be reviewed carefully and supported, provided that this area is in a semi-arid area where irrigation projects would be important in the future to secure food security in this region.

CHAPTER 7 IMPLEMENTATION PROGRAMMES

7.1 General

Implementation programmes were prepared for the projects and plans proposed in the development and management plans of the NWMP 2030 in order to ascertain the realisation of the projects and plans by the target year 2030. The implementation programmes were prepared for an implementation term of 18 years from the 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).

The projects and plans in the implementation programmes were assessed to be economically, technically, environmentally and socially viable.

7.2 Criteria for Prioritisation for Implementation

7.2.1 Criteria for Prioritisation of Development Plans

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

(1) Prioritisation by Project Status

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

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

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

(2) Prioritisation by Subsector

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

1) Water supply:

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

2) Sanitation:

a) Rehabilitation of the existing facilities will be made prior to their expansion.
b) Sewerage projects in the urban area with more severe impacts on the environment have higher priority.
c) On-site sanitation facilities will be installed progressively by individuals and communities.

3) Irrigation:

a) Rehabilitation of existing facilities will be made prior to their expansion.
b) Projects with higher economic viability including large- and small-scale projects proposed by the government organisations have higher priority.
c) Other small-scale projects and private projects will be implemented progressively under counties and by private companies, respectively.

4) Hydropower:

a) There is no hydropower development plan proposed for ENNCA.

5) Water resources

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

7.2.2 Criteria for Prioritisation of Management Plans

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

(1) Criteria for Water Resources Management Plan

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

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

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

(2) Criteria for Flood and Drought Disaster Management Plan

1) For Flood Disaster Management Plan

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

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

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

2) For Drought Disaster Management Plan

a) Drought disaster management plans such as preparation of water use restriction for reservoirs and establishment of a Basin Drought Conciliation Council should be implemented, as early as possible, wherever applicable.

(3) Environmental Management Plan

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

a) Environmental survey to set the environmental flow rate, which should be conducted during the short term.

b) Locations of setting environmental flow rate should be prioritised by referring to the implementation programme of development plans such as dams.

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

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

7.3 Implementation Programmes of the Proposed Plans

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

a) All proposed projects and plans should be realised by the target year 2030.

b) The programmes should follow the existing implementation schedules prepared by the government.

d) The programmes should be prepared in close harmony with the requirements of other water subsectors.

e) The programmes should be prepared, of which annual disbursement costs will be as even as possible.

The proposed implementation schedules are shown in Figures 7.3.1 to 7.3.4 for the development plans and Figures 7.3.5 to 7.3.7 for the management plans. Prior to implementation of the development projects, environmental impact assessment (EIA) should be implemented including the issues of compensation.

Tables

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

(m^3/s)

Sub-basin	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Des	Annual (MCM/year)
5AA	0.6	1.4	1.7	1.0	0.6	0.8	0.6	0.6	1.0	1.4	1.0	1.1	30
5AB	0.1	0.4	0.6	0.3	0.1	0.2	0.1	0.1	0.3	0.4	0.3	0.3	9
5AC	0.1	0.9	1.6	1.1	1.1	0.6	0.1	0.1	0.5	0.9	0.8	0.9	23
5AD	0.1	0.4	0.8	0.5	0.6	0.3	0.1	0.1	0.3	0.5	0.4	0.4	12
5BA	0.0	0.5	0.8	0.8	1.2	0.5	0.0	0.0	0.4	0.6	0.3	0.5	15
5BB	0.1	1.5	2.3	2.3	3.5	1.6	0.1	0.1	1.4	1.7	1.0	1.4	44
5BC-1	0.2	1.4	2.0	2.0	3.0	1.4	0.2	0.2	1.2	1.5	1.0	1.3	41
5BC-2	0.0	1.1	1.7	1.6	2.6	1.1	0.0	0.0	1.0	1.2	0.7	1.0	31
5BD	0.1	0.4	0.6	0.6	0.8	0.4	0.1	0.1	0.4	0.4	0.3	0.4	12
5BE	0.4	3.5	5.2	4.7	6.9	3.4	0.4	0.4	3.0	3.7	2.4	3.2	98
5CA	0.1	1.1	1.8	1.7	1.7	0.9	0.1	0.1	0.7	1.2	1.0	1.1	30
5CB	0.0	0.1	0.2	0.2	0.2	0.1	0.0	0.0	0.1	0.1	0.1	0.1	4
5CC	0.1	0.2	0.3	0.3	0.3	0.2	0.1	0.1	0.1	0.2	0.2	0.2	5
5DA	0.5	8.0	13.7	12.4	13.5	6.6	0.5	0.5	5.2	8.9	6.9	8.1	222
5DB	0.0	1.1	1.9	1.7	1.7	0.8	0.0	0.0	0.6	1.1	0.9	1.1	29
5DC	0.1	1.1	1.9	1.7	1.8	0.8	0.1	0.1	0.7	1.2	1.0	1.1	30
5DD	0.0	0.2	0.4	0.4	0.4	0.2	0.0	0.0	0.1	0.2	0.2	0.2	6
5EA	0.6	1.9	2.9	2.6	3.3	1.8	0.6	0.6	1.4	2.1	1.7	1.8	56
5EB	0.4	1.7	2.8	2.5	3.2	1.7	0.4	0.4	1.2	2.0	1.5	1.6	51
5EC	0.2	1.9	3.3	2.7	3.7	1.8	0.2	0.2	1.3	2.2	1.6	1.7	54
5ED	0.6	23.4	42.7	34.0	47.5	22.5	0.6	0.6	15.4	27.4	19.4	21.4	670
5FA	0.4	34.4	64.2	54.8	74.5	33.8	0.4	0.4	22.3	40.9	29.2	31.8	1,016
5FB	0.1	0.5	0.9	0.8	1.0	0.5	0.1	0.1	0.4	0.6	0.4	0.5	15
5G	1.0	7.3	12.5	9.6	10.9	6.1	1.0	1.0	4.6	7.4	7.0	7.7	200
5HA	0.2	1.5	2.6	2.0	2.2	1.3	0.2	0.2	1.0	1.5	1.5	1.6	41
5HB	0.5	3.1	5.6	4.0	4.9	2.9	0.5	0.5	2.2	3.0	3.1	3.5	89
5J	0.2	0.9	1.5	1.1	1.3	0.8	0.2	0.2	0.6	0.8	0.8	0.9	25
Total	6.8	99.7	176.5	147.2	192.4	93.1	6.8	6.8	67.3	113.0	84.7	94.8	2,857

Source: JICA Study Team

Table 4.2.1 Water Service Providers (WSPs) (ENNCA)

WSPs	Service Towns/Areas	Service Population in 2010	Capacity (m^3/day)	NRW
[Urban]				
Nyahururu WSC	Nyahururu, Mairo Inya	46,014	4,552	57%
Nanyuki WSC	Nanyuki	57,252	10,610	43%
Isiolo WSC	Isiolo	34,168	3,220	51%
Mandera WSC	Mandera	13,890	1,672	52%
Maralal WSC	Maralal	17,328	798	47%
Rumuruti WSC	Rumuruti	990	185	27%
Marmanet WSC	Marmanet		2,400	N.A
Moyale WSC	Moyale	9,110	67	30%
[Rural]				
Tuuru	Laare	158,950	3,692	75%
Upper Chania	Njabini	7,600	0	N.A
Nyandarua North	Nyandarua,	19,239	671	42%
Total		364,541	27,867	

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

Table 4.2.2 Proposed Water Supply Development Plan for UWSS (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 was 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 was counted as service population.

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

Table 4.2.3 Proposed Water Supply Development Plan for LSRWSS (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 4.2.4 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 4.3.1 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 4.3.2 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 4.4.1 Large Scale Irrigation Projects Selected for Implementation by 2030

No	Name of Project	County	Sub-basin Code	Irrigation Area (ha)	Project Type*1	Water Source Facilities*2		Present Status*3	Estimated Cost*4 (KSh mil.)	Executing Agency
						Type	Name of Dam			
1.	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	1,320	ENNDA

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

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

	Surface Water (m^3/s)													Groundwater
Sub-basin	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average	(MCM/year)
5AA	1.9	1.0	0.7	3.3	4.3	2.4	3.0	4.0	2.8	2.0	2.8	2.6	2.6	5.1
5AB	0.8	0.3	0.2	1.5	1.8	0.8	1.1	1.3	0.8	0.7	1.2	1.0	1.0	2.1
5AC	1.1	0.3	0.1	1.3	2.2	0.7	0.6	0.8	0.4	0.3	1.1	1.2	0.8	3.1
5AD	0.6	0.2	0.1	0.6	1.2	0.3	0.3	0.4	0.3	0.2	0.6	0.8	0.5	0.6
5BA	0.8	0.4	0.3	1.1	2.7	0.8	0.3	0.2	0.2	0.3	1.2	1.2	0.8	1.4
5BB	1.6	0.8	0.7	3.0	5.4	1.6	0.7	0.5	0.5	1.2	3.0	2.5	1.8	1.1
5BC-1	4.2	1.8	1.2	5.9	11.6	3.3	1.9	1.9	1.6	2.3	6.7	6.4	4.1	7.4
5BC-2	0.4	0.2	0.1	0.6	1.1	0.3	0.2	0.2	0.2	0.2	0.7	0.6	0.4	0.3
5BD	1.4	0.7	0.5	1.9	2.7	1.2	1.2	1.3	1.1	1.0	1.8	1.8	1.4	0.6
5BE	4.5	1.6	1.6	7.6	10.1	2.3	0.5	0.3	0.3	2.5	11.7	9.8	4.4	9.5
5CA	1.8	0.8	0.7	5.1	4.1	2.0	1.4	2.2	1.1	0.6	2.4	3.0	2.1	3.6
5CB	0.9	0.2	0.0	3.6	1.4	0.4	0.2	0.1	0.1	0.0	0.5	1.7	0.8	0.8
5CC	1.0	0.2	0.1	4.5	2.7	0.7	0.2	0.2	0.2	0.1	1.2	2.4	1.1	0.9
5DA	11.2	3.8	3.0	15.6	13.0	1.9	0.6	0.3	0.2	4.1	26.1	25.7	8.8	26.5
5DB	2.6	0.9	0.3	1.4	1.3	0.3	0.1	0.0	0.0	0.1	1.7	3.3	1.0	3.1
5DC	0.9	0.3	0.1	0.7	1.0	0.5	0.3	0.3	0.2	0.1	0.6	1.3	0.5	2.6
5DD	1.0	0.3	0.1	1.2	0.8	0.4	0.1	0.2	0.2	0.1	0.4	1.4	0.5	1.3
5EA	10.4	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.3	35.6	25.1	6.0	27.1
5EB	12.4	0.3	0.0	2.5	5.8	0.3	0.0	0.0	0.0	1.2	57.7	36.8	9.8	44.2
5EC	12.3	0.3	0.2	4.9	14.4	2.1	1.2	0.8	0.6	1.0	39.2	29.9	8.9	44.9
5ED	25.0	7.4	2.1	6.4	19.7	1.1	0.0	0.0	0.0	0.0	58.5	79.0	16.6	157.2
5FA	18.1	4.3	1.7	0.6	0.0	0.0	0.0	0.0	0.0	0.0	1.9	38.5	5.4	65.3
5FB	3.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.8	10.0	1.7	5.3
5G	12.4	0.3	0.0	2.5	5.8	0.3	0.0	0.0	0.0	1.2	57.7	36.8	9.8	25.1
5HA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	2.2	0.4	0.4	1.8
5HB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.8	0.3	0.4	4.6
5J	16.4	5.8	2.8	18.0	48.2	14.2	6.2	3.0	1.6	5.6	50.5	32.7	17.1	29.3

Source: JICA Study Team

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

(m^3/s)

Sub-basin	Domestic		Industrial		Irrigation		Livestock		Wildlife		Fisheries	
	2010	2030	2010	2030	2010	2030	2010	2030	2010	2030	2010	2030
5AA	0.13	0.45	0.00	0.02	0.04	0.11	0.03	0.07	0.00	0.00	0.08	0.02
5AB	0.06	0.06	0.00	0.00	0.01	0.04	0.01	0.03	0.00	0.00	0.01	0.03
5AC	0.04	0.03	0.00	0.00	0.10	0.15	0.01	0.03	0.00	0.00	0.06	0.01
5AD	0.02	0.02	0.00	0.00	0.24	0.25	0.01	0.01	0.00	0.00	0.01	0.03
5BA	0.02	0.02	0.00	0.00	0.10	0.12	0.00	0.01	0.00	0.00	0.00	0.00
5BB	0.04	0.04	0.00	0.00	0.32	0.33	0.01	0.02	0.00	0.00	0.01	0.01
5BC-1	0.11	0.09	0.00	0.00	0.24	0.39	0.02	0.05	0.00	0.00	0.02	0.03
5BC-2	0.00	0.00	0.00	0.00	0.23	0.24	0.00	0.00	0.00	0.00	0.00	0.00
5BD	0.05	0.04	0.00	0.00	0.05	0.06	0.01	0.02	0.00	0.00	0.01	0.01
5BE	0.11	0.36	0.00	0.02	0.71	0.79	0.02	0.05	0.00	0.00	0.01	0.01
5CA	0.06	0.07	0.00	0.00	0.12	0.16	0.02	0.04	0.00	0.00	0.01	0.03
5CB	0.02	0.03	0.00	0.00	0.00	0.02	0.01	0.01	0.00	0.00	0.00	0.00
5CC	0.02	0.03	0.00	0.00	0.00	0.02	0.02	0.02	0.00	0.00	0.00	0.00
5DA	0.13	0.44	0.00	0.02	1.45	5.18	0.03	0.06	0.00	0.00	0.00	0.00
5DB	0.02	0.02	0.00	0.00	0.16	0.20	0.01	0.02	0.00	0.00	0.00	0.00
5DC	0.01	0.02	0.00	0.00	0.14	16.10	0.01	0.03	0.00	0.00	0.01	0.02
5DD	0.01	0.02	0.00	0.00	0.04	3.14	0.00	0.01	0.00	0.00	0.00	0.00
5EA	0.14	0.36	0.00	0.00	0.09	0.22	0.22	0.27	0.00	0.00	0.00	0.00
5EB	0.12	0.17	0.00	0.00	0.15	0.46	0.16	0.20	0.00	0.00	0.00	0.00
5EC	0.06	0.12	0.00	0.00	0.29	0.61	0.06	0.07	0.00	0.00	0.00	0.00
5ED	0.27	0.42	0.00	0.00	0.00	1.14	0.11	0.20	0.00	0.00	0.01	0.02
5FA	0.16	0.19	0.00	0.00	0.00	0.47	0.15	0.19	0.00	0.00	0.00	0.00
5FB	0.02	0.04	0.00	0.00	0.03	0.06	0.05	0.06	0.00	0.00	0.00	0.00
5G	0.12	0.44	0.00	0.00	0.00	0.12	0.46	0.56	0.00	0.00	0.00	0.00
5HA	0.03	0.09	0.00	0.00	0.65	0.65	0.10	0.13	0.00	0.00	0.00	0.00
5HB	0.04	0.30	0.00	0.00	0.00	0.02	0.18	0.23	0.00	0.00	0.00	0.00
5J	0.05	0.09	0.00	0.00	0.00	0.26	0.11	0.13	0.00	0.00	0.00	0.00
5AA	0.13	0.45	0.00	0.02	0.04	0.11	0.03	0.07	0.00	0.00	0.08	0.02
5AB	0.06	0.06	0.00	0.00	0.01	0.04	0.01	0.03	0.00	0.00	0.01	0.03
5AC	0.04	0.03	0.00	0.00	0.10	0.15	0.01	0.03	0.00	0.00	0.06	0.01
5AD	0.02	0.02	0.00	0.00	0.24	0.25	0.01	0.01	0.00	0.00	0.01	0.03
5BA	0.02	0.02	0.00	0.00	0.10	0.12	0.00	0.01	0.00	0.00	0.00	0.00
5BB	0.04	0.04	0.00	0.00	0.32	0.33	0.01	0.02	0.00	0.00	0.01	0.01
5BC-1	0.11	0.09	0.00	0.00	0.24	0.39	0.02	0.05	0.00	0.00	0.02	0.03
5BC-2	0.00	0.00	0.00	0.00	0.23	0.24	0.00	0.00	0.00	0.00	0.00	0.00
5BD	0.05	0.04	0.00	0.00	0.05	0.06	0.01	0.02	0.00	0.00	0.01	0.01
5BE	0.11	0.36	0.00	0.02	0.71	0.79	0.02	0.05	0.00	0.00	0.01	0.01
5CA	0.06	0.07	0.00	0.00	0.12	0.16	0.02	0.04	0.00	0.00	0.01	0.03

Source: JICA Study Team

Table 4.6.3 Reserve Quantity by Sub-basin for Water Balance Study

Sub-basin	Catchment Area (km^2)	Accumulated Catchment Area (km^2)	River Name	Reserve *1	Node *2
5AA	1,314		Ewaso Ng'iro North River	0.2	10
5AB	557			0.1	12
5AD	511			0.0	18
5AC	1,031	3,413		0.3	21
5BA	260			0.1	23
5BB	433			0.2	25
5BC-1	1,472	2,165		0.8	30
5BD	710			0.3	32
5BC-2	144	3,019		0.8	37
5BE	1,220			0.1	39
5DC	1,277	8,928		1.3	55
5DD	1,920	10,849		1.2	59
5DB	1,260			0.0	61
5DA	2,192	14,300		1.6	73
5CA	2,374			0.1	75
5CB	2,267	4,641		0.0	79
5CC	2,983	7,624		0.0	83
5EC	21,938	29,562		0.0	91
5ED	20,602	64,464		0.0	102
5FA	17,286	81,749		0.0	118
5EA	26,938			0.0	129
5EB	26,049			0.0	131
5G	20,461			0.0	141
5HA	3,262			0.0	147
5HB	6,946			0.0	153
5J	37,169			0.0	155
5FB	8,000			0.0	157

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

Source: JICA Study Team

Table 4.6.4 Dam Candidates (ENNCA)

(1) Priority Dams proposed in NWMP (1992)

Catchment Area		NWMP (1992)				Current Status			
		Proposed Dams	Sub-basin	Stage	Purpose	Related Agency/ Owner	Status/ Construction Year	Source of Information	Remarks
6.	ENN	27. Rumuruti	5AA	Pre-F/S	W	NWCPC	No further study is done.	NWCPC	2008-12 Flagship Projects under Vision 2030
		28. Nyahururu	5AA	M/P	W	NWCPC	No further study is done.	NWCPC	2008-12 Flagship Projects under Vision 2030

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

Catchment Area		NWMP (1992)				Current Status			
		Future Development Potential Dams		Sub-basin	Purpose	Related Agency/ Owner	Status/ Construction Year	Source of Information	Remarks
6.	ENN	38	Archers Post	5DA	W, I, P	ENNDA/ MORDA	(Wajir) F/S, D/D, T/D not started.	MORDA	2008-12 Flagship Projects under Vision 2030, MORDA 18 Projects
		39	Crocodile Jaw	5DC	P,W, I	-	No further study is done.	WRMA	
		40	Kirium	5DC	P	-	No further study is done.	WRMA	
		41	Kihoto	5BC	W, I	-	No further study is done.	WRMA	
		42	Nundoto	5CA	W	-	No further study is done.	WRMA	
		43	Lag-Bor	5EA	W	-	No further study is done.	WRMA	
		44	Buna	5EA	W	-	No further study is done.	WRMA	
		45	Habaswein	5EC	W	-	No further study is done.	WRMA	
		46	Meri (Merti)	5EC	W	-	No further study is done.	WRMA	
		47	Modogashe	5FA	W	-	No further study is done.	WRMA	
		48	Dadab	5FA	W	-	No further study is done.	WRMA	
		49	Kutulo-Elwak	5GA	W	-	No further study is done.	WRMA	
		50	Takaba	5GA	W	-	No further study is done.	WRMA	
		51	Mandera	5GB	W	-	No further study is done.	WRMA	
		52	Neboi-Mandera	5GB	W	-	No further study is done.	WRMA	
		53	Rham Mandera	5GB	W	-	No further study is done.	WRMA	
		54	Arabic (Arabia)	5GB	W	-	No further study is done.	WRMA	
		55	Fino	5GB	W	-	No further study is done.	WRMA	
		56	Kalatiyo	5H	W	-	No further study is done.	WRMA	
		57	Markamari	5H	W	-	No further study is done.	WRMA	

(3) Dam Schemes Studied by Government

Catchment Area		Identified Dams				Current Status			
		Dams not in NWMP (1992)		Sub-basin	Purpose	Related Agency/ Owner	Status/ Construction Year	Source of Information	Remarks
6.	ENN	22	Isiolo	5DA	W	NWCPC	F/S ongoing	NWCPC	NWCPC Strategic Plan 2010-15
		23	Badasa	5EC	W	NWCPC	U/C (to be completed in 2013)	NWCPC	2008-12 Flagship Projects under Vision 2030
		24	Yame (Maralal)	-	-	NWCPC	No study is started.	NWCPC	NWCPC Strategic Plan 2010-15
		25	Wiyumiririe	-	W	NWCPC	Some study was done.	NWCPC	NWCPC Plans for Vision 2030

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

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

Table 4.6.5 Water Transfer Candidates (ENNCA)

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

a) Intra-basin Bulk Water Transfer Schemes

Catchment Area		No.	NWMP (1992) Intra- basin Water Transfer: Sub-basin	Water Source		Sub-basin	Notes	Current Status: Related Agency / Owner	Status/ Construction Year	Source of Information	Remarks
6.	ENN	R23	5AA	Nyahururu Dam		5AA		NWCPC	No further study is done.	NWCPC, NWSB	
		R24	5AA	Rumuruti Dam		5AA		NWCPC	No further study is done.	NWCPC, NWSB	

b) Inter-basin Bulk Water Transfer Schemes

Catchment Area		No.	NWMP (1992) Inter- basin Water Transfer: Sub-basin	Water Source		Sub-basin	Notes	Current Status: Related Agency / Owner	Status/ Construction Year	Source of Information	Remarks
6.	ENN	E16	5ED	Ewaso Ng'iro River		5EA		MWI/ NWCPC	No further study is done.	NWSB	

(2) Water Transfer Schemes Studied by Government

a) Intra-basin Bulk Water Transfer Schemes

None

b) Inter-basin Bulk Water Transfer Schemes

Catchment Area		No.	Sub-basin	Water Source		Sub-basin	Related Agency / Owner	Status/ Construction Year	Source of Information	Remarks
6.	ENN		5EC	Badasa Dam*		5EC	NWCPC	Under construction	NWCPC	

Note:
Project Stage: M/P=master plan, Pre-F/S=prefeasibility study, F/S=feasibility study, D/D=detailed design, T/D=tender documents, U/C=under construction
* = Listed by NWCPC as “Inter-basin Transfer Schemes.”

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

Table 4.6.6 Proposed Dams and Water Transfer (ENNCA)

(1) Proposed Dams

No.	Name of Dam	Sub-basin	Relevant County	Purpose [1)]	Effective Storage Volume (MCM)	Storage Volume Allocation (MCM)			
						Domestic and Industrial	Irrigation	Hydro-power	Flood Control
55	Nyahururu	5AA	Nyandarua	W (Nyahururu, Rumuruti)	11.0	11.0	0.0		
56	Rumuruti	5AA	Laikipia	W (Rumuruti)	1.0	1.0	0.0		
57	Kihoto	5BC	Laikipia	I (18,000 ha)	389.0	0.0	389.0		
58	Isiolo	5DA	Isiolo	W (Isiolo)	2), 3) *21.0*	*21.0*	*0.0*		
59	Archers' Post	5DA	Isiolo, Samburu	W, I (4,000 ha)	100.0	7.0	93.0		
	Total				522.0	40.0	482.0		

Note:
1) W=Domestic and industrial water supply, I=Irrigation, P=Hydropower, F=Flood control
2) Figures in Italic Font are those proposed by the Kenyan Government.
3) An adjustment is made to the effective storage volume by deducting dead storage volume from the reservoir storage volume indicated in the existing reports.
Source: JICA Study Team

(2) Proposed Water Transfer

No Water Transfer Scheme proposed in ENNCA.

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

(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	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 4.6.8 Naturalised River Flow, Reserve, Water Demands, and Yields and Supply Reliability at Reference Points (ENNCA)

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			
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 5.2.1 Cost Estimate for Proposed Urban Water Supply Development (ENNCA)

Urban Centre	Service Population in 2030	Water Demand in 2030 (m^3/day)	Rehabilitation Works (m^3/day)	Development Capacity (m^3/day)	Project Cost (KSh million)					O&M Cost (KSh million/year)
					Total	Rehabilitation Works	Major Dam/ Major Transmission	Intake/ Minor Transmission	Distribution	
1 Isiolo	231,501	27,549	13,748	13,801	3,438	791	0	441	2,206	129
Isiolo					1,795	0	1,795	0	0	9
2 Nanyuki	192,282	22,882	10,610	12,272	2,964	610	0	392	1,961	115
3 Nyahururu	183,483	21,835	4,552	17,283	3,577	262	0	552	2,762	161
4 Rumuruti	50,661	6,029	0	6,029	1,156	0	0	193	964	56
Nyahururu					869		869			4
Rumuruti					946		946			5
5 Mandera	108,071	12,860	1,672	11,188	2,242	96	0	358	1,788	104
6 Wajir	102,042	12,143	0	12,143	2,329	0	0	388	1,941	113
7 Moyale	46,075	5,483	1,087	4,396	906	63	0	141	703	41
8 Rhamu	32,494	3,867	0	3,867	742	0	0	124	618	36
9 Elwak	30,031	3,574	0	3,574	685	0	0	114	571	33
10 Takaba	27,305	3,249	0	3,249	623	0	0	104	519	30
11 Maralal	19,546	2,326	798	1,528	339	46	0	49	244	14
12 Marsabit	16,317	1,942	0	1,942	372	0	0	62	310	18
Total	1,039,808	123,737	32,467	91,270	22,981	1,867	3,611	2,917	14,586	870

Source: JICA Study Team

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

Item	Service Population in 2030	Water Demand in 2030 (m^3/day)	Rehabilitation Works (m^3/day)	Development Capacity (m^3/day)	Project Cost (KSh million)					O&M Cost (KSh million/year)
					Total	Rehabilitation Works	Major Dam/ Major Transmission	Intake/ Minor Transmission	Distribution	
1 Other Urban Pop.	720,957	85,794	6,948	78,846	15,527	401		2,520	12,606	740
2 Rural Pop.	435,473	33,096	0	33,096	6,347	0		1,058	5,290	311
Major Water Sourece Works										
Kihoto							0			
Archers' Post							0			
Total	1,156,430	118,890	6,948	111,942	21,874	401	0	3,578	17,895	1,051

Source: JICA Study Team

Table 5.2.3 Cost Estimate for Proposed Sewerage Development (ENNCA)

Major Urban Area		Service Population in 2030	Required Capacity in 2030 (m^3/day)	Current Capacity in 2010 (m^3/day)	Capacity to be developed (m^3/day)	Project Cost (KSh million)			O&M Cost (KSh million/year)
						Total	Rehabilitation Works	Expansion/ New Construct.	
1	Isiolo	231,501	17,640	2,000	15,640	2,769	102	2,666	146
2	Nanyuki	192,282	14,652	0	14,652	2,498	0	2,498	137
3	Nyahururu	183,483	13,981	2,617	11,364	2,071	134	1,937	106
4	Mandera	108,071	8,235	0	8,235	1,404	0	1,404	77
5	Wajir	102,042	7,776	0	7,776	1,326	0	1,326	73
Total		817,380	62,284	4,617	57,667	10,067	236	9,831	538

Source: JICA Study Team

Table 5.2.4 Cost Estimate for Proposed Irrigation Development (ENNCA)

Category	Irrigation Area in 2030 (ha)	Project Cost* (KSh million)			Annual O&M Cost (KSh million)
		Irrigation System	Multipurpose Dam Cost Allocation**	Total Project Cost	
Large Scale Irrigation	26,202	15,380	30,925	46,305	139
Small Scale Irrigation	8,116	5,245	-	5,245	26
Private Irrigation	7,165	13,890	-	13,890	139
Total	41,483	34,515	30,925	65,440	304

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

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

Table 5.2.5 Cost Estimate for Proposed Dams (ENNCA)

Catchment Area	Name of Dam		Sub-basin	Purpose 1)	Effective Storage (MCM)	Study Stage 2)	Cost (KSh million)
ENNCA	55	Nyahururu	5AA	W	11.0	NWMP 2030	852
	56	Rumuruti	5AA	W	1.0	NWMP 2030	938
	57	Kihoto	5BC	I	389.0	NWMP 2030	13,894
	58	Isiolo	5DA	W	21.0	F/S ongoing	2,642
	59	Archers' Post	5DA	W, I	100.0	NWMP 2030	17,900
	Total				522.0		36,226

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

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

Table 5.2.6 Cost Estimate for Proposed Water Resources Management Plan (ENNCA)

Development Cost (Unit: KSh thousand)

No.	Item	ENNCA			
		Unit cost	Q'ty	Unit of Q'ty	Cost
1) Monitoring					**66,900**
	Installation/Rehabilitation of River Gauging Stations	240	5	nos.	1,200
	Installation/Rehabilitation of Rainfall Gauging Stations	100	14	nos.	1,400
	Installation of Dedicated Boreholes for Groundwater Monitoring	2,000	5	nos.	10,000
	Replacement of iron post for river gauge to concrete post	100	13	nos.	1,300
	Upgrade manual gauge to automatic (surface water level)	1,000	13	nos.	13,000
	Upgrade manual gauge to automatic (groundwater level)	200	5	nos.	1,000
	Upgrade manual gauge to automatic (rainfall)	1,000	34	nos.	34,000
	Flood Discharge Measurement Equipment (each sub-region)	1,000	5	nos.	5,000
2) Evaluation					**62,710**
	Hydromet DB Upgrade (Software + Hardware) including training	2,500	18	nos.	45,000
	Establishment of additional Water Quality Test Laboratory (Lodwar, Kapenguria, Mombasa, Garissa, Marsabit, Wajir) - Building and Utility	6,750	2	nos.	13,500
	Laboratory Equipment and Reagents	2,105	2	nos.	4,210
3) Permitting					
	PDB Upgrade (Software + Hardware) including training	1,500	18	nos.	27,000
4) Watershed Conservation					
	Forestation to achieve 10% of Forest Cover	79	592,000	ha	46,768,000
	Total				**46,924,610**

Recurrent Cost (Annual) (Unit thousand KSh)

No.	Item	ENNCA			
		Unit cost	Q'ty	Unit of Q'ty	Cost*
1) Monintoring and Analysis					**68,868**
	Surface Water Monitoring (Daily)	12	156	nos.	1,872
	River Discharge Measurement (Monthly)	80	156	nos.	12,480
	Groundwater Monitoring (Monthly)	12	60	nos.	720
	Rainfall Monitoring (Daily)	12	408	nos.	4,896
	Flood Discharge Measurement (Three times a year)	100	468	nos.	46,800
	Surface Water Quality Monitoring (Monthly)	30	12	nos.	360
	Surface Water Quality Monitoring (Quarterly)	30	48	nos.	1,440
	Gruondwater Quality Monitoring (Twice a year)	30	10	nos.	300
2) Others					
	Catchment Forum Operation (Venue and Allowances to WRUAs)	500	2	times	1,000
	Total				**69,868**

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

Table 5.2.7 Cost Estimate for Proposed Flood Disaster Management Plan (ENNCA)

CA	No.	Description		Project Cost for Structure (KSh million)	Project Cost for Non-Structure (KSh million)	Recurrent Cost* (KSh million /year)	Source	Remarks
ENN	E1	**Mandera**		**172.75**	**60.00**	**0.30**		
	B	E1.1	River Training Works	172.75		-		
	D	E1.2	Preparation of Hazard Map		30.00	0.15		10M/M
	E	E1.3	Formulation of Evacuation Plan		30.00	0.15		10M/M
	E2	**Isiolo**		**155.34**	**30.00**	**0.15**		
	B	E2.1	River Training Works	155.34		-		
	D	E2.2	Preparation of Hazard Map		30.00	0.15		10M/M
	H	E2.3	Implementation of Urban Drainage Measures	(382.71)		-	NWMP (1992)	US$3.60 million in 1992

Note: 1. US$1.0 = KSh 85.24 (as of November 1, 2012)

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

* Recurrent cost includes operation and maintenance costs

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

Table 5.2.8 Cost Estimate for Proposed Environmental Management Plan (ENNCA)

Description		Development Cost: River and Lake Environment Survey (KSh million)	Development Cost: Setting of Environmental Flow Rate (KSh million)	Recurrent Cost* (KSh million /year)
1.Environmental River Flow				
1.1	Ewaso Ng'iro North River	11.9	1.6	-
2.Environmental Monitoring				
2.1	Ewaso Ng'iro North River	-	-	0.0

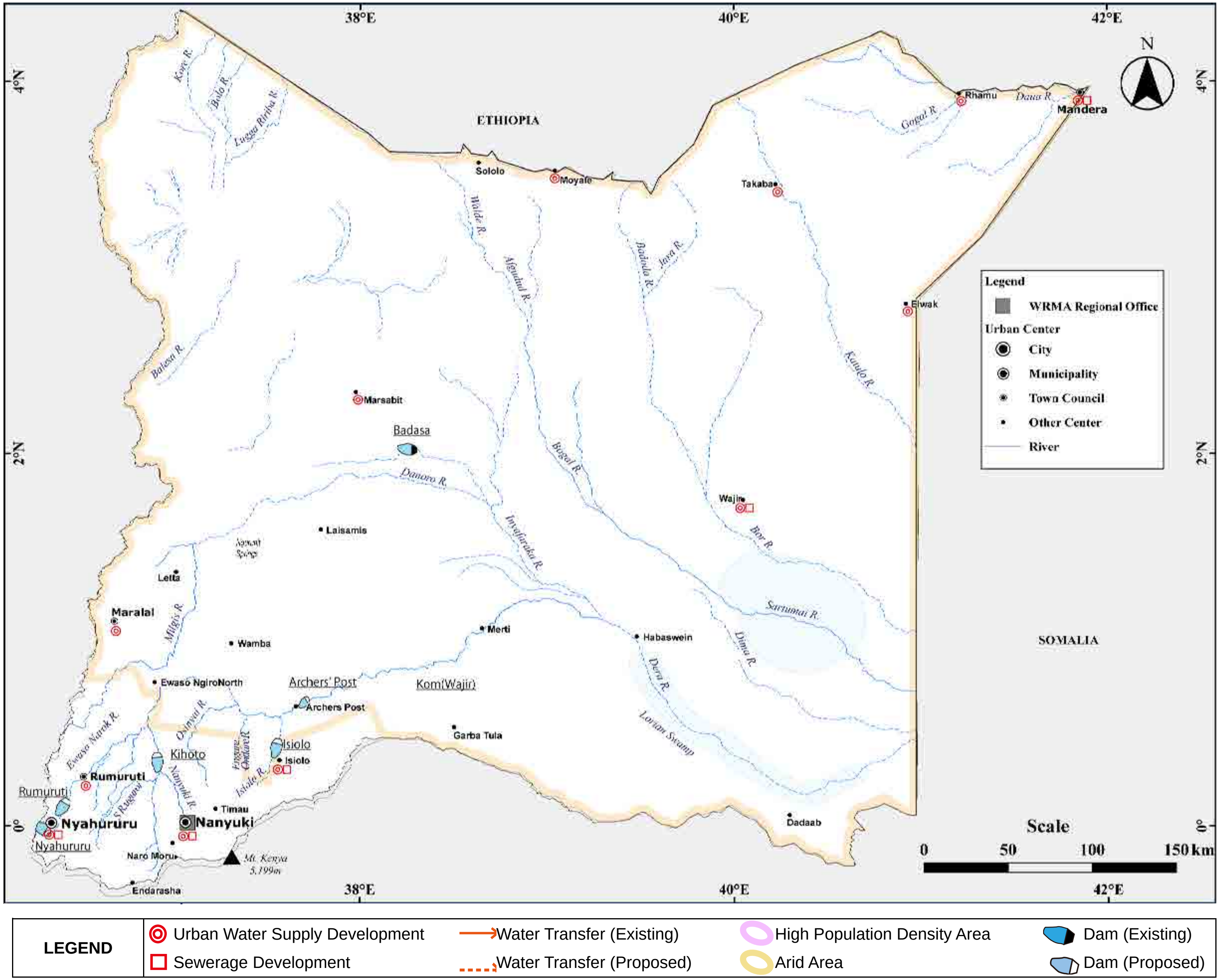
Note: Basic conditions for cost estimate are supposed as follows;

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

* Recurrent cost includes operation and maintenance costs

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

Figures



Source: JICA Study Team

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

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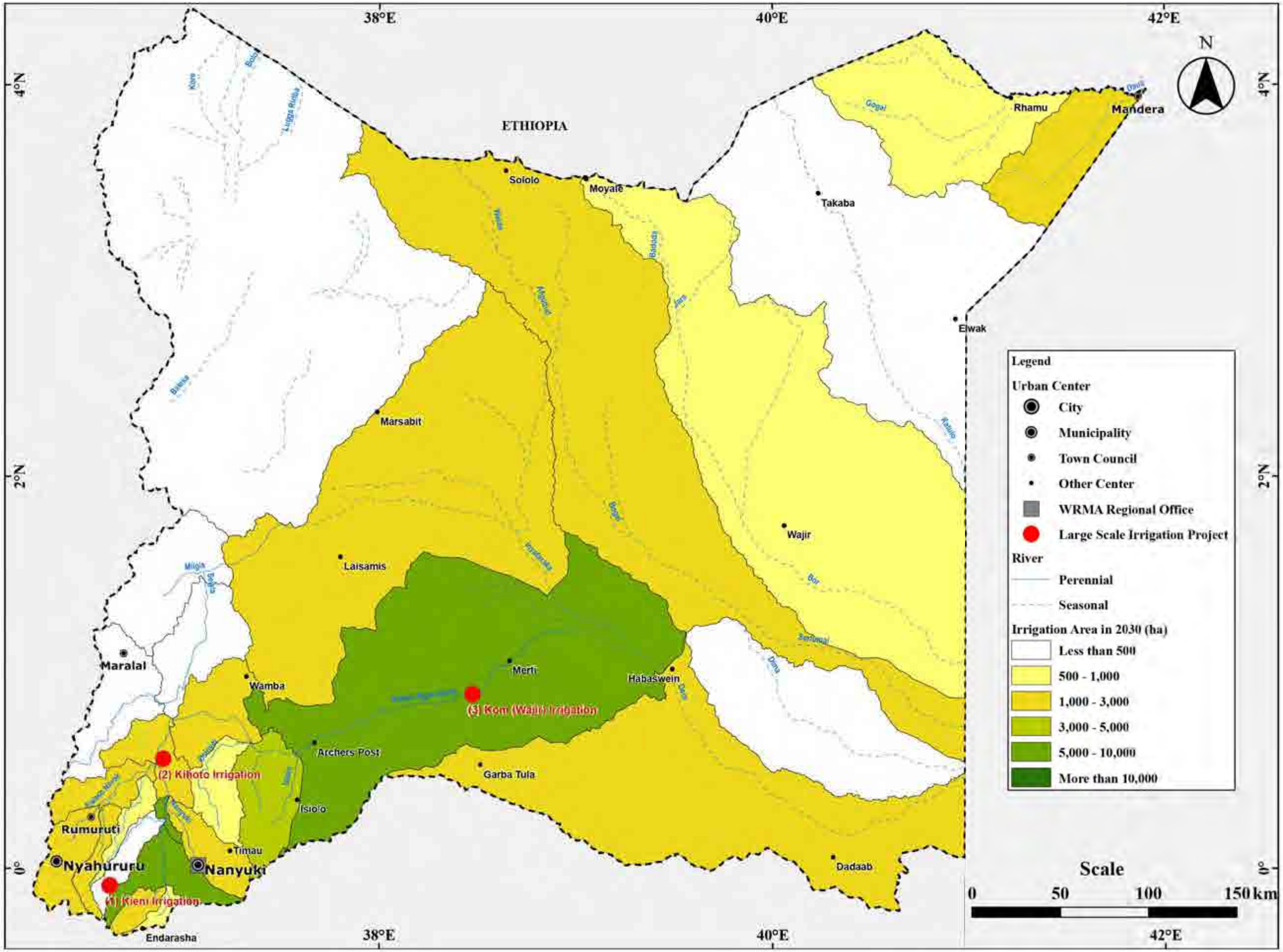

Source: JICA Study Team

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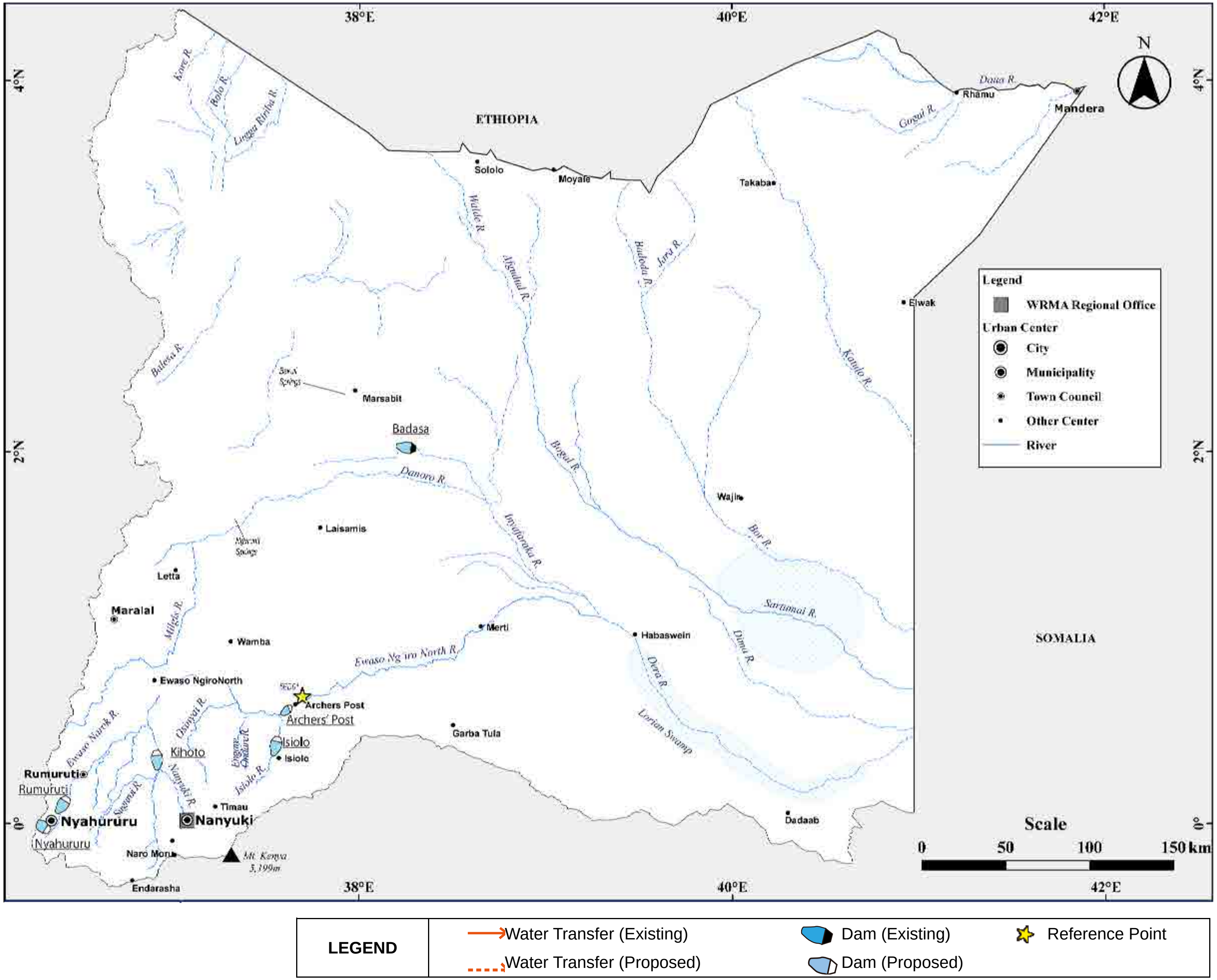
Figure 4.4.1
Proposed Irrigation Development Plan (ENNCA)



Source: JICA Study Team

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Figure 4.6.1
Existing and Proposed Dams and Water Transfer Facilities (ENNCA)

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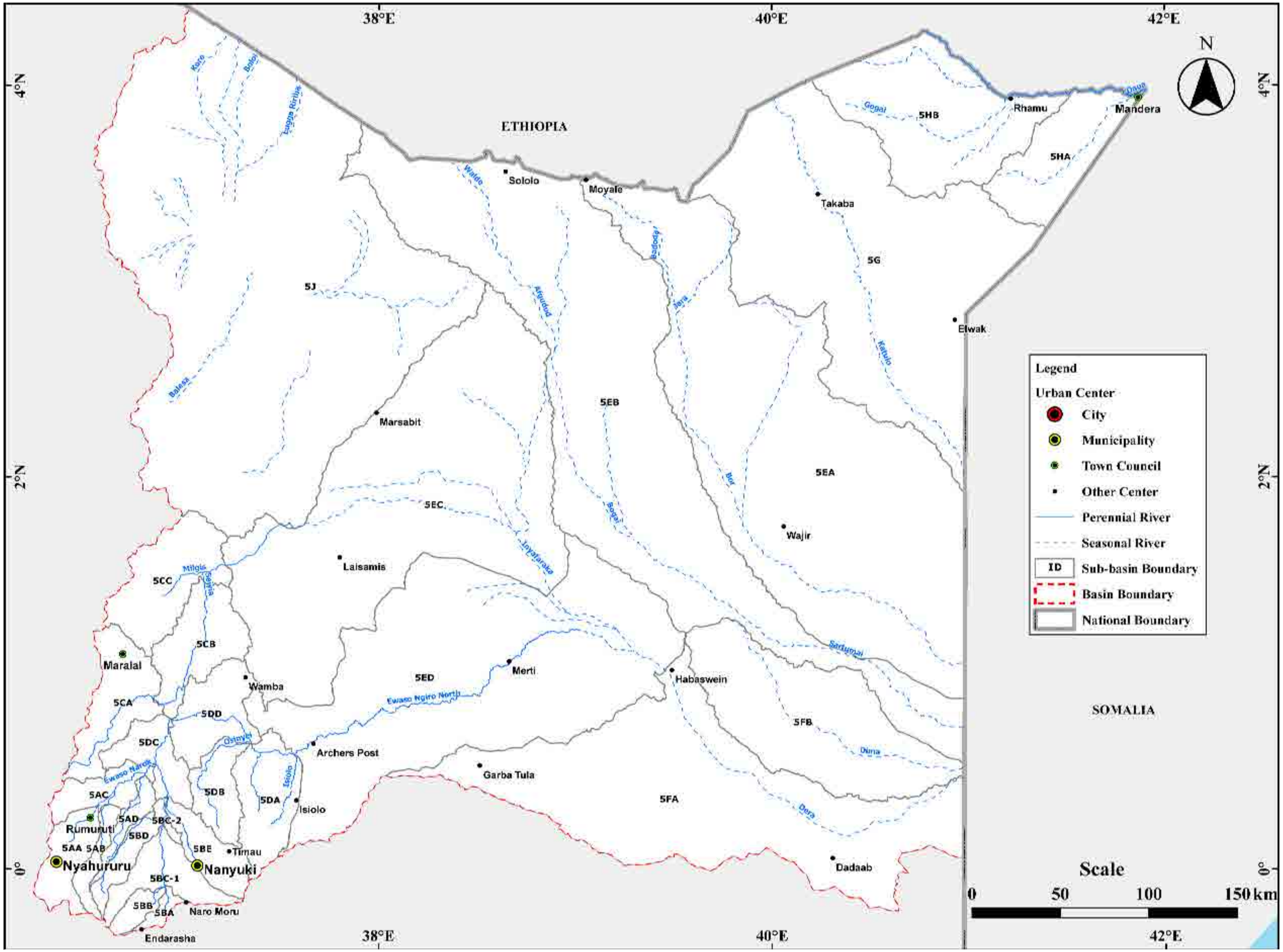
Figure 4.6.2
Sub-basin Division Map
(ENNCA)



Source: JICA Study Team

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Source: JICA Study Team

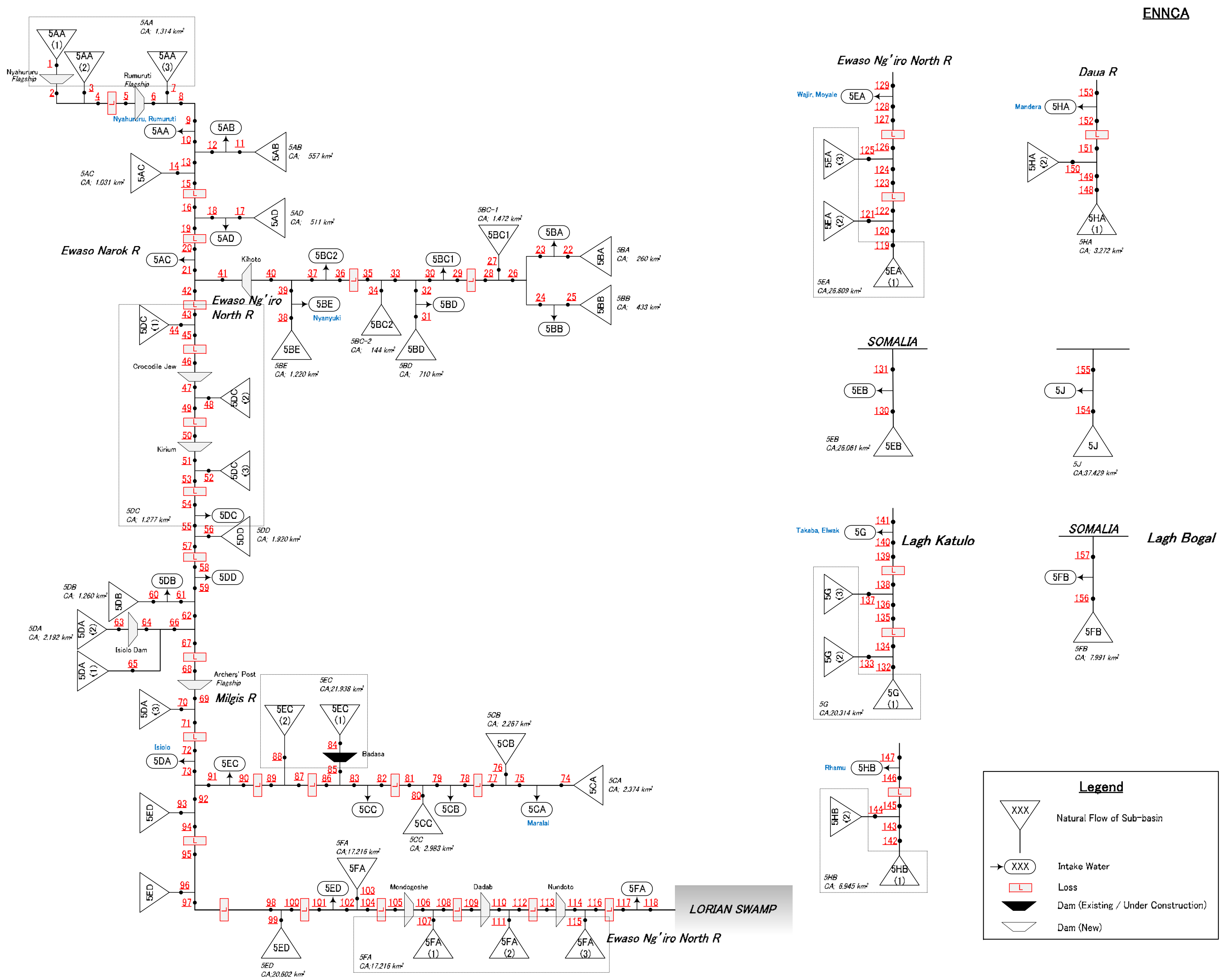
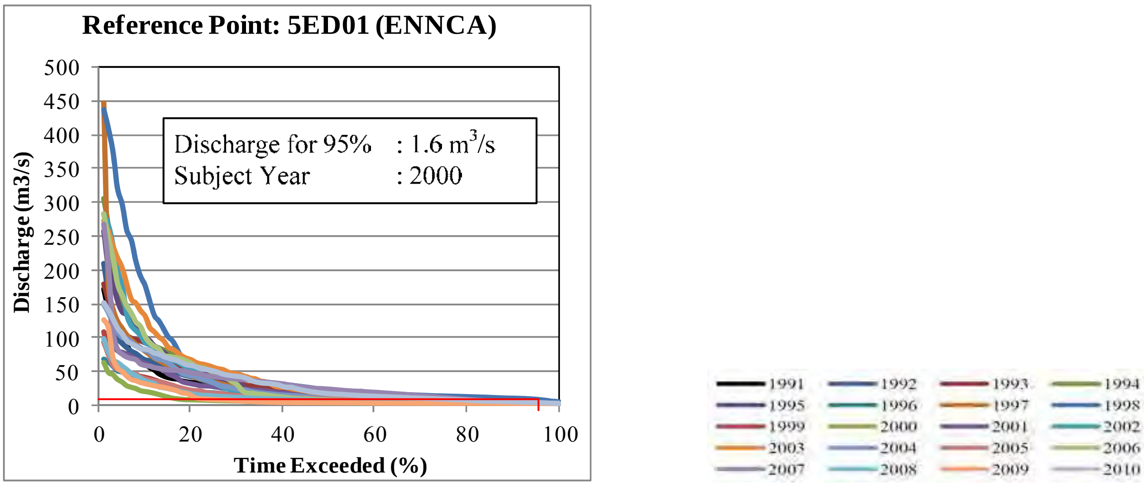


Figure 4.6.3
Surface Water Balance Calculation Model (ENNCA)



Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 4.6.4** Simulated Flow Duration Curves for Estimate of Reserve at Reference Points (ENNCA)
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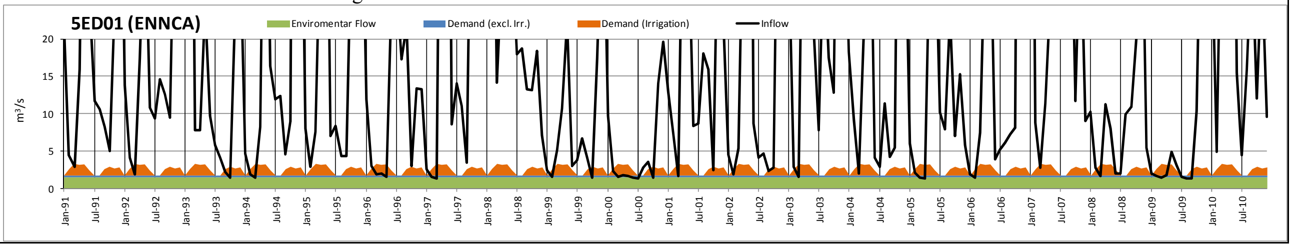
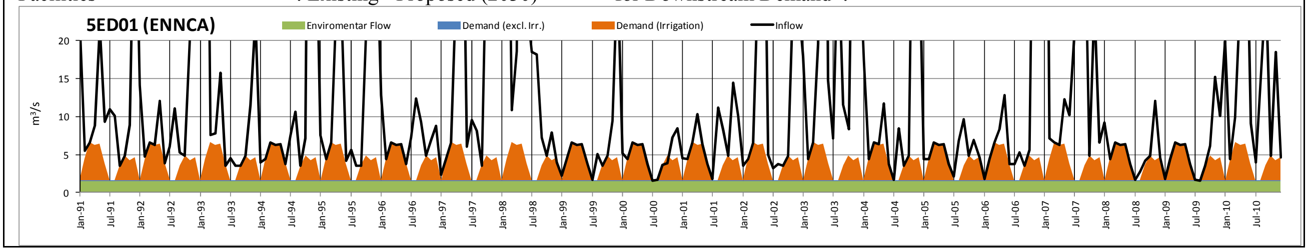
River Name: Ewaso Ng'iro North River (ENNCA)
Reference Point: 5ED01

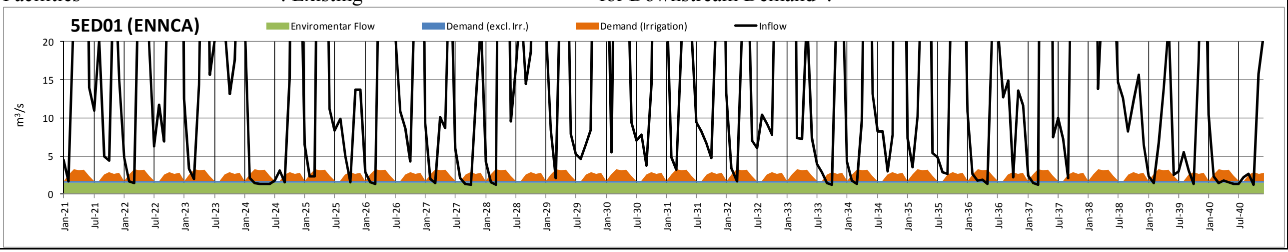
River Flow	: Present (1991-2010)	Reserve:	1.6	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained	1.4	(m^3/s)
Facilities	: Existing	for Downstream Demand*:		



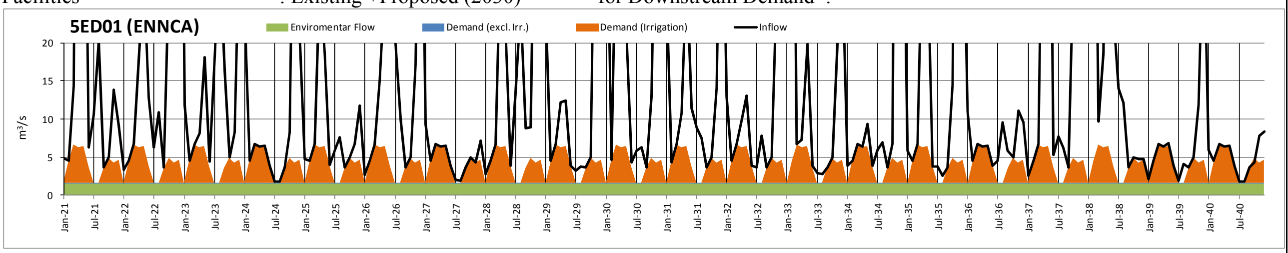
River Flow	: Present (1991-2010)	Reserve:	1.6	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained	4.9	(m^3/s)
Facilities	: Existing +Proposed (2030)	for Downstream Demand*:		



River Flow	: Future (2021-2040)	Reserve:	1.6	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained	1.4	(m^3/s)
Facilities	: Existing	for Downstream Demand*:		



River Flow	: Future (2021-2040)	Reserve:	1.6	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained	4.9	(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

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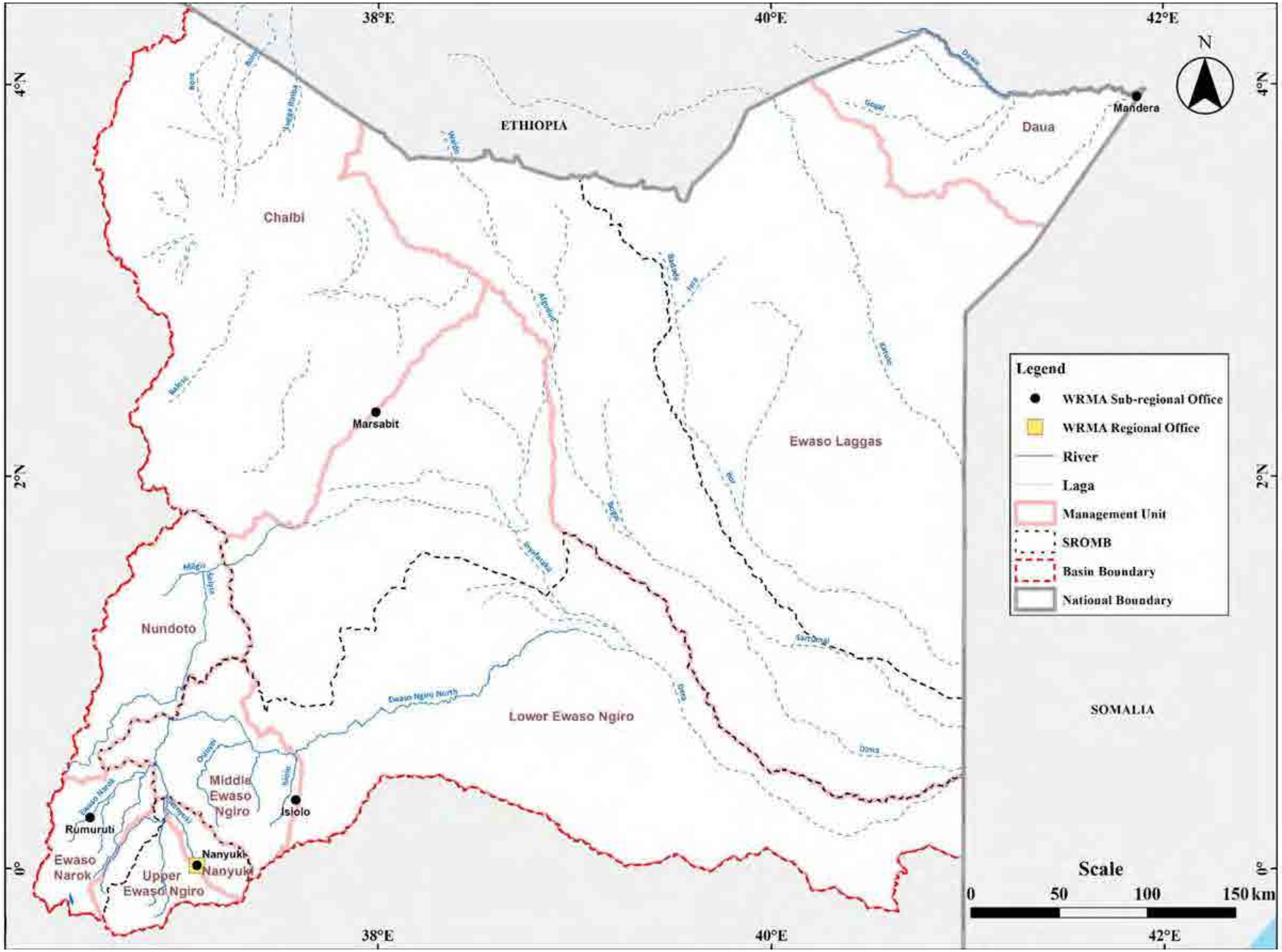
Figure 4.6.5 River Flow at Reference Point 5ED01 under Present and Future Water Demands and Facilities Conditions (ENNCA)



Source: JICA Study Team

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Figure 4.7.1
Rivers and Boundaries for Administration (ENNCA)

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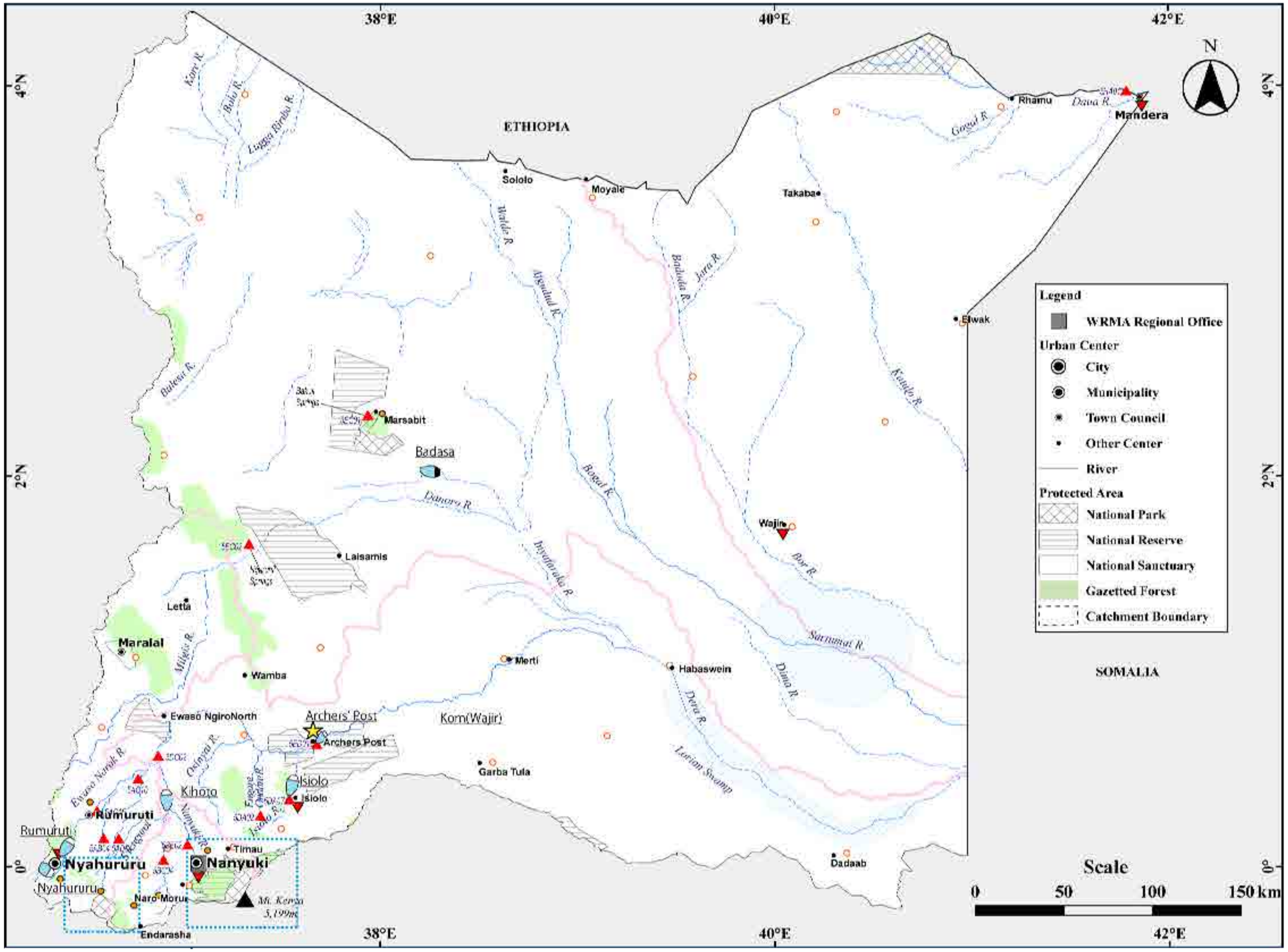
Source: JICA Study Team

Figure 4.7.2
Proposed Monitoring Stations for Water Resources Management (ENNCA)



LEGEND				
	Surface Water Monitoring Station	13 locations	Groundwater Monitoring Station	5 locations
	Existing / Newly Proposed		Proposed Monitoring Station	
	Rainfall Monitoring Station	34 locations	Reference Point	1 location
	Existing / Newly Proposed		Proposed Reference Point	

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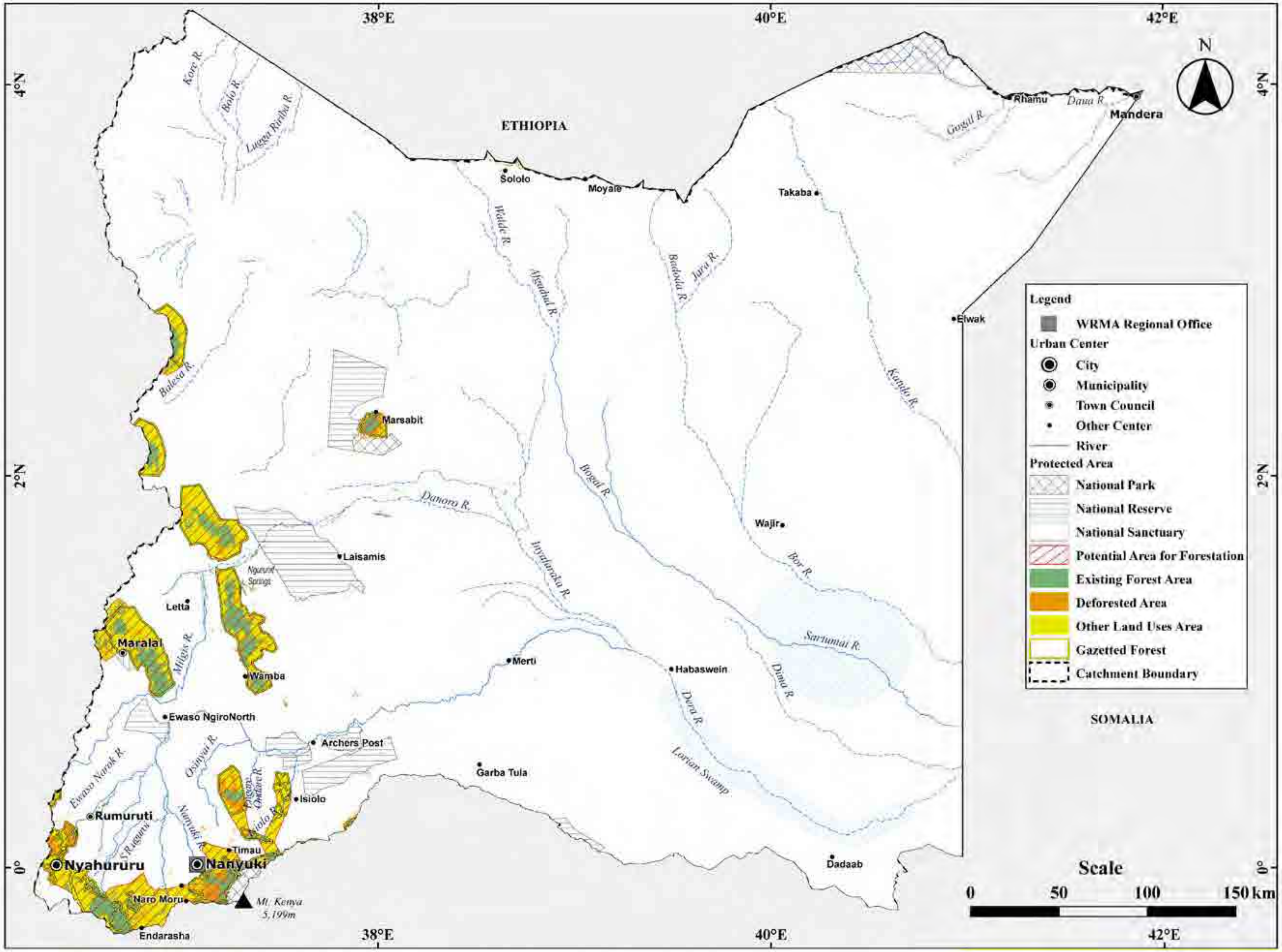
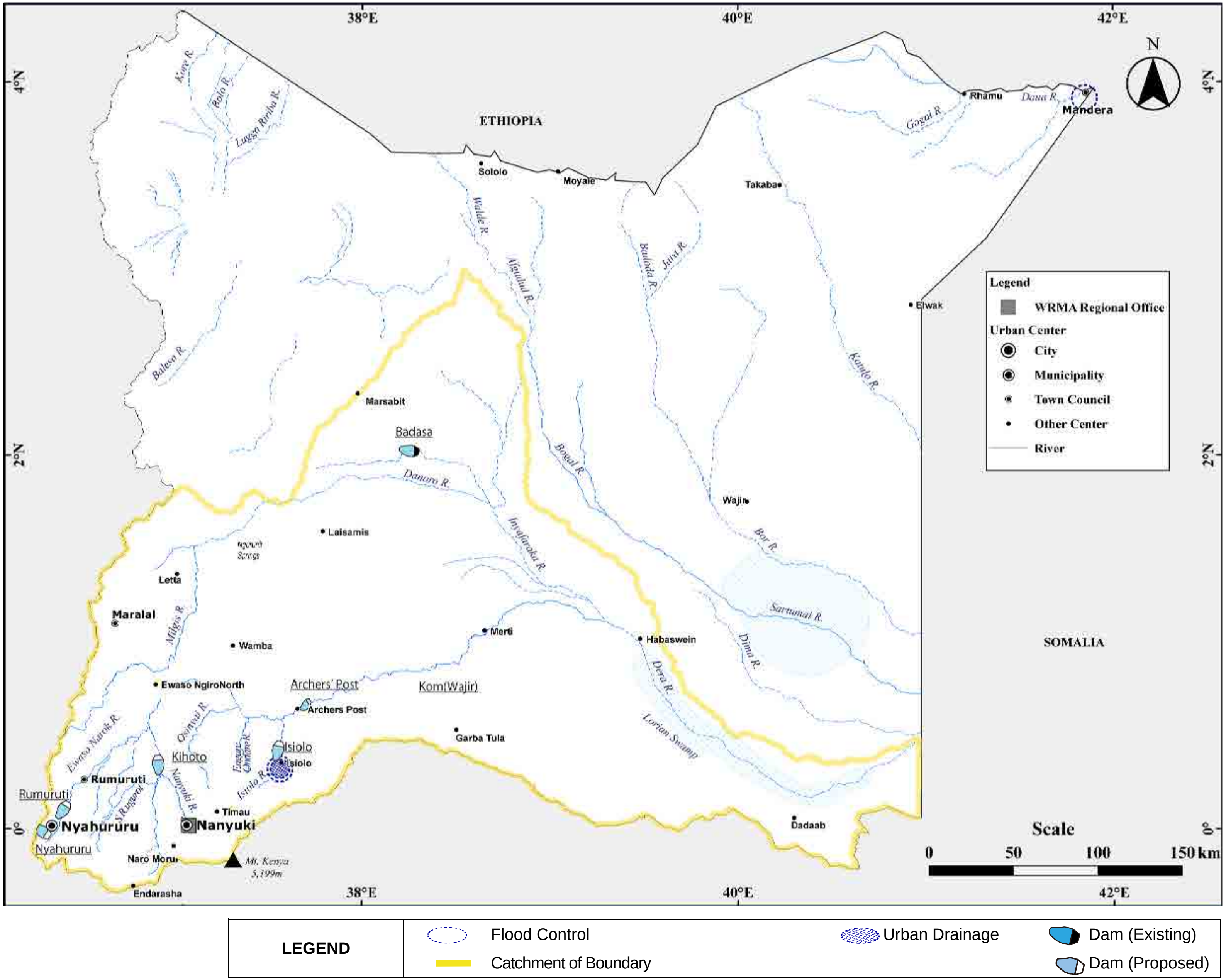
Figure 4.7.3
Current Situation of Forest Areas and Potential Forestation Areas (ENNCA)

Source: JICA Study Team, based on satellite images





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

Source: JICA Study Team

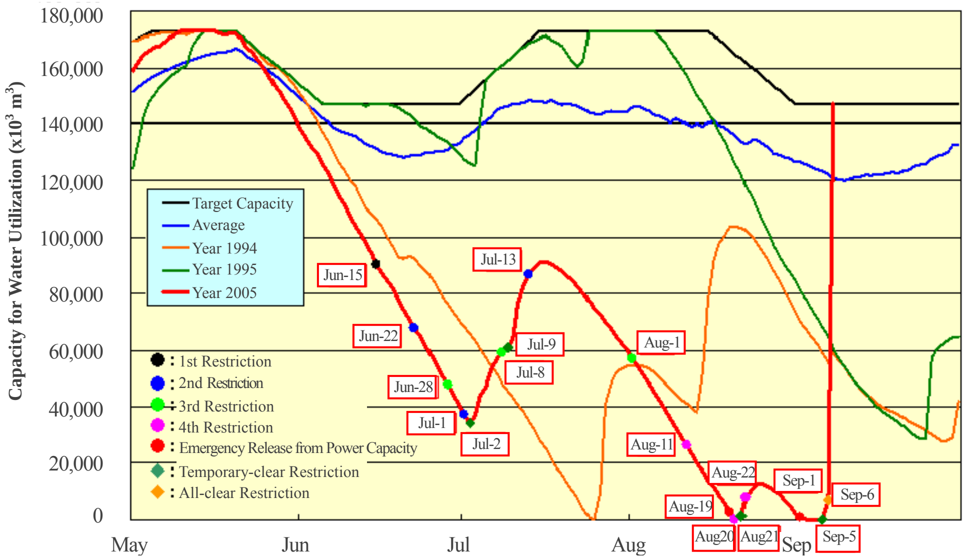
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 4.8.1
Proposed Flood and Drought Disaster Management Plan (ENNCA)

Flow of Water Use Restriction of the Sameura Dam in 2005 Drought

Date	Reserve	Water Use Restriction	Organizational Arrangement
May 26	96.40%		15:00 Setting up a head office of special task force for water restriction in Shikoku Regional Development Bureau (a) 15:00 Setting up a branch office of special task force for water restriction in Integrated Management Office of Dams in Yoshino River (b)
Jun 13	66.60%	0:00 Voluntary water-saving [Tokushima 5.9%]	
Jun 15	61.20%	9:00 The first water restriction [Tokushima 14.1% (new 20%), Kagawa 20%]	9:00 Setting up a branch office of special task force for water restriction in Tokushima River and National Highway Office (c)
Jun 22	46.00%	9:00 The second water restriction [Tokushima 15.9% (new 35%), Kagawa 35%]	
Jun 28	32.40%	9:00 The third water restriction [Tokushima 17.6% (new 50%), Kagawa 50%]	
Jul 1	25.10%	22:00 Ease the second water restriction [Tokushima 17.2% (new 35%), Kagawa 35%]	
Jul 2	22.80%	6:00 Temporary-clear water restriction	
Jul 8	36.80%	0:00 The third water restriction [Tokushima 19.0% (new 50%), Kagawa 50%]	
Jul 9	37.50%	15:00 Temporary-clear water restriction	
Jul 13	51.20%	18:00 The second water restriction [Tokushima 17.2% (new 35%), Kagawa 35%]	
Aug 1	32.90%	9:00 The third water restriction [Tokushima 19.0% (new 50%), Kagawa 50%]	
Aug 11	15.10%	9:00 The forth water restriction [Tokushima 22.0% (new 75%), Kagawa 75%]	9:00 Setting up a head office of emergency task force for extraordinary drought in Shikoku Region (d)
Aug 19 (20:00)	1.5% (0.0%)	20:00 Start emergency release from power generation capacity [Tokushima 1.85 m^3/s, Kagawa 1.81 m^3/s]	
Aug 20	0.00%	22:00 Temporary ease the forth water restriction [Tokushima 22.0% (new 75%), Kagawa 75%] Stop emergency release from power generation capacity	
Aug 21	1.10%	11:00 Temporary-clear water restriction	
Aug 22	4.90%	22:00 Restart the forth water restriction [Tokushima 22.4% (new 75%), Kagawa 75%]	
Sep 1 (8:00)	0.5% (0.0%)	8:00 Start emergency release from power generation capacity [Tokushima 1.85m^3/s, Kagawa 1.81m^3/s]	
Sep 5	0.00%	5:00 Stop emergency release from power generation capacity 9:00 Temporary-clear water restriction	
Sep 6 (20:00)	4.6% (100%)	18:00 All-clear water restriction	18:00 Breaking up the office (a) 18:00 Breaking up the office (d) 18:00 Breaking up the office (c) 20:00 Breaking up the office (b)



Time Series Graph of Water Use Capacity of the Sameura Dam and Restriction Actions in 2005 Drought

Source: Shikoku Regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism, Japan

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030

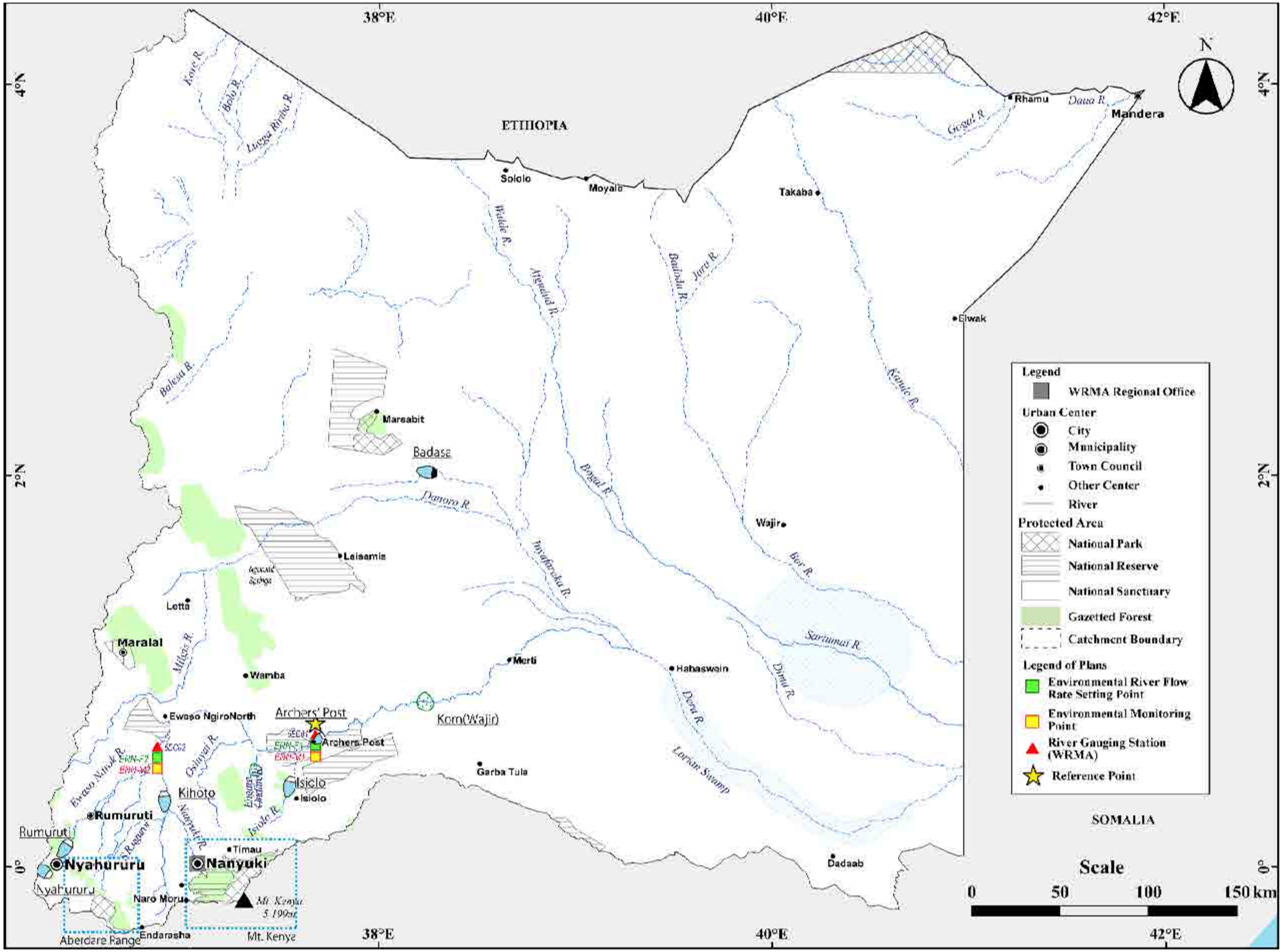
JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 4.8.2 Example for Water Use Restriction of Sameura Dam in 2005 Drought

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030
JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 4.9.1
Proposed Environmental Management Plan (ENNCA)

Source: JICA Study Team



WRMA Catchment	No.	Name of Project	Project Status	Capacity to be developed (m³/day)			Implementation Schedule																	
							Short Term					Medium Term					Long Term							
				Total	Initial Develop.	Ratio	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
							13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29	29/30	30/31
ENN	1	Isiolo	WSB, MTP	13,801	6,552	47%							Isiolo Dam											
	2	Nyahururu	WSP	17,283	10,822	63%			Nyahururu Dam							Rumuruti Dam								
	3	Rumuruti	-	6,029	1,809	30%																		
	4	Wajir	MTP	12,143	3,643	30%																		
	5	Moyale	MTP	4,416	1,325	30%																		
	6	Maralal	MTP	1,528	458	30%																		
	7	Nanyuki	-	12,272	3,682	30%																		
	8	Mandera		11,188	3,356	30%																		
	9	Rhamu	-	3,867	1,160	30%																		
	10	Elwak	-	3,574	1,072	30%																		
	11	Takaba	-	3,249	975	30%																		
	12	Marsabit	-	1,942	583	30%																		
	Rehabilitation for 6 Urban Centres																							
	Total Urban Water Supply Projects			91,292	35,436	39%																		
	Water Resources Development for Rural Water Supply													Archers' Post Dam										
	Rural Water Supply Projects																							

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

Source: JICA Study Team

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

WRMA Catchment	No.	Urban Centre	F/S Status	Capacity to be developed (m^3/day)			Implementation Schedule																	
							Short Term					Medium Term					Long Term							
				Total	Initial Develop.	Ratio	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
							13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29	29/30	30/31
ENN	1	Nyahururu	WSB, F/S	11,364	3,347	29%																		
	2	Mandera	WSB, D/D	8,235	4,000	49%																		
	3	Isiolo	MTP	15,640	4,692	30%																		
	4	Wajir	MTP	7,776	2,333	30%																		
	5	Nanyuki	_	14,652	4,396	30%																		
	Rehabilitation Works for 2 Urban Centres																							
	Total			57,667	18,767	33%																		

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

Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 7.3.2 Implementation Schedule of Proposed Sewerage System Development Plan (ENNCA)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

No	Name of Project	County	Irrigation Area (ha)	Multi-purpose Dam	Short Term					Medium Term					Long Term							
					2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
					13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29	29/30	30/31
A. Large Scale Irrigation Project (New)																						
1	Kieni Irrigation	Nyeri	4,202	-				P														
2	Kom (Wajir) Irrigation	Isiolo, Samburu	4,000	Archer's Post							P						*Dam*					
3	Kihoto Irrigation	Laikipia	18,000	Kihoto											P		*Dam*					
	Total		26,202		0					4,202					22,000							
B. Small Scale Irrigation Project (New)																						
1	Weir Irrigation		0		0					0					0							
2	Dam Irrigation		0		0					0					0							
3	Small Dam/Pond/Water Pan Irrigation		950		190					285					475							
4	Groundwater Irrigation		7,166		1,433					2,150					3,583							
	Total for B		8,116		1,623					2,435					4,058							
C. Private Irrigation Project (New)																						
1	Weir Irrigation		0		0					0					0							
2	Groundwater Irrigation		7,165		1,433					2,150					3,582							
	Total for C		7,165		1,433					2,150					3,582							
	Total for ENNCA		41,483		3,056					8,787					29,640							

Note:
- F/S and/or D/D
- P Procurement
- Construction of Irrigation System
- Construction of Multipurpose Dam

Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 7.3.3 Implementation Schedule of Proposed Irrigation Development Plan (ENNCA)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

WRMA Catchment	No.	Name of Project	Purpose	Effective Storage Volume (MCM)	Project Status	Implementation Schedule																	
						Short Term					Medium Term					Long Term							
						2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
						13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29	29/30	30/31
ENN	1	Isiolo Dam	W	21	F/S ongoing		P																
	2	Nyahururu Dam	W	11	Flagship					P													
	3	Archers' Post Dam	W, I	100	Flagship								P										
	4	Rumuruti Dam	W	1	Flagship											P							
	5	Kihoto Dam	I	389														P					

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

Source: JICA Study Team

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 7.3.4
Implementation Schedule of Proposed Water Resources Development Plan (ENNCA)

No.	Description	Implementation Schedule																	
		Short Term					Medium Term					Long Term							
		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
		13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29	29/30	30/31
Development Activities																			
(1)	Monitoring																		
M1	Replacement of iron post for river gauge to concrete post	■	■	■															
M2	Upgrade manual gauge to automatic (surface water level)			■	■	■	■	■											
M3	Upgrade manual gauge to automatic (groundwater level)			■	■	■	■	■											
M4	Upgrade manual gauge to automatic (rainfall)			■	■	■	■	■											
M5	Installation of Dedicated Boreholes for Groundwater Monitoring	■	■	■															
M6	Installation/Rehabilitation of River Gauging Stations	■	■				■	■				■	■						
M7	Installation/Rehabilitation of Rainfall Gauging Stations	■	■				■	■				■	■						
M8	Flood Discharge Measurement Equipment (Each SRO)		■	■	■								■	■	■				
(2)	Evaluation																		
E1	Hydromet DB Upgrade (Software + Hardware)			■	■				■	■				■	■				
E2	Establishment of additional Water Quality Test Laboratory in Marsabit and Wajir	■	■																
(3)	Permitting																		
P1	PDB Upgrade (Software + Hardware)			■	■				■	■				■	■				
(4)	Watershed Conservation						■	■	■	■									
W1	Forestation (Gazetted Forest Area)	■	■	■	■	■													
W2	Forestation (Non-gazetted Forest Area)						■	■	■	■	■	■	■	■	■	■	■	■	■
Recurrent Activities																			
(1)	Monitoring																		
M1	Surface Water Level Monitoring	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
M2	River Discharge Measurement	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
M3	Groundwaer Level Monitoring	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
M4	Rainfall Monitoring	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
M5	Flood Discharge Measurement			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
M6	Surface Water Quality Monitoring	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
M7	Groundwater Quality Monitoring	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
(2)	Others																		
O1	Catchment Forum Operation (Venue and Allownce to WURAs)	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

Source: JICA Study Team

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 7.3.5
Implementation Schedule of Proposed Water Resources Management Plan (ENNCA)

WRMA Catchment	No.	Description	Implementation Schedule																		Remarks
			Short Term					Medium Term					Long Term								
			2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	
			13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29	29/30	30/31	
ENN	E1	Mandera																			
		E1.1 River Training Works	F/S																		
		E1.2 Preparation of Hazard Map																			
		E1.3 Formulation of Evacuation Plan																			
	E2	Isiolo																			
		E2.1 River Training Works			F/S																
		E2.2 Preparation of Hazard Map																			
		E2.3 Implementation of Urban Drainage Measures																			

Note: Construction Schedule for River Training Works (to be determined in the Feasibility Study)

Drought Disaster Management Plan

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

Legend: Establishment Update / Expansion

Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	Figure 7.3.6 Implementation Schedule of Proposed Flood and Drought Disaster Management Plan (ENNCA)
JAPAN INTERNATIONAL COOPERATION AGENCY	

WRMA Catchment	No.	Name of Project	Target	Related Project (Dams and Irrigation)	Implementation Schedule																	
					Short Term					Medium Term					Long Term							
					2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
					13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29	29/30	30/31
ENN	1	Setting of Environmental Flow	Ewaso Ng'iro North River	Isiolo, Archers' Post and Kihoto Dams		Set																
	2	Environmental Monitoring	Ewaso Ng'iro North River																			

Environmental Survey for Setting Environmental Flow

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

Environmental Monitoring (including Planning)

Source: JICA Study Team

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 7.3.7
Implementation Schedule of Proposed Environmental Management Plan (ENNCA)

Part H
Action Plan for WRMA Regional Offices toward 2022

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

FINAL REPORT
VOLUME - III MAIN REPORT (2/2)

PART H: ACTION PLAN FOR WRMA REGINAL OFFICES TOWARD 2022

Abbreviation

Table of Contents

Page

List of Figures

Page

List of Abbreviations and Acronyms

CMS	:	Catchment Management Strategy
EDCP	:	Effluent Discharge Control Plan
ENNCA	:	Ewaso Ng'iro North Catchment Area
GIS	:	Geographic Information System
GPS	:	Global Positioning System
ICT	:	Information and Communication Technology
JICA	:	Japan International Cooperation Agency
KenGen	:	Kenya Electric Generating Company
KMD	:	Kenya Meteorological Department
LVNCA	:	Lake Victoria North Catchment Area
LVSCA	:	Lake Victoria South Catchment Area
MORDA	:	Ministry of Regional Development Authorities
MWI	:	Ministry of Water and Irrigation
NIB	:	National Irrigation Board
PDB	:	Permit Database
SCMP	:	Sub-catchment Management Plan
SRO	:	Sub-regional Office
SWOT	:	Strength Weakness Opportunities Threats
WRQO	:	Water Resources Quality Objectives
WRMA	:	Water Resource Management Authority
WRUA	:	Water Resources Users Association

Abbreviations of Measures

Length

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

Area

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

Volume

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

Weight

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

Time

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

Money

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

Energy

kcal	=	Kilocalorie
kW	=	kilowatt
MW	=	megawatt
kWh	=	kilowatt-hour
GWh	=	gigawatt-hour

Others

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

NOTE

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

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

3. Information to be updated

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

   (1) Information on the proposed development projects

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

   (2) Information on the water demand

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

4. Exchange rate for cost estimate

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

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

CHAPTER 1 INTRODUCTION

Action plans that are necessary for strengthening the system and capacity on water resources management of the WRMA regional offices toward year 2022[1] were prepared.

Pilot activities were conducted in the Tana Catchment Area, as a sample catchment, to grasp and analyse issues on water resources management. Through examination of the issues identified from the pilot activities, action plans were prepared.

Pilot activities were conducted for the following four major items related to water resources management:

i) Assistance to the establishment and operations of a catchment forum for the improvement of river basin governance,
ii) Assistance to the strengthening of hydrometeorological information management,
iii) Assistance to the improvement of water permit database management, and
iv) Assistance to the improvement of flood and drought disaster management.

The pilot activities were conducted by the WRMA Tana Regional Office as the main player with technical and administrative support from the national consultant and JICA Study Team. The results of the pilot activities are described in the Sectoral Report (N) Pilot Activities. All the outputs of pilot activities are detailed in the data book.

In addition to pilot activities, issues on water resources management of the WRMA regional offices were identified through existing documents of WRMA, such as the Catchment Management Strategy (CMS) and the WRMA Strategic Plan.

[1] The year 2022 is an interim goal of mid-term development plan under the frameworks of Kenya Vision 2030.

CHAPTER 2 CURRENT ISSUES ON WATER RESOURCES MANAGEMENT OF WRMA REGIONAL OFFICES

2.1 Issues in the WRMA Documents

Among the documents prepared by WRMA, there are two major documents which describe the issues on water resources management especially for the WRMA regional offices. These two documents are the CMS and the WRMA Strategic Plan 2009-2012. CMS was prepared for each of the six regional offices of WRMA, while the WRMA Strategic Plan was prepared to specify the strategic directions of WRMA for a period of four years.

2.1.1 Catchment Management Strategy

Of the six CMSs prepared for the six catchment areas of WRMA, the issues related to water resources management in the WRMA regional offices were extracted by catchment area as follows:

(1) Lake Victoria North Catchment Area (LVNCA)

1) Flooding due to catchment destruction and destruction of control structures
2) Wetland degradation due to pressure on arable land and demand for wetland products
3) Effluent discharge due to poor planning, weak enforcement and inefficient monitoring
4) Weak law enforcement due to weak legislation framework
5) Conflicts over water (human/wildlife) due to competition for resources
6) Groundwater over abstraction due to inadequate supply from existing schemes
7) Lack of water resource information due to lack of measuring devices, and lack of or poor monitoring network

(2) Lake Victoria South Catchment Area (LVSCA)

1) Water scarcity
2) Water quality degradation due to point and nonpoint sources of pollution
3) Climate variability
4) Water resources assessment and monitoring
5) Degradation of water resources
6) Transboundary water resources
7) District and political boundaries mismatched with hydrological boundaries

(3) Rift Valley Catchment Area (RVCA)

1) Illegal and over abstraction
2) Pollution
3) Water scarcity
4) Decline in rivers flow
5) Water use conflicts
6) Destruction and encroachment of water catchment areas

(4) Athi Catchment Area (ACA)

<u>Upper Athi</u>

1) Catchment destruction
2) Over abstraction of both surface water and groundwater due to high population density
3) Excessive concentration of fluoride, iron, manganese, etc. in groundwater.
4) Substantial pollution of water resources due to high number of agro-based industries and urbanisation

<u>Middle Athi</u>

5) Catchment degradation due to low potential of water resources
6) Poor water quality and quantity due to quarrying, sand harvesting and farm chemical wastes
7) Excessive hardness and salinity

<u>Lower Athi</u>

8) Water scarcity in time and space
9) Groundwater with salinity
10) Sea water intrusion

(5) Tana Catchment Area (TCA)

<u>Upper Tana</u>

1) Water quality (too high fluoride) - health issue
2) Potential over abstraction
3) Catchment degradation from land use changes (water quality deterioration risk)

<u>Middle Tana</u>

4) Water scarcity - unevenly distributed groundwater availability
5) Seasonal variation of shallow groundwater levels
6) Water quality - salinity

<u>Lower Tana</u>

7) Water scarcity
8) Water quality - salinity
9) Wet season flooding (a groundwater issue that may affect water quality)
10) Water quality deterioration as a result of saline intrusion
11) Groundwater pollution from sewerage and pit latrines
12) Over abstraction risk of groundwater

<u>Springs</u>

13) Spring encroachment (e.g. Tamani Springs, Meru: Kambiti Springs, and Maragua), eucalyptus and shallow groundwater depletion
14) Catchment degradation has led to landslides and subsequent siltation of spring eyes (many places, such as in Maua and Murang'a)
15) Contamination of agrochemicals (pesticides and fertilisers, such as in Kitimui) and human waste (such as in Embu Town, near the waste water treatment plant)

(6) Ewaso Ng'iro North Catchment Area (ENNCA)

1) Acute water scarcity
2) Salinity of groundwater mostly in areas covered by basement rocks and colluvial deposits mostly in Daua and Ewaso Laggas management units
3) Catchment degradation, particularly in Mt. Kenya and the Aberdare slopes – steep slopes, intensive land pressure, small plot sizes, and charcoal burning in lower zones
4) Soil erosion due to poor farming methods in the middle zone
5) Encroachment on springs' sources in the upper zones, riparian lands and wetlands
6) Effluent discharges in the urban areas and poor solid waste management
7) Social conflict due to over abstraction of water especially in the upper zones of the catchment
8) Pollution of water resources from agrochemical effluents in agricultural areas
9) Encroachment
10) Illegal abstraction and poor compliance to water laws

2.1.2 WRMA Strategic Plan 2009-2012

In the WRMA Strategic Plan 2009-2012, key issues were derived from a comprehensive strength-weakness-opportunities-threats (SWOT) analysis conducted by the National Task Technical Team and by staff of the WRMA regional and subregional offices. Strategic objectives and strategies were formulated to address the key issues. The key issues were clustered according to strategic thematic areas as outlined below as based on the CMSs of the regional offices. Of the key issues, the items related to water resources management activities of WRMA regional offices are as follows:

1) Water Allocation, Use and Compliance to Water Resources Regulations
   a) Inadequate quality data and information for decision making
   b) Lack of water allocation plans
   c) Low compliance and weak enforcement
   d) Low levels of revenue collection
2) Institutional Development
   a) Limited professional and technical skills of the WRMA staff in specialised fields
   b) Inadequate resources (financial, logistical (transport), equipment and material resource, e.g. SROs, office space and laboratories)
   c) Inadequate procurement systems and ineffective information and communication technology (ICT) systems
3) Water Resources Assessment, Monitoring and Information Management
   a) Non-functioning monitoring stations, obsolete monitoring equipment and vandalism
   b) Inadequate and unreliable water resources data
   c) Limited capacity and funding to carry out water resource assessments and classification
   d) Inadequate monitoring networks and poor monitoring infrastructure
   e) Limited dissemination of water resources information and underdeveloped database
4) Water Resource Protection

a) Catchment degradation and human encroachment into the watershed
b) Deterioration of the quality of water resources (water pollution)
c) Inadequate water resource protection measures
d) Lack of enforcement
e) Poor collaboration and coordination between WRMA and stakeholders
f) Lengthy procedures due to conflicting interests (e.g. gazettement of catchment areas)

5) Mainstreaming Cross-Cutting Issues

a) Inadequate data and systems to ensure timely response to impacts of climate change and variability
b) Poor information dissemination and communications with stakeholders

2.2 Issues Identified Through Pilot Activities

The pilot activities that were undertaken in the WRMA TCA were meant to assist in strengthening the capacity and system for water resources management in the WRMA regional offices. The issues on water resources management extracted from the plot activities in WRMA TCA are as follows:

(1) Issues on Establishment and Operations 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
c) Enhancement of forum operations in the various WRMA regional offices
d) Selection of the forum topics by involvement of WRUA members since the main objective of the forum is for WRUAs to discuss issues that are important to their mandates and operations
e) Capacity building of the forum secretariat

(2) Issues on Strengthening of Hydrometeorological Information Management

a) Issues on hydrometeorological observation
   - Broken-down equipment
   - Vandalism of installed equipment
   - Inadequate resources for regular operations (equipment, transport, etc.)
   - Inadequate hydrometeorological network
   - Lack of measured discharge data on floods
   - Lack of dedicated boreholes for groundwater monitoring
   - Lack of technical capacity of gauge readers, etc.
b) Lack of system resources, such as computers and peripherals, for management of observed hydrometeorological data

(3) Issues on Water Permit Database Management

a) Lack of system resources, such as computers, for water permit issuance and control, and insufficient network resources and environment
b) Lack of functions of the water permit database
c) Lack of information on locations of existing and applied water permits
d) Capacity building of the WRMA staff on water permitting procedures
e) Capacity building of the WRMA staff on their operational skills for the water permit database system

(4) Issues on Improvement of Flood and Drought Disaster Management

(Flood Disaster Management)

a) Lack of information sharing and coordination among related organisations and flood information propagation
b) Lack of information on past floods, systems that indicate risk of flood, and survey and analysis of floods
c) Lack of long-term planning and implementation of flood mitigation measures
d) Weak hydrometeorological database
e) Lack of flood flow forecasting system on flood prone rivers and real-time observation of rainfall and river discharge by the KMD and WRMA

(Drought Disaster Management)

a) Lack of system to coordinate water use during droughts
b) Lack of rules for water use restriction during droughts
c) Lack of information on damages of past droughts

CHAPTER 3 PROPOSED ACTION PLANS TOWARD 2022

3.1 Strategy for Capacity Development

As mentioned in the previous section, the pilot activities in the WRMA Tana Regional Office were conducted according to the following four themes:

a) Establishment and Operations of Catchment Forum for Improvement of River Basin Governance
b) Strengthening of Hydrometeorological Information Management
c) Water Permit Database Management
d) Improvement of Flood and Drought Disaster Management

On the other hand, through analysis of the issues extracted from the CMSs and the WRMA Strategic Plan, it was realised that the above four themes are important for strengthening the system and capacity for water resources management of the WRMA regional offices.

Furthermore, through a questionnaire survey to other regional offices of WRMA, it was realised that other regional offices of WRMA also recognised the above four themes for the issues on water resources management.

In this connection, action plans for the WRMA regional offices are to be formulated based on the above four themes in order to strengthen the system and capacity for water resources management toward 2022.

3.2 Proposed Action Plans

Based on the strategy as mentioned in Section 3.1, the action plans for the WRMA regional offices toward 2022 are proposed as follows:

(1) Actions for Establishment and Operations of Catchment Forum for Strengthening of River Basin Governance

a) Establish a “Catchment Forum” in the six regional offices of WRMA with legal status. The Ministry of Water and Irrigation (MWI) and the WRMA headquarters are to take actions on the establishment of the legal status of the forum.
b) Secure budget for the operations of the catchment forum in each regional office and continue holding the forum periodically (twice a year).
c) Promote the establishment of WRUAs in each catchment area and promote participation of WRUAs to the forum[2].

Of the above three items, a) and b) need coordinative assistance from MWI and WRMA headquarters. For item c), promotion should be made by regional and subregional offices to

[2] It is expected that active participation to water resources management activities at community levels will be strengthened through promotion of establishment of WRUAs.

encourage water users to form WRUAs. WRMA should share experiences on assisting the establishment of existing WRUAs.

(2) Actions for Strengthening of Hydrometeorological Information Management

a) Improvement of operations of monitoring stations

i) Replace the present iron posts for river gauging with concrete posts in order to prevent vandalism.
ii) Upgrade the existing manual gauging stations to automatic gauging stations (surface and groundwater levels, and rainfall).
iii) Periodically patrol gauging stations at least once a year.
iv) Introduce flood discharge measurement equipment to prepare accurate rating curves.
v) Involve members of WRUAs as gauge readers for more responsible gauging.
vi) Install dedicated boreholes for groundwater monitoring.

b) Improvement of water quality monitoring and pollution control system

i) Publish guidelines on water quality monitoring.

As for water quality monitoring, it is recommended to publish guidelines for measurement items, locations, and frequency on mandatory water quality monitoring to clearly indicate the required activities for water quality monitoring.

ii) For pollution control, require industries to prepare an effluent discharge control plan (EDCP) .

To functionalise EDCP effectively, it is recommended to enforce the preparation of EDCPs by industries for pollution control.

iii) Establish water resources quality objectives (WRQO) for major water bodies.

As stipulated in Section 12 of the Water Act 2002, MWI should recommend a system for classifying resource quality objectives for each class water resource. The Water Act 2002 further mentions that under the recommended classification system, water resources may be classified according to type, location or geographical or other factors. To establish WRQO, it is recommended to form a team consisting of a water quality officer from the WRMA regional office as the leader, who is supported by water quality officers from subregional offices. The WRMA headquarters should take lead in disseminating the concept of WRQO by facilitating training courses for the team.

c) Improvement of hydrometeorological database management

i) Enhance system resources (computers and related equipment) based on assessment of the current situation.

For the strengthening of hydrometeorological database management, it is recommended to enhance system resources (computers and related equipment) for timely and efficient data input and analysis using the hydrometeorological database. For this, it is recommended to assess the current system resources against the required database management works in each regional and subregional office. The results of assessment should be reflected on the budget of the regional and subregional offices.

ii) Renew/update the hydrometeorological database system (every five years).

It is recommended to periodically renew/update the hydrometeorological database system. Considering the depreciation period of computers, software and other equipment, it is recommended to renew/update the system at least every five years. As a start, the current system should be renewed/updated within five years.

d) Establishment of training courses

Training of the WRMA staff on required skills for hydrometeorological information management is recommended in parallel with other activities. The required training courses for consideration include, but are not limited to, the following items:

i) Training course on discharge measurement
ii) Training course on water quality analysis in the laboratory for both surface water and groundwater
iii) Training course on the operations of the hydrometeorological 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.

It is required to enhance system resources (computers and related equipment) for timely and efficient data input and processing using the PDB. For this, it is necessary to assess the current system resources against the required permit processing works in each regional and subregional office. The results of assessment should be reflected on the budget of the regional and subregional offices.

ii) Enhance data communication environment (internet/intranet environment) based on assessment of the current situation.

For smooth interactions of required data for permit application and approval, it is required to enhance the data communication environment, such as internet or intranet, among the WRMA headquarters, regional offices and subregional offices. For this, it is necessary to assess the communication environment against the required permit processing works in each regional and subregional office. The results of assessment should be reflected on the budget of the regional and subregional offices.

iii) Establish a map-based permit information management system using global positioning system (GPS).

Water permit information should be linked with maps and managed using GPS equipment in order to know the exact locations of abstraction points and their geographical distributions. Ideally it is recommended to apply a geographic information system

(GIS); however, preliminary assessment on the current system is recommended to justify the introduction of a GIS based system.

iv) Renewal/updating of the PDB system (every five year).

It is recommended to periodically renew/update the PDB system. Considering the depreciation period of computers, software and other equipment, it is recommended to renew/update the system at least every five years. As a start, the current system should be renewed/updated within five years.

b) Establishment of training courses

Training of the WRMA staff on required skills for water permit database management is recommended in parallel with other activities. The required training courses for consideration include, but are not limited to, the following items:

i) Training course on the operations of the 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 the Kenya Meteorological Department (KMD), the Ministry of Regional Development Authorities (MORDA), the Kenya Electricity Generating Company (KenGen), the National Irrigation Board (NIB), local governments, and communities with clear demarcation and flow of information.
ii) Prepare flood hazard maps based on numerical analysis for major urban centres.
iii) Prepare a flood damage database to accumulate records of past flood damages.

A flood damage database should be prepared to accumulate records of past drought, which will be necessary for drought management.

iv) Install colour-coded staff gauges for flood risk indications.

For flood risk indications, it is recommended to install colour-coded staff gauges at strategic locations for flood risk indications. Strategic locations should be decided by the WRMA regional and subregional offices by referring to the flood damage database or relevant information.

v) Guide WRUAs to include flood aspects in the subcatchment management plan (SCMP).

In preparing the SCMP for the target management area, the WRMA regional or subregional offices should guide the WRUA in charge to include flood aspects. Such information will be useful to capture the characteristics of floods in specific locations.

vi) Conduct flood surveys and analysis of flood prone areas.

Since there is hardly any accurate data for survey and analysis of floods, it is recommended to conduct flood surveys and analysis of flood prone areas. For flood prone areas, information from the flood damage database or the SCMP prepared by WRUAs can be referred to.

b) Improvement of drought information management

i) Establish a basin drought conciliation council.

To coordinate water use among different users during drought periods, it is recommended to establish a basin drought conciliation council with legal status to avoid water conflicts. Such activity needs the involvement of the WRMA headquarters so as to set up the legal status of the council.

ii) Establish water use restriction rules of reservoirs.

As part of the activities of the basin drought conciliation council, it is necessary to establish water use restriction rules of reservoirs. For existing reservoirs, rules should be set up as early as possible by involving all the stakeholders of the reservoir. For planned reservoirs, restriction rules should be set up once the project features become clear.

iii) Prepare a drought damage database to accumulate past drought records.

A drought damage database should be prepared to accumulate past drought records, which will be necessary for drought management.

iv) Guide WRUAs to include drought aspects in the SCMP.

In preparing the SCMP for the target management area, the WRMA regional or subregional offices should guide the WRUA in charge to include drought aspects. Such information will be useful to capture the characteristics of droughts in specific locations.

The implementation schedules of the proposed action plans are shown in Figure 3.2.1.

Figures

No.	Description	Implementation Schedule									
		Short Term					Medium Term				
		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
		13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23
(1)	Actions for establishment and operation of catchment forum for strengthening of river basin governance										
a)	Establishment of a "Catchment Forum" in six regional offices of WRMA with legal status	■	■								
b)	Continuous operation of "Catchment Forum"		■	■	■	■	■	■	■	■	■
c)	Promotiono of establishment of WRUAs and promotion of participation of WRUAs to "Catchment Forum"	■	■	■	■	■	■	■	■	■	■
(2)	Actions for strengthening of hydro-meteorological information management										
a)	Improvement of operation of monitoring stations										
	i) Replacement of present iron post for river gauging by concrete post against vandalism	■	■	■							
	ii) Upgrade of existing manual gauging into automatic gauging (surface and groundwater level, and rainfall).			■	■	■	■	■			
	iii) Periodical patrol of gauging stations	■	■	■	■	■	■	■	■	■	■
	iv) Introduction of flood discharge measurement equipment for preparation of accurate rating curve		■	■	■						
	v) Involvement of members of WRUAs as gauge readers for more responsible gauging	■	■	■	■	■	■	■	■	■	■
	vi) Installation of dedicated boreholes for groundwater monitoring	■	■	■							
b)	Improvement of water quality monitoring and pollution control system										
	i) Publishing a guideline for water quality	■	■								
	ii) Enforce preparation of Effluent Discharge Control Plan (EDCP) by industries for pollution control.	■	■	■	■	■					
	iii) Establishment of water resources quality objectives for major water bodies	■	■	■							
c)	Hydro-meteorological database management										
	i) Enhancement of system resources (computers and related equipment) based on assessment of the current situation			■	■				■	■	
	ii) Renewal/update Hydro-meteorological Database System (every five year)			■	■				■	■	
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) Enhancement of system resources (computers and related equipment)			■	■				■	■	
	ii) Enhancement of data communication environment (internet/intranet environment)			■	■				■	■	
	iii) Establish a map-based permit information management system using GPS			■	■						
	iv) Renewal/update of PDB (every five year).			■	■				■	■	
(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 organizations	■	■								
	ii) Preparation of flood hazard maps based on numerical analysis for major urban centres	■	■								
	iii) Preparation of flood damage database to accumulate past flood damages	■	■	■							
	iv) Installation of color-coded staff gauges for flood risk indications	■	■								
	v) Guidance to WRUAs to include flood aspects to Sub-catchment Management Plan (SCMP)	■	■	■	■	■	■	■	■	■	■
	vi) Flood survey and analysis for flood prone areas	■	■	■	■	■	■	■	■	■	■
b)	Improvement of Drought Information Management										
	i) Establishment of a basin drought conciliation council	■	■								
	ii) Establishment of water use restriction rules of reservoirs	■	■								
	iii) Preparation of drought damage database to accumulate past drought records	■	■	■							
	iv) Guidance to WRUAs to include drought aspects to Sub-catchment Management Plan (SCMP)	■	■	■	■	■	■	■	■	■	■

Source: JICA Study Team

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 3.2.1
Implementation Schedule of Proposed Action Plans